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M.Sc. in Textile Engineering

EBRU ÇERÇİ

UNIVERSITY OF GAZİANTEP
GRADUATE SCHOOL OF
NATURAL & APPLIED SCIENCES

IMPROVEMENT OF COMFORT PROPERTIES OF DENIM FABRIC AFTER COATING PROCESS

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ABSTRACT

IMPROVEMENT OF COMFORT PROPERTIES OF DENIM FABRIC AFTER COATING PROCESS

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Denim, which is characterized with certain physical properties, is a generally cotton fabric produced for work and sportswear for years thanks to superior abrasion and tear resistance than other fabric types like gabardine. The importance of this sector is easily accepted when considering approximately 3,5 billion meters annual worldwide manufacture. Denim fabrics are subjected to coating to give new appearance, create new market and increase performance. However decrease in air / water vapour permeability of the fabric after coating is a disadvantage. The garments have to help obtaining thermal balance between body and environment and make consumer feel comfort by transferring, perspiration, heat and moisture.

In this thesis, commonly used conventional type PU coating was made with denim samples to the laboratory and micro cracking process was applied in order to increase the breathability of the fabric. Acetone, dimethylformamide (DMF) and ethanol solvents were used for micro cracking process and fabric samples comfort (water vapor permeability, air permeability, wicking) and mechanical (tensile strength-elongation, abrasion, water repellency) parameters were measured. Analyses of variance (ANOVA) was performed in order to understand the statistical importance of solvent type, bath rate and duration time on denim fabric properties and were used to determine variations.

Key Words: Clothing comfort, denim fabric, coating.

ÖZET

DENİM KUMAŞLARIN KAPLAMA SONRASI KONFOR ÖZELLİKLERİNİN İYİLEŞTİRİLMESİ

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Denim kumaş belirli fiziksel özelliklerle karakterize edilen, ağırlıklı olarak pamuk ipliğinden üretilen ve gabardin gibi kumaşlara göre yüksek aşınma ve yırtılma dayanımı gösterdiği için uzun yıllardır iş elbisesi ve spor giysilik amacıyla üretilen bir kumaş tipidir. Günümüzde tüm dünyada yıllık denim kumaş üretiminin 3,5 milyar metre civarında olduğu göz önüne alındığında bu sektörün önemi ortaya çıkmaktadır. Ürüne yeni bir görünüm kazandırmak, yeni bir pazar payı oluşturmak ve kullanım performansını arttırmak amacıyla denim kumaşlara kaplama işlemi uygulanmaktadır. Ancak kaplama işleminden sonra kumaşın sahip olduğu hava/ su buharı geçirgenlik özelliklerinin azalması bir dezavantaj olmaktadır. Kullanıcıların giysi içinde konforlu hissetmeleri için, kumaşların vücudun ürettiği ter, ısı ve nemi ileterek dış ortamla vücut arasında dengenin kurulmasında destek olması gerekmektedir.

Bu tezde, yaygın olarak kullanılan konvansiyonel tip PU ile denim kumaş numunelerine laboratuar ortamında kaplama yapılmış ve kumaşların nefes alabilirliğini arttırmak amacıyla mikro-çatlatma işlemi uygulanmıştır. Mikro-çatlatma için aseton, dimetilformamid (DMF) ve etanol çözgenleri kullanılmış ve kumaş numunelerinin konfor (su buharı geçirgenliği, hava geçirgenliği, kılcallık) ve mekanik (kopma mukavemeti-uzaması, aşınma, su geçirmezlik,) parametreleri ölçülmüştür. Çözelti tipi, banyo oranı ve bekletme süresinin kaplanmış denim kumaş özellikleri üzerine etkisinin istatistiksel açıdan önemi varyans analizleri yapılarak araştırılmış ve işlem varyasyonları belirlenmiştir.

Anahtar Kelimeler: Giyim konforu, denim kumaş, kaplama.

Dedicated to my mother…

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Top finishes began to be used in the 18th century and fabric surfaces were coated with linseed oil to produce oil cloth. It was the first processes of coating various agents to the textile surface. The textile fabric surfaces coated with chemical structures and have been improved unceasingly for several last decades [Kovacevic et al., 2010]. Coating process is increasingly significant technique to technical textile materials. It improves and extends the range of specific performance properties of textiles such as tear resistance, breaking strength, abrasion resistance and also air/water resistance. The coating technique is developing rapidly for technical textile applications become more diverse [Singha, 2012].

Other usage area is clothing industry. However coating process is limited the use of the fabric as clothing. Because of coating polymer is covered the fabric surface and so clothing breathability properties is lower. Human body is a dynamic system and it is produced constantly sweat or vapour and the clothing must be allow to transfer from the human body's skin to the environment. Generally, it keeps human body temperature stable at 35 ± 2 °C under several climatic conditions and also feels comfortable [Pamuk, 2007; Yonenaga, 2001]. The coating process is breathable garment made of fabric (air and vapor permeable) many studies to improve the feature is available. Hydrophilic coating agents are commercial products, micro porous membrane materials and so on. Nowadays, a rapidly changing fashion effect causes a new search. The coating is visually striking and changing the perception of fashion, pants, jackets, blouses and knitted fabrics such as the implementation of the coating and has led to the formation of a new garment market. So this application, modified to assist in the provision of breathable garment breathability, ecological polyurethane (PU) polymer is used.

Denim fabrics finishing is one of the most extensively used finishing treatments that have enormous practice, because of its effects on appearance and comfort. There are almost countless variations of dry and wet processing techniques used by designers and textile chemists to achieve fashionable looks that are distinctive and desirable. It can be supply the strength and different appearance views for the fabric surfaces. When it is managed the various properties denim garment, and so many people (from younger to older) can be wearing the denim garment such as; jeans, jackets, shirts [Yi, 2011; Khalil, 2015]. Recently, coated denim fabrics are fashioned especially different colour such as; gray, metallic, etc.

In this thesis, denim fabric samples were coated with commonly used of conventional type Polyurethane (PU) in the laboratory condition and after that micro-cracking process was applied in order to increase the breathability of the coated denim fabrics. For micro-cracking process; Acetone, DMF (dimethylformamide) and Ethanol solvents were used and in order to specify comfort properties of the fabric samples (air/water vapour permeability and wicking) and mechanical or performance properties of the fabric samples (water repellency, breaking strength-elongation and abrasion resistance) were measured in the laboratory. These properties were determined before coating process (untreated denim fabrics) and after coating process or before micro-cracking process and after micro-cracking process.

1.2 Aim of Thesis

The aim of this thesis, to enhance the comfort properties of commercial polyurethane coated denim fabric and to provide breathable coated denim fabrics with lower cost compared to membrane laminated fabrics.

As part of this thesis, the purposes can be sorted as follow;

1. To measure comfort parameters (air permeability, water vapour permeability, wicking) and mechanical parameters (water repellent, breaking strength and elongation and abrasion resistance) of polyurethane coated denim fabrics,
2. To apply micro-cracking process,
3. To determine effect of denim fabrics comfort and mechanical properties after the micro-cracking process,
4. To compare micro-cracking process parameters.

1.4 Structure of Thesis

The study composes of five chapters.

Chapter 1 introduces back ground, aims and significance of this study.

Chapter 2 contains literature survey as well as the knowledge of denim fabrics, textile coating and clothing comfort.

Chapter 3 provides experimental details which involves experimental adjustment and also the specifications of the denim fabrics.

Chapter 4 includes the results and discussions of comfort and mechanical tests applied on different types of coated denim fabrics.

The conclusion of thesis is given in Chapter 5.

CHAPTER 2

LITERATURE SURVEY

2.1 Denim Fabrics

Denim fabrics were appreared in America in the late of 18th century. At first, villagers and workers worn denim which is a variety of pants or common uses known as the "Blue Jean" is found for the first time in the middle of the 19th century. In the 1950's it became fashionable thanks to famous stars such as James Dean, Marlon Brando and it has expand quickly throughout the world during World War II. Nowadays, usage area of the denim fabrics are quite expand such as jeans (trouser), shirt, jacket, working clothes, bags, accessory, etc. [Aslan and Körlü, 2009; Sülar and Kaplan, 2010; Yi, 2011; Babalık, 2012; Toksöz and Mezarcıöz, 2013; Khalil, 2015].

Among all the textile products, no other fabric has received such a wide acceptance as denim. It has been used extensively by people of all ages, classes and genders. Denim jeans can be considered as the most widely used garment in the fashion business. Jeans have become symbols for women, youth and economic status. Through the ages, jeans have evolved from work wear to casual wear and then to premium wear and functional wear. Consumers evaluate jeans based on style, brand, country of origin and company ethics. Designer jeans as well as premium jeans first influenced a small group of luxury consumers, but now consumers from all social and economic classes embrace them. Challenges faced by denim apparel manufacturers and fashion designers include the need for reinventing products for niche markets, and meeting consumer demands for better apparel sizing [Aslan and Körlü; Yi, 2011; Toksöz and Mezarcıöz, 2013; Khalil, 2015]. Denim fabric manufacture has a significant place not only Turkey but also worldwide. The production of denim fabric and the consumption have augmented day after day. Tablo 2.1 and Tablo 2.2 are given information about the denim fabric exports in Turkey between 2010 and 2013. As it can be seen the denim fabric ratio and denim clothing ratio are changeable according to years.

And also Figure 2.1 indicated that Turkey's denim fabric exports increase from 101.626.363 $ to 435.897.124 $ according to years between 2000 and 2013.

Tablo 2.1 The Share of Turkey on Textile Exports

Currency; ABD $	**Export of Denim Garments** **The Share of Turkey on Textile Exports**		
Years	**Textile Exports**	**Denim Fabric Exports**	**Denim Fabric Ratio (%)**
2010	6.352.784.994	388.962.538	6,1
2011	7.709.701.423	426.657.304	5,5
2012	7.749.225.552	372.011.203	4,8
2013	8.370.751.010	435.897.124	5,2

Reference: İTKİB Genel Sekreterliği/AR&GE/June, 2014

Tablo 2.2 The Share of Turkey on Garment Industry Exports

Currency; ABD $	**Export of Denim Garments** **The Share of Turkey on Garment Industry Exports**		
Years	**Garment Industry Exports**	**Denim Clothing Exports**	**Denim Clothing Ratio (%)**
2010	14.205.917.174	1.502.143.744	10,6
2011	15.664.973.824	1.556.622.886	9,9
2012	15.753.400.255	1.488.677.983	9,4
2013	17.158.866.915	1.609.388.754	9,4

Reference: İTKİB Genel Sekreterliği/AR&GE/June, 2014

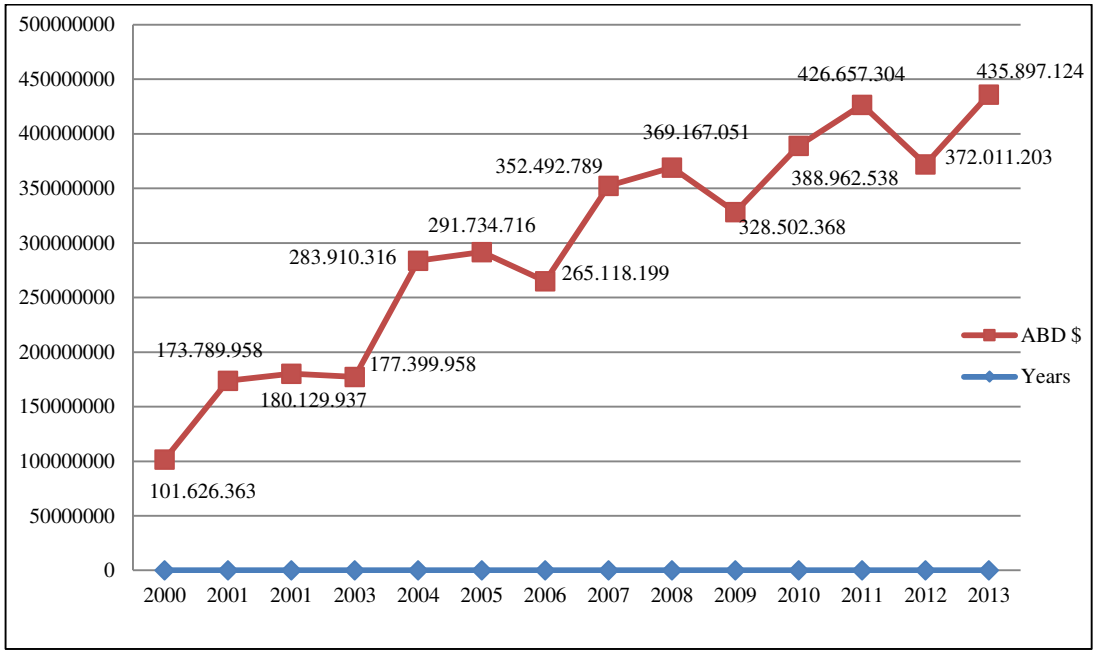


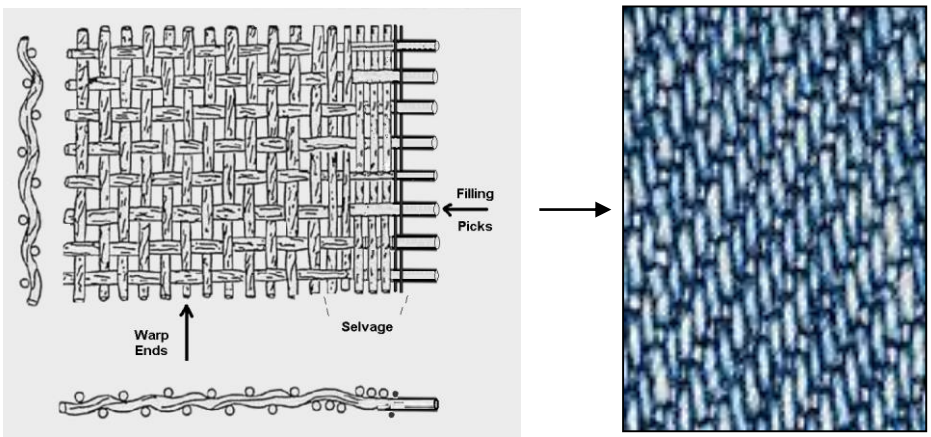
Figure 2.1 According to years (2000-2013) Turkey's denim fabric exports

Reference: İTKİB Genel Sekreterliği/AR&GE/June, 2014

2.1.1 Denim Fabric Production

Denim fabrics are generally developed from cotton yarns for clothing. It is usually produced with 100 % cotton and the fabric construction is a twill weave (the weft yarns pass under two or more warp yarns. The denim fabric yarns made from dyed warp yarns and undyed weft yarns. Generally, the denim fabric is a heavy fabric with the yarn used in the denim weaving have the yarn number is from 6 to 10 Ne. Normally, the denim fabric, warp yarns are thicker than the weft yarns because, the warp yarn require held in a higher tension in the weaving process [Yi, 2011; Bilişik and Yolacan, 2011; Toksöz and Mezarcıöz, 2013].

The typical denim fabric construction is generally a warp - faced 3/1 right hand side twill (Figure 2.2). The dyed warp yarns are faced on one side of the fabric surface, the face side of the denim is blue. The twill weave fabrics have a technical face and back. The technical face is generally more durable or strength than the technical back. High count woven fabric, for instance; high amount of interlacing, gives a strong, durable, compact and stable fabric. Low count fabric, for instance; fewer amount of interlacing, gives a flexible and soft fabric. To resist big dimensional changes it is significant point with a good balance between warp and weft yarns [Yi, 2011, Bilişik and Yolacan, 2011; Babalık, 2012; Nilsson and Lindstam, 2012].



Right (Z)

Figure 2.2 Denim fabric structure 3/1 Z twills [https://www.dreamstime.com]

Denim was traditionally colored blue with indigo dye. The indigo dye, which is the substantial of the natural dyes there have been sustained to use. It is a blue dye come

from the “Indigofera tinctoru” in India. The group of the colorants indigo is one of the oldest known as the natural dyes [Yi, 2011; Babalık, 2012].

The indigo dye is one of the dyestuffs with an original blue color and it has good wet fastness properties, moderate lightfastness properties, and even there have the fading of the color, there without change of the color. For the natural dyes which come from some of the different species of plant. However recenlty, the indigo dying (Figure 2.3) procedure is synthetic and not natural. Traditional denim fabrics are woven by interlacement of indigo dyed warp and grey weft. The denim fabrics are made with open end rotor yarn in both warp and weft direction. However, ring yarn, ply yarn, filament yarn, lycra core yarn are extensively used in denim to achieve some special effect, smoothness and comfort in denim products [Yi, 2011; Babalık, 2012].

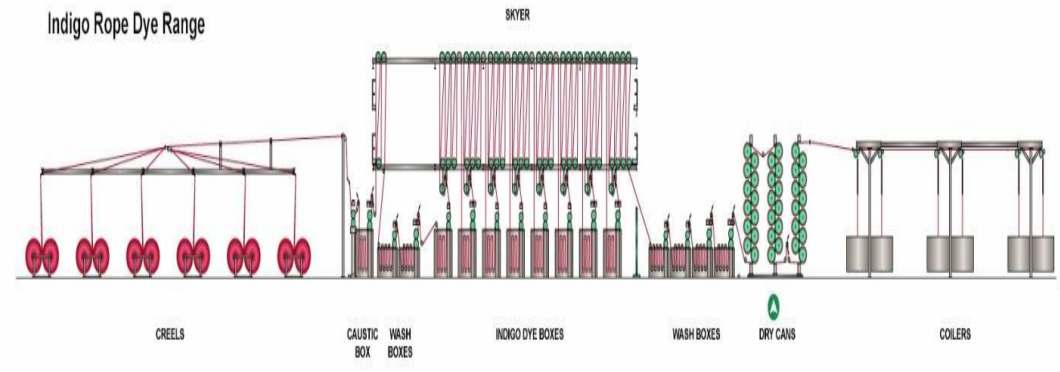


Figure 2.3 Indigo dying range [http://www.denimsandjeans.com]

Denim fabric manufacturing starts with the yarn spinning and Figure 2.4 shows that the necessary steps in the manufacture of denim fabrics, beginning with the production of the warp yarns used [Babalık, 2012].

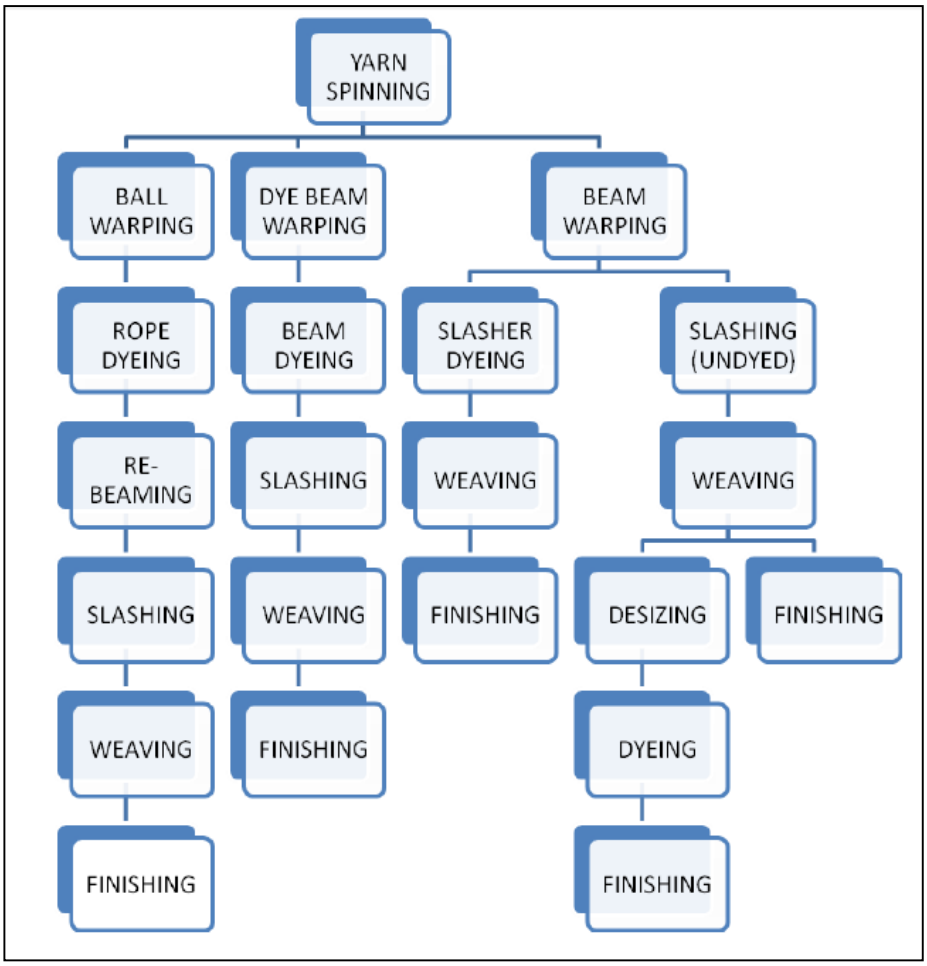


Figure 2.4 Process flow for warp yarn in denim manufacturing [Babalık, 2012]

2.1.2 Denim Fabric Washing Processes

Generally the denim fabrics are produced for sports clothes and working clothes for years thanks to remarkable abrasion resistance and also tear resistance than other fabric types such as poplin and gabardine. They have always been used for very durable outdoor work clothing. Because of its thickness, weight and rigidity denim is chosen for casual jeans, jackets, skirts, and etc. [Yi, 2011; Sülar and Kaplan, 2011; Toksöz and Mezarcıöz, 2013; Khalil, 2015].

Its usage has always an increase trend and has various appearances, designs and colors obtained by different washing and fading processes support trend after 1990's. Now that so many garment finishing techniques are applied to denim. Denim is still mostly used for pants and jackets, with most attention focused on interesting jeans. The significant factors influence consumers when choosing garments are appearance, fashion and aesthetic. Additionally all these factors, the comfort properties of

clothings during usage are also subtantial parameter. Comfort, at its maximum level, is needed for the human body to feel comfortable. Nowadays, companies have been trying to enhance the visual aspects of denim fabrics with washing and finishing processes. Industrial washing process is one of the most significant finishing treatments on the denim fabric surfaces. Different washing process can be applied in case of denim fabrics [Juciene et al., 2006, Özdil, 2008; Khedher et al., 2009; Rahman, 2011; Yi, 2011; Sülar and Kaplan, 2011; Eryürük et al., 2012; Mezarcıöz and Toksöz, 2014; Khalil, 2015].

2.1.2.1 Physical Processes

The fading and washing processes are changed the appearances of denim products. The denim garments applying physical (mechanical) processes such as; sanding, spraying, scraping and grinding [Khedher et al., 2009; Sülar and Kaplan, 2011; Eryürük et al., 2012; Toksöz and Mezarcıöz, 2013; Mezarcıöz and Toksöz, 2014].

(i) Sanding

Sanding is based on blasting an abrasive substrate in granular, powdered or other different form through a nozzle at very high pressure and speed onto specific areas of the fabric surface to be applied to give the desired distressed look. This process has some advantages and disadvantages such as;

- This process is completely mechanical, there is not using any chemical substrates.
- There is no water process so it is no drying need.
- Different distressed or abraded looks possible.
- Various designs can be produced by special techniques [http:// www. fibre2 fashion.com].

(ii) Spraying

This process can be produce to achieve various effects on the fabric surface by spraying on pigments or chemicals substrates. It saves water, time and energy [Nilsson and Lindstam, 2012].

(iii) Scraping and Grinding

The scraping and grinding are two different examples of the mechanical treatments. With the scraping process, the colour is removed by using sand paper. The grinding process destroys or tears the fabric apart. Both processes cause to damage on the fabric surfaces. These processes have negative effect on the durability (strength) of the fabrics [Nilsson and Lindstam, 2012].

2.1.2.2 Chemical Processes

Chemical processes such as; pre-washing, stone washing, enzyme washing, rinse washing and bleaching [Khedher et al., 2009; Sülar and Kaplan, 2011; Eryürük et al., 2012; Toksöz and Mezarcıöz, 2013; Mezarcıöz and Toksöz, 2014].

(i) Pre-Washing

First step is the pre-washing in the denim production line. Several garments or clothings, especially denim jeans (trousers), are pre-washed at the beginning. The pre-washing process minimizes the risk of unwanted shrinkage and the colour loss when it is in the hands of the customer. It is also removes stains appeared during the handling of fabrics. It does not damage the fibres and fabric surface and it is also very easy to control [Nilsson and Lindstam, 2012].

(ii) Stone Washing

This washing process is a textiles manufacturing typically applied by the fashion industry, in order to give a newly assembled cloth garments a worn appearance. It is a traditional washing treatment where pumice stone or volcanic rocks are added to the clothing during wash as abradants. Usually, this washing method is made on indigo dyed garments that easily loses colour during abrasion. The stone washing treatments are made with artificial and natural stones. This process causes to damage to fibres and also fabric surfaces. The degree of damage depends upon type of stones used and process time. It assists to improve the flexibility and softness of otherwise rigid and stiff fabrics such as denim, canvas, etc. [Nilsson and Lindstam, 2012; Mezarcıöz and Toksöz, 2014].

(iii) Enzyme Washing

Recently, there is using biodegradable enzymes for washing process. This method is also non-toxic and environmentally friendly in the modern textile finishing applications. A certain number of chemical and mechanical processes can be replaced by enzymatic processes. These processes have been used to enhance the fabric quality and the comfort properties. The enzyme washing is a process when the garments are washed in a cellulase-based liquid instead of washed with stones. In the textile industry, the enzymes are applied usually to get a cleaner fabric surface with fuzz, to smooth the surface combining, to decrease tendency to pill formation, to enhance the fabric handle and different valuable properties with traditional softener agents [Aslan and Körlü, 2009; Rahman, 2011; Nilsson and Lindstam, 2012; Mezarcıöz and Toksöz, 2014].

(iv) Rinse Washing

The rinse washing is the last step before the drying in the classical denim washing treatment. Touch effect demanded on the product is provided with softening properties. Several chemical substrates are used to provide good touching effect. The softener used gives specific handle and drape of the fabric. They can be influence inflator and lubricant improver [Mezarcıöz and Toksöz, 2014].

(v) Bleaching

After bleaching process is generally blue tone on the denim fabric surface. The bleaching process can be done in various ways with various chemical agents:

- Calcium hypochlorite
- Sodium hypochlorite
- Hydrogen peroxide
- Potassium permangate

Calcium and sodium hypochlorite are generally used for medium worn appereance denim fabrics. It can be possible to obtain the light colors with hypochlorite bleaching. It has to be studied carefully, because the excessive loss of resistance of hypochlorite. Hydrogen peroxide can be applied when a light bleaching effect is wanted on the denim fabric surface. Potassium permangate is applied for super

vintage and light shade looks [Nilsson and Lindstam, 2012; Mezarcıöz and Toksöz, 2014].

2.1.2.3 Special Washing Processes

The recent developments of the environment friendly, sustainable, and emerging industrial approaches; laser, ozone and water jet for the denim fabric finishing processes [Juciene et al., 2006; Rahman, 2011; Khalil, 2015].

(i) Laser Fading

Recently, the laser fading is very popular dry process for denim fabric. It is used widely as the replacement of some conventional physical processes such as; the sanding, spraying, grinding and etc. The laser fading systems are used in fashion design, pleating, cutting and modification of fabric surface [Khalil, 2015]. This process has some advantages such as;

- The laser fading system is controlled with computer.
- It enables patterns to be created such as dots, lines, images and even pictures.
- This process is no used water.
- It is completely automatic system.
- Also it is called spray painting process in denim surfaces.
- This process has also relatively higher cost [http://www.fibre2fashion.com].

(ii) Ozone Fading

Ozone typically acts as a mild bleaching agent as well as a sterilizing agent. In this process of denim fading, the garment is bleached with ozone dissolved in water in a washing machine. However, it can also be carried out in a closed chamber by using ozone gas. Some advantages of this method are;

- This process is a simple fading method.
- A minimum loss of strength.
- Water and chemical free that is environment friendly.
- Low energy costs and short treatment time. Nowadays, ozone fading can also be achieved by plasma equipment. As a result, the color fading effect of the indigo dyed textile is achieved [Khalil, 2015].

(iii) Water Jet

Water jet process has been improved for patterning and to enhance the surface finish, texture, durability and other characteristics of denim garments. Hydro jet treatment usually involves exposing one or both fabric surfaces with hydro jet nozzles. The degree of color washout, pattern clarity and fabric softness are depended to the dye type in the fabric and the amount and manner of fluid effect energy applied to the fabric surface. Especially, good results are procured with blue indigo dyed denim fabric. This process does not involve any chemical agents, and it also is no pollution [Khalil, 2015].

2.2 Textile Coating

Textile material surfaces coated and laminated with chemicals have been improved constantly for several last decades. The basic substrate of the surface material is commonly coated and laminated on the textile fabric surface one or both sides with one or more polymer layers [Masteikaite and Saceviciene, 2005; Dubrovski, 2010; Singha, 2012].

Generally, the coating is a finishing process in which a polymer is applied generally in viscous form directly to one or both on the fabric surface. A variety of techniques are used (foaming, calendering, etc.). The polymer coating must stick to the textile surface and a blade controls the thickness of viscous polymer. The coated fabric is heated and also the polymer substrate is polymerized. On the other hand, laminating process is bonded a film onto the substrate, it is usually with adhesive or thermal bonding. Curing process is generally not need. In Figure 2.5 shows clearly coated and laminated fabric cross-sectional view [Masteikaite and Saceviciene, 2005; Dubrovski, 2010; Singha, 2012].

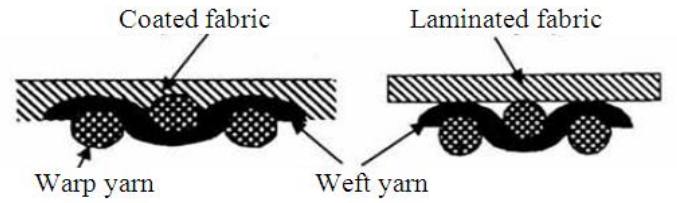


Figure 2.5 Schematized cross-section along yarn direction on coated and laminated fabrics [Masteikaite and Saceviciene, 2005]

Coating and laminating improve and extend the specific performance properties of textile materilas and to create specific properties with a material. These methods are arising rapidly as the technical textile applications become more diverse. The coating and laminating fabrics have diverse applications in the areas, such as airbag, geotextile, industrial fabric, medical textiles etc. Nowadays, these materials used in protective and outwear garments. Especially the use of these products is increasing and they are enhancing greater significance in the clothing industry. The coatings can be coloured, translucent, retro-reflective, photo-luminescent or fluorescent, according to the end user needs [Masteikaite and Saceviciene, 2005; Dubrovski, 2010; Singha, 2012; Bulut and Sülar, 2015].

2.2.1 Coating Substrates

2.2.1.1 Coating Polymers

When the choice of the basic coating polymer substrate properties are as follows: water, heat and air conductivity, thermo-plasticity, melting point, stiffness, mechanical properties of polymers, good adhesion, film formation, resistance to UV, radiation, solvents, hydrolysis, abrasion and etc. On the other hand, the coating has polymers to be foamed, to production, and the type of coating machinery to be used [Dubrovski, 2010; Kovacevic, 2010; Singha, 2012; Akovali, 2012].

There are some of coating polymers ; Poly Vinyl Chloride (PVC), Polyviylidene Chloride (PVDC), Polyurethane (PU), Acrylic, Ethylene Vinyl Acetate (EVA), Polyolefins, High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), Polypropylene (PP), Silicone rubbers, Poly Tetra Fluoro Ethylene (PTFE), Neoprene Rubber, Natural Rubber (NR), Nitrile Rubber (NBR), EPDM Rubber, Polychlororpene rubber (neoprene), Chlorosulphonated Polyethylene (hypalon), Fluoro Elastomer [Hall, 2000; Singha, 2012; Akovali, 2012].

The selection of coating polymer substrates is very significant point to get desirable characteristics of the finished product, and the coating application range is confirmed according to the application of the finished product. Table 2.3 indicates some coating polymers properties and application areas and Table 2.4 given information about coating types according to applying coating range and application areas [Kovacevic, 2010; Dubrovski, 2010; Bulut and Sülar, 2015].

Table 2.3 Coating polymer properties and application areas [Bulut and Sülar, 2015; Singha, 2012]

Some Coating Polymers	Properties	Products
Poly Vinyl Chloride (PVC)	High elasticity and abrasion resistance, flame resistance.	Tarpaulins, large tents, seat uphosttery, tent cover, leather, industry textiles.
Polyviylidene Chloride (PVDC)	Protect to chemicals, flame resitance, luster, hard, brittle, expensive.	Protective clothing againts flame, aprons, banners.
Polyurethane (PU)	High elongation strength, resistant to air conditions, abrasion and tearing resistance, oil repellent.	Waterproof and breathable protective clothing, shoes, hand bag, tents.
Ethylene Vinyl Acetate (EVA)	High elasticity, low resistant to washing.	Adhesives, backing for carpets and upholstery, wall covering.
Polyolefins, LDPE,HDPE,PP	Resistant to chemicals, low cost, environment friendly, low melting temperature.	Adhesives, light weight coverings, tarpaulins.
Poly Tetra Fluoro Ethylene (PTFE)	Chemical protective, heat and corrosive resistant, good water and oil repellent, expensive.	Parachtes, food and medical applications, woven curtains,architectural applications.
Silicone	Thermal resistance&insulating, high tear and burst strength, expensive.	Bulk bags, air bags, food and medical applications
Hypalon	Resistant to chemicals and oil.	Bulk bags, air bags, protective clothing.
Natural Rubber (NR)	Resistant to breaking and abrasion, high elasticity properties.	Protective clothing, gasket, seats, carpet backing.
Stryrene Butadiene Rubber (SBR)	High abrasion resistance, no effect by air.	Conveyor belts, protective clothing, carpet backing.
Nitrile Rubber	High heat and UV resistance, good oil repellent and breaking strength and abrasion resistance.	Oil resistant clothing, oil seals.
Neoprene Rubber	High resistant to chemicals, good flame resistance, low heat resistance 120º.	Resistance to chemicals, Neoprene/nylon- industrial covers, protective clothing.
Floura elastomers	High resistant to chemicals, heat and air conditions.	Special protective clothing, tents.
Acrylic	High UV resistance, good flame resistance.	Tents, otomotive upholstery.

Table 2.4 Application areas of coating

Coating Types	Applying coating range (g/m^2)	Application Areas
Thin coating	<30	Clothing, raincoat, sports
Middle coating	30-60	Bag, lining
Dense coating	>60	Table cloth, overalls

2.2.1.2 Properties of Surface Material for Coating

Polymer coated textile materials have various application, from the technical textiles to the textile clothing industry and it provides new fabric properties. The advantage of textile materials in the clothing industry is their water impermeability, while on the other hand they are air/water vapor permeability, resulting in good properties of simultaneous comfort and protection [Heller and Pringe, 2001; Dubrovski, 2010].

The textile substrate used related to the type of product desired. Some factors such as fabric conctruction, warp-weft sett, fabric thickness, breaking and tear strength, flexibility and dimensional stability are affected by the selection of the textile material. The common fabric construction types are woven, knit, and nonwoven [Heller and Pringe, 2001; Dubrovski, 2010].

- ***Woven fabric*** is very strong fabric and also it is resistant to breaking, tear and elongation.
- ***Knitted fabric*** allows to contoured and also stretched. The stretching allows for tear resistance, but the coating must be able to flex along with the fabric.
- ***Nonwoven fabric*** is not expensive production, but they are not strong unless they are coated. Unlike knit and woven fabric surfaces, the coating process must be used to perform stability to a nonwoven fabrics [Heller and Pringe, 2001; Dubrovski, 2010].

As far as coated fabric properties are related to the yarn type. Man-made fibers can be similar to natural fibers, and also sometimes they can surpass the properties of natural fibers, resulting in an increasing application for coated materials [Dubrovski, 2010].

Cotton, rayon, polyamide, polypropylene, polyester and also blends are the most common types of textile coated substrates. Among these yarn types, cotton, polyester and polyamide accounted for over 90 % of coated fabrics.

- ***Cotton*** transmits and absorbs moisture very easily and quickly. It is generally used in clothings. It can act as a barrier under intense heat and it is stronger when wet than dry [Heller and Pringe, 2001].
- ***Rayon*** is a synthetic or man-made form of cotton. It is not as strong as cotton and also it is tends to shrink. Mechanical adhesion is difficult, but chemical adhesion and dyes are easily applied to the fabric [Heller and Pringe, 2001].
- ***Polyamide*** is the strongest textile material used for coated fabrics. It has performance include resistance to abrasion, high breaking strength, wet strength, elasticity and excellent flexibility. Although UV degrades its performance properties, the coating process can be eliminates such this problem [Heller and Pringe, 2001].
- ***Polyester*** is not unlike polyamide and it is used in many similar productions. It is the most usually used substrate fiber. While polyester fibers is more resistant to environmental degredation. The fibers have very smooth surface that creates bonding difficulties [Heller and Pringe, 2001].
- ***Polypropylene*** is not expensive and like polyester, it is difficult to apply a durable coating to polypropylene. It is also easily susceptible to heat damage [Heller and Pringe, 2001].

The fabric coatings industry produces a wide several of products. The final product takes on properties of both the coating and substrate. The products made by the industry include clothing, upholstery, air bags, tarpaulins, tents, wall coverings, pond liners, air inflated structures, and so on. The almost infinite several combinations of coating and fabric materials allow for the production of highly technical products with specialized performance properties. As a result of, the coated fabrics can be found serving very various functions in the manufacturing, garment, aircraft, road building, boating, automotive, mining, outdoor equipment, transportation and other different applications [Heller and Pringe, 2001].

2.2.2 Types of Coating Processes

There are various methods for the production of coating to the textile material surfaces. The methods are selected depending on the requirement of end product, the properties of the substrate and the coating materials. Generally all production methods, the fabric is placed under tension and is directed through a system of cylinders. The cylinders are combined with different types of equipment used to apply the coating material [Heller and Pringe, 2001; Kut and Güneşoğlu, 2005; Singha, 2012]. The most commonly used techniques are knife (direct), foamed coating, reserve coating, transfer coating, hot-melt exturison coating, calendering, rotary screen coating, lick roll and gravure coating [Hall, 2000; Heller and Pringe, 2001; Kut and Güneşoğlu, 2005; Singha, 2012; Bulut and Sülar, 2015]. These processes are explained below and also Table 2.5 given an information about that coating application process and their usage areas.

Table 2.5 Coating types and application areas [Hall, 2000; Heller and Pringe, 2001; Singha, 2012]

Types of coating	**Application areas**
Knife coating	Water-proof protective clothing fabric, tarpaulins, light weight material, automotive car seat fabrics.
Foamed coating	Apparel goods, floor-wall coverings, curtain linings, black-out curtains, filter materials.
Reserve coating	Magnetic tapes, foam fabrics, electrographic reproduction papers, pressure sensitive tapes.
Transfer coating	Waterproof protective clothing, gloves, luggage, upholstery, footwear.
Hot-melt extrusion coating	Carpets for car interiors.
Calender coating	Thinner coating fabrics, sheets.
Rotary screen coating	Paper, foil, nonwoven.
Lick roll	Fitting carpets, upholstery with fire-retardant finishings, hardening of filter materials, applications in agriculture and stock breeding.
Gravure coating	Thinner coating fabrics.

These are all the traditional methods of coating applications, however in today's era the needs of human beings has been completely changed. Some of these coating process are *phase change coatings (pcc), flame retardancy, conductive coating, antibacterial coating, sol-gel and plasma applications etc.* [Bulut and Sülar, 2009; Singha, 2012].

2.2.2.1 Knife Coating Process

In this process, the coating material is applied fluid form directly to the fabric surface and it spread in a uniform manner by means of a fixed knife. The knife is placed in direct contact with the fabric surface under tension. The coating substrate is putted in front of the knife, and the coating thickness is provided the control by the gap between the top of the fabric and bottom of the knife, like Figure 2.6. It is prevalently applied in the production of polyurethane (PU) coated fabrics. This method is commonly used with thin coating and slow production rates. It is indicated in Figure 2.7 [Hall, 2000; Heller and Pringe, 2001; Singha, 2012].

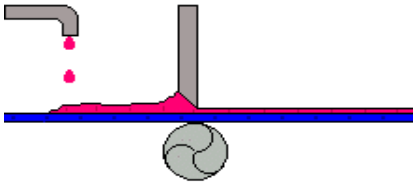


Figure 2.6 Knife coating process [http://www.tciinc.com]

The gap between the fabric and knife is controlled determines the type of machinery used. The main techniques are used;

- Knife on air,
- Knife over the table,
- Knife over the rollers,
- Knife over the rubber blanket.

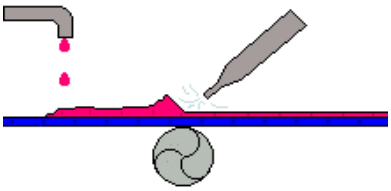


Figure 2.7 Knife on air [http://www.tciinc.com]

In knife over the table and knife over the rollers coating, the fabric passes under a blade that spreads the coating onto the fabric surfaces (Figure 2.8 a-b).

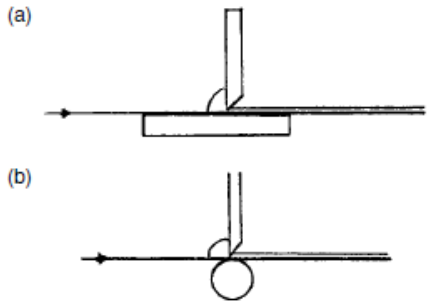


Figure 2.8 Knife coating (a) knife over the table and (b) knife over the roller [Hall, 2000]

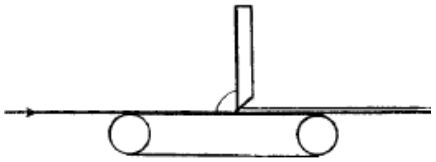
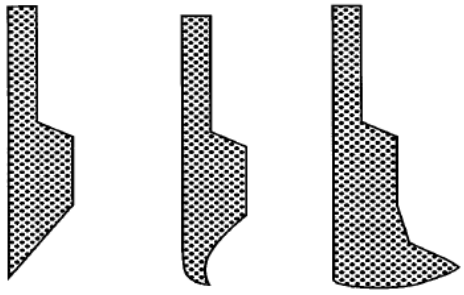


Figure 2.9 Knife over blanket [Hall, 2000]

The main advantage of this technique (Figure 2.8 and Figure 2.9) is that any irregularities in the fabric surface do not influence the speed of the machine. But, it is not the case with the knife over table and knife over roller processes (Figure 2.9), the thickness of coating can be certainly controlled, any fabric defects in the fabric surface are likely to jam under the blade causing fabric breakage [Hall, 2000; Heller and Pringe, 2001].

The knife geometry and the angle of application also have an important role to play in the efficiency and penetration of the coating substrate. In addition the profile of the knife can have a marked influence on the coating weights. There are three types of knife profile, it is shown that in Figure 2.10 [Hall, 2000].

- ***Pointed knife;*** the more of the coating compound is scraped off and thereby the lower the coating weight (Figure 2.10-a).
- ***Round knife;*** it gives a relatively higher coating weight than a sharp point (Figure 2.10-b).
- ***Shoe knife;*** it gives the highest coating weight (Figure 2.10-c) [Hall, 2000].



a b c

Figure 2.10 Types of blade (a) pointed (b) round (c) shoe

The machines which use knife coating method are generally simple to operate and it can be used for different coating thicknesses from 1 mm to 30 mm [Hall, 2000]. Uses; generally waterproof protective clothing fabric, tarpaulins, automotive car seat fabrics and light weight material for inflatable are produced by the knife process [Singha, 2012].

2.2.2.2 Foamed Coating Process

This method (Figure 2.11) can be applied coating polymer to woven and knitted fabric surfaces. It is possible because the foam, it also decreases penetration of resin into the fabric surface, which allows the production of much better drape and softer handles than can commonly produced by the knife coating process. Uses; floor and wall coverings, filter materials, apparel goods and curtain linings [Singha, 2012].

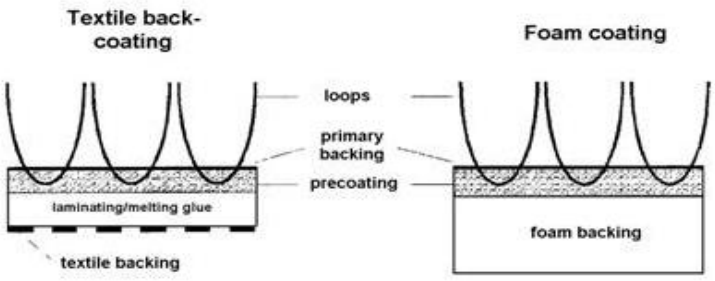


Figure 2.11 Foam coating [http://ied.ineris.fr/sites]

2.2.2.3 Reserve Coating Process

The most expensive coating process is reverse cylinder coating, which uses three precisely ground cylinders to apply a coating polymer to the fabric surface (Figure

2.12). The cylinders need to have precisely regulated drive speeds to get the desired coating impact. Reverse cylinder coating method is versatile and it can be used with the widest deversity of coating polmer viscosities and production rates. The distance between the support roll and the appication roll specifies the coating thickness. It is generally makes use of solvents. Uses; magnetic tapes, foam fabrics, electrographic reproduction papers and pressure sensitive tapes.

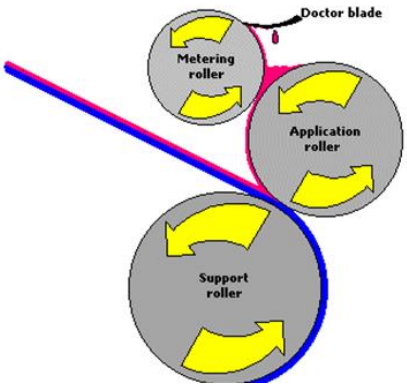


Figure 2.12 Reserve coating [http://www.tciinc.com]

2.2.2.4 Transfer Coating Process

In the transfer coating process, the coating material is preformed into a continuous sheet which is laminated to the substrate either by the use of an adhesive or by the application of heat. The main advantage of the transfer coating process over all the other methods is that the coating film may be made totally free of holes and faults before it is applied to the fabric surface (Figure 2.13). Generally, this method will obtain the softest coating of all coating methods in terms of fabric handle. Besides, there is no possibility of the coating bleeding through onto the face of the coated fabric surface [Hall, 2000; Heller and Pringe, 2001; Singha, 2012]. The transfer coating methods is divided in few steps;

- The coating polymer on to the transfer paper and evaporate off the solvent.
- Coating polymer on the second layer, which will become the base.
- Lay the fabric on top of the coating, nip together, evaporate the solvent and crosslink the two layers together.
- Peel the coated fabric surface off the release paper [Singha, 2012].

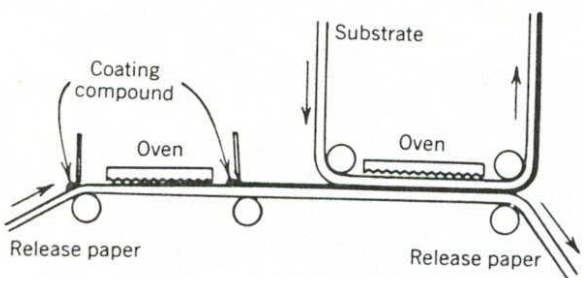


Figure 2.13 Transfer coating [Heller and Pringe, 2001]

Uses; waterproof protective clothing, luggage, upholstery, luggage, gloves, footwear, waterproof mattress covers, woven velvet automotive seat fabrics, carpets, etc. [Singha, 2012].

2.2.2.5 Hot-Melt Extrusion Coating Process

The hot-melt extrusion coating process is commonly used for thermoplastic polymers such as polyurethane (PU), polyvinylchloride and polyolefins, which are applied by feeding granules of the material into the nip between moving heated rollers. In this tecniques (Figure 2.14) can apply resin to the fabric surface at a faster rate than that can be achieved by transfer or knife coating process [Singha, 2012; Hall, 2000]. However, the big difference from the coating polymer is that the thermoplastic coating has no solvents to evaporate and no water that has to be evaporated. And also the main advantages of this method are ecological and economical. The molten polymer is generally calendered directly onto the textile surface or in some cases extruded directly from a slotted die. Uses; tarpaulins or light weight coverings, applied in the production of carpets for car interiors, etc. [Singha, 2012; Hall, 2000].

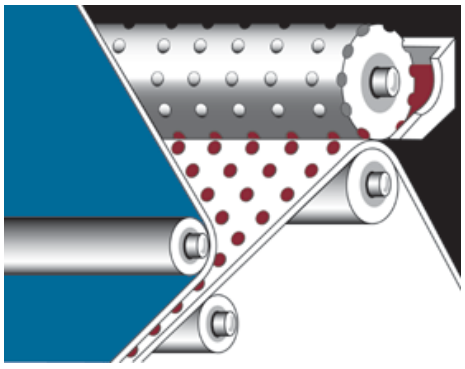


Figure 2.14 Hot-melt extrusion coating [http://beckmannconverting.com]

2.2.2.6 Calender Coating Process

Calendering is the most efficient method of coating. It allows for high speed processing using three vertically arranged rolls. A fabric under tension is passed between two of the rollers, one of which applies the coating. The coating passes over heated rolls before being applied to the substrate (Figure 2.15). Coatings thickness is from 0.1 to 0.5 mm can be applied to the fabric. The coating thickness is determined by the gap separation of the cylinders. However, there is generally a limit to the thinness of films which may be produced by this process. The more rollers, film produced is more accurrate [Heller and Pringe, 2001; Singha, 2012]. Uses; used to form or smooth a sheet of material such as paper or plastic film, interior and exterior textile, construction, automotive, clothing, leisure, medical, etc.

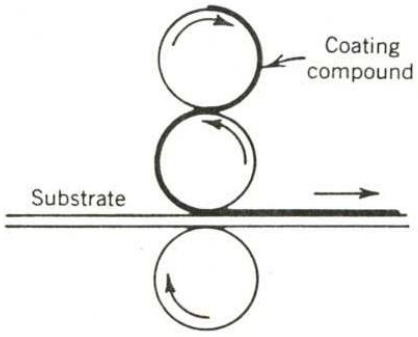


Figure 2.15 Calender coating [Heller and Pringe, 2001]

2.2.2.7 Rotary Screen Coating Process

This process which is applied compound to a fabric surface by forcing it through a cylindrical screen. It is commonly used for textile fabric printing. It can also be used for coating polymer onto fabric with add on, it is claimed from 5 to 500 g/m^2. The rotary screen coating process is similar to the rotary screen printing process that is used to apply coloured patterns to the fabric surface (Figure 2.16). The coating weight and coating thickness can be controlled by the number of holes per unit area and the coating weights are very precise. The rotary screen process can be used to apply foamed coatings or for foam processing of fabric finishes instead of padding [Hall, 2000; Singha, 2012].

In this process, the coating polymer is placed inside a screen cylinder, and the fabric material passes underneath. The coating passes through the screen and onto the substrate [Heller and Pringe, 2001]. Uses; paper, foil, nonwoven, etc.

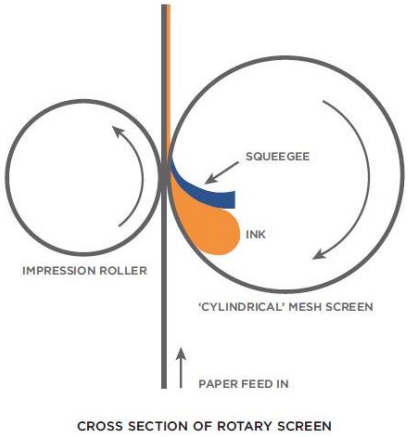


Figure 2.16 Rotary coating [http://autogarment.com]

2.2.2.8 Lick Roll Coating Process

The fabric is passed over the coating roll which is rotated in a trough of the coating polymer as indicated that in Figure 2.17. The main disadvantage of this system is that the coating amount on the fabric surface is depended upon the viscosity and surface tension of the coating polymer and also the surface condition of the fabric. To overcome this problem the knife coating process is developed [Hall, 2000]. Uses; fitting carpets with a pre-coat or anti-skid, upholstery with fire-retardant finishings, hardening of filter materials, applications in agriculture and stock breeding.

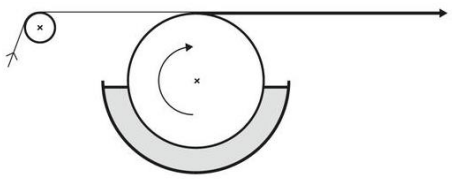


Figure 2.17 A lick roll [http://www.finipur.eu]

2.2.2.9 Gravure Coating Process

The gravure cylinder in coating is improved from the printing industry. The process (Figure 2.18) involves the use of a solid roller, the surface of which has been engraved with a closely packed series of small hemispherical depressions. These act as metering devices for the coating fluid, which fills the hemispheres with coating fluid from reservoirs of the fluid. The excess fluid is scraped from the roll with a

doctor blade, leaving the depressions with an exact amount of fluid in each. This is then transferred to the substrate to be coated. The quantity of fluid transferred depends upon the volume of the engraved depressions and the packing on the surface of the roll [Hall, 2000].

The main disadvantage to this process is that for a fixed depth of engraving a fixed coating weight is obtained. So, if a different coating weight or thickness is need then a new engraved roller has to be produced. Further, unless the viscosity properties of the coating polymer are controlled. Here the coating polymer is printed onto a rubber roller before being transferred onto the substrate [Hall, 2000]. Uses; thinner coating fabrics, sheets, etc.

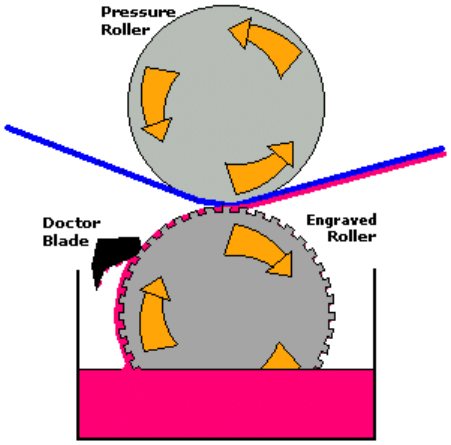


Figure 2.18 Gravure print coating [http://www.tciinc.com]

2.3 Clothing Comfort

2.3.1 Comfort Defination and Classification

Many researches have described comfort in relation with clothing. According to Nielsen (1991) viewed that the comfort in a physical sense as the body being in a heat balance with the environment (thermal comfort), that the body is not being subject to pressure from narrow designed clothing (movement comfort) and that skin irritation does not occur from unpleasant contact with clothing (sensorial comfort).

Barker (2002) defined that the comfort is not only a function of the physical properties of the materials and clothing but also must be interpreted within the human physiological and psychological responses.

Therefore, generally the term comfort is defined as “the absence of unpleaseness or discomfort” or “a neutral state compared to the more active state of pleasure”. With other words, comfort is an experience that is caused by integration of impulses passed up the nerves from a variety of peripheral receptor smell, color, smoothness, consistency, etc. in the human brain. It is a qualitive term and it is one of the most significant aspects of clothing. Clothing comfort is an immensely complex event and has been recognized for a long time that it is difficult to describe positively, but discomfort can be easily described in such terms as prickle, itch, cold, hot etc. [Milenkovic et al., 1999; Li, 2001; Li and Wong 2006; Das et al., 2007a; Pamuk, 2008; Nayak et al., 2008; Raj and Sreenivasan, 2009; Kamalha et al., 2013; Kandi et al., 2013].

In the literature, generally the clothing comfort id divided three main classes and it is include that; *physical (sensorial/tactile), psychological and physiological*. The comfort is a pleasant state of physical (sensorial/tactile), psychological and physiological harmony between the human body and the environment [Li, 2001; Das et al., 2007a; Öner and Okur, 2007; Pamuk, 2008; Nayak et al., 2008; Wardiningsih, 2009; Raj and Sreenivasan, 2009; Oğlakcıoğlu and Marmaralı; 2010; Kamalha et al., 2013; Kandi et al., 2013]. The human and clothing system have a number of processes occuring interactively which determine the status of comfort of a wearer;

- ***Physical (Sensorial) processes;*** in the clothing and the enviroment, such as the moisture and heat transport in the clothing structure, mechanical interactions between the clothing and the human body, reflection, absorbtion of light by the clothing which provide physical signals to the human body.

- ***Physiological processes***,
  - Thermophysiological process; such as the thermal balance and comfort of the human body, and its thermoregulatory responses and dynamic interactions with the clothing and the environment system, which determine the physiological status of the body and its survival under critical conditions.
  - Neurophysiological processes; mechanisms of the sensory reception system of the body in the skin, eyes, and other organs, by which

sensory signals are formulated from the interaction of the body with the clothing and surrounding enviroments.

- ***Psychological processes***; the processes of the brain which form subjective perception of sensory sensation from the neurophysiological signals and the formulate subjective overall perception and preferences by evaluating and weigthing several sensory perceptions against past experiences and internal desires [Li, 2001; Kothari, 2006; Wardiningsih, 2009; Öner and Okur, 2007; Raj and Sreenivasan, 2009; Marmaralı and Oğlakcıoğlu, 2013; Kamalha et al., 2013].

2.3.2 Physical (Sensorial/Tactile) Comfort

Physical comfort includes the several sensations toward discomfort by the wearer when the clothing totally or partially touches the wearer's skin. During activity, physical stimuli from skin clothing interaction stimulates various sensory receptors (such as; mechanoreceptors, thermoreceptors and photoreceptors), giving increase to a psychophysical perception. The sensorial comfort is related to the mechanical interaction between the clothing and the human body and essential performance requirement in clothing. By touching cloth, the sensory signals sent to the brain are formulated and gathered as subjective perception of sensations such as;

- ***Tactile sensations;*** like roughness, smoothness, stickiness, prickliness, softness, stifness, scratchiness, craggy, itchy, etc.
- ***Thermal sensations;*** coolness, warmth, hotness, breathability, chilliness, etc.
- ***Moisture sensations;*** dampness, clamminess, clingy, wetness, stickiness, etc.
- ***Pressure sensations;*** include snugness, looseness, lightweight, heaviness, softness and stiffness [Bishop, 1996; Dhinakaran et al., 2007; Öner and Okur; 2007; Raj and Sreenivasan, 2009; Kamalha et al., 2013]. Figure 2.19 shows generally that these sensory perceptions on the human body.

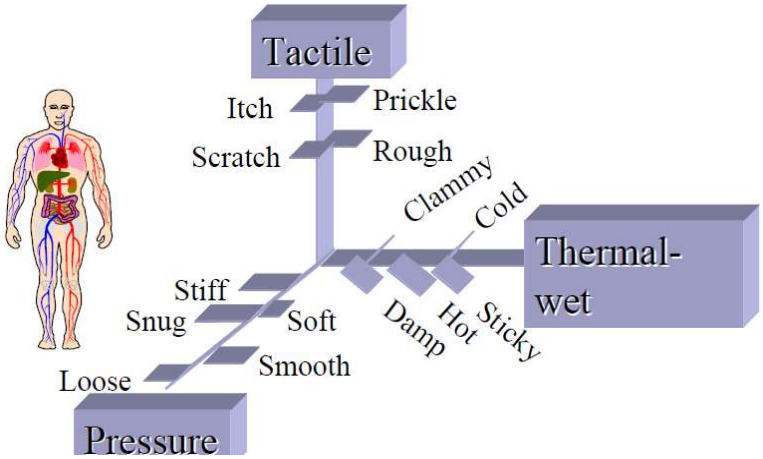


Figure 2.19 Sensory perceptions [Li, 2001]

The fabric sensorial comfort is influencing some factors;

- ***Fiber properties***; types of material, morphological structure, fiber fineness, length, friction property of the fibers, resilience, compressibility etc.
- ***Yarn properties***; types of yarns (staple fiber, continuous filament, textured), linear density, twist etc.
- ***Fabric properties***: types of production (woven, knitted, non-woven), fabric construction, fabric weight and thickness, softness, handle, surface roughness, drape structure, etc. [Kayseri 2012; Milenkovic et al., 1999; Öner and Okur; 2007; Pamuk, 2008].

2.3.3 Physiological (Thermal or Thermophysiological) Comfort

Physiological or thermal comfort, as expressed by British Standard-BS EN ISO 7730, is "the condition of mind which expresses satisfaction with the thermal environment." Apart from the environment, body physiological comfort is also dictated by body mechanisms such as pulmonary system, thermoregulation, central nervous system, cardiovascular system, skeletomuscular system and digestive system [Saville 2004; Öner and Okur; 2007; Kamalha et al., 2013].

The thermal comfort relates to the ability of the fabric to maintain thermal equilibrium between the body and the environment or the other words, it relates to the body thermal regulation and coordinates between production and loss of body heat. The heat and moisture transport properties of clothing and the way that clothing helps to maintain the heat balance of the body during various levels of activity.

Thermal, moisture and air resistance properties of the clothing collectively contribute to the state of thermophysiological comfort of the wearer [Saville 2004; Öner and Okur; 2007; Raj and Sreenivasan, 2009; Wardiningsih, 2009; Kamalha et al., 2013].

The thermo-physiological comfort is associated with the thermal balance of the human body, which strives to maintain a constant body core temperature of about 37 ºC and a fall or rise of ~ ±5 ºC can be fatal [Das et al., 2007; Oğulata, 2007; Pamuk, 2008; Parkova and Vilumsone, 2011]. If the temperature ranges within the limits of 1.5 ºC – 3 ºC, a human is a little cold or hot; if the temperature ranges within the limits of more than 4.5 ºC, a human feels discomfort. Hypothermia and hyperthermia may result due to the deficiency or excess of heat in the body, which is considered to be a significant parameter in limiting work performance [Das, 2007; Parkova and Vilumsone, 2011].

The basic thermal comfort elements have been stated to include that numerous parameters;

- ***Environmental factors;*** mainly season, air and radiant temperature, air/wind velocity and humidity.
- ***Person factors;*** including clothing insulation, age, work rate / metabolic heat flow and level of activity.
- ***Clothing parameters;*** which relate to the fabric aspects, and also garment design [Öner and Okur; 2007; Kamalha et al., 2013; Kandi et al., 2013].

2.3.3.1 Properties of Clothing Thermal Comfort

One of the main functions of clothing is to protect the wearer against environmental condition (extreme heat or cold). The human body is affected by various external conditions in the summer and winter. These external conditions can include changes in ambient temperature, vapour pressure, air velocity, and clothing insulation, among other factors that affect skin temperature. On the other hand, the body continuously produces heat, which must be transferred to the environment. The temperature and humidity of the environment may profoundly influence the body's skin and interior temperature [Milenkovic et al., 1999; Öner and Okur; 2007; Oğulata, 2007].

In general, the thermal comfort depends on some factors such as heat transfer, thermal absorption, air/ water vapour permeability, etc. The general informations about these factors are explained shortly.

- Thermal conductivity
- Thermal resistance
- Thermal absorptiveness
- Heat transfer
- Air permeability
- Moisture permeability
- Water repellence and water absorbtion
- Wicking [Milenkovic et al., 1999; Öner and Okur, 2007; Parkova and Vilumsone, 2011].

(i) Thermal Conductivity

Thermal conductivity of clothing influence that some factors. Conduction of heat and humidity steam through textile materials is one of the most important issues in the development of clothes for special purposes [Parkova and Vilumsone, 2011].

The thermal conductivity of a fabric is determined by the rate of transmission of heat through fabric. It is reciprocal of thermal insulation or thermal resistance. The thermal conductivity λ ($Wm^{-1}K^{-1}$) is the quantity of heat that passes in unit time through unit area of a slab of infinite extent and unit thickness when unit difference of temperature exists between its faces [Pamuk, 2008; Wardiningsih, 2009]. The measurement result of thermal conductivity is based on equation where (Equation 2.1):

$$\lambda = \frac{\theta}{F\tau\frac{\Delta T}{\sigma}} \qquad (2.1)$$

Q ; the amount of conducted heat,

F ; the area through which the heat is conducted,

τ ; the time of heat conducting,

ΔT ; the drop of temperature,

σ ; the fabric thickness [Frydrych, 2002].

For textile substrates, still air in the fabric structure is the most significant factor for the thermal conductivity and also, still air has the lowest thermal conductivity value compared to all fiber types (Table 2.6). Thus as the amount of entrapped air in the structures increases, the fabric provide high thermal insulation with lower thermal conductivity values [Oğlakcıoğlu and Marmaralı, 2010; Parkova and Vilumsone, 2011; Özdil and Anand, 2014]. Textile thermal conductivity very much depends upon the quantity of air in fabric and to the fibre composition. Thus the thermal transfer into textile fabrics affects the degree of porosity, weave structure (woven, knitted), fabric sett, fabric stiffness or looseness, and also depending on the fibre arrangement of yarn, fiber types, etc. [Parkova and Vilumsone, 2011].

Table 2.6 Some fibers conductivity values [Parkova and Vilumsone, 2011; Marmaralı and Oğlakcıoğlu, 2013]

Yarns	**Thermal conductivity ($Wm^{-1}K^{-1}$)**
Air	25
Silk	50
Wool	54
Cotton	71
Polypropylene	120
Polyester	140
Polyamide	250
Polyethylene	340

(ii) Thermal Resistance

Thermal resistance R (m^2KW^{-1}) of a fabric is the ratio of the temperature difference between the two faces of the fabric to the rate of flow of heat per unit area normal to the faces [Pamuk, 2008]. The thermal resistance is connected with the fabric thickness by the relationship where (Eguation 2.2):

$$R = \frac{\sigma}{\lambda} \tag{2.2}$$

σ ; the fabric thickness (m)

λ ; the thermal conductivity ($m^{-1}KW^{-1}$) [Hes, 1987; Hes, 2000; Frydrych, 2002].

The clothing reduces the body's heat loss. The most significant thermal feature in most clothing is insulation against heat flow. The measure of the insulation of a material is its thermal resistance. Therefore, the clothing is classified according to its insulation values. There are two specially units of thermal resitance in current use, the ***tog*** and ***clo*** [Ukponmwan, 1993; Li, 2001].

The tog is described as one tenth of the ratio of the temperature difference across a fabric to the resulting rate of heat flow in watts per square metre. Thus;

1 tog = 0.1 ºC m^2 W^{-1} [Ukponmwan, 1993].

The tog is a psysical unit of the thermal resistance stated in terms of measureable physical quantities. The warmth of clothing fabrics and other textile materials are measured in togs. Typical tog values for some clothing values are indicated in Table 2.7. The higher tog value is that means that, the greater is the thermal insulation provided [Ukponmwan, 1993].

Table 2.7 Typical thermal resistance values for some fabrics [Ukponmwan, 1993]

Textile materials	**Thermal resistance values (togs)**
Shirtings	0.1
Sheets	0.2
Suitings	1
Blankets	1
Carpets	2
Continental quilts	10

The clo unit of insulation is stated the thermal resistance of 0.155 ºC m^2 W^{-1}. This is also the insulation required to keep a resting man comfortable in an environment at 21 ºC with air movement of 0.1 m/s. The clo is generally described as the amount of clothing insulation necessary to maintan in comfort a seated resting subject in a normally ventilated room.

1 clo = 1.55 tog = 0.155 ºC m^2 W^{-1} [Ukponmwan, 1993].

The thermal insulation of clothing or garments (clo) can also be estimated from the type of clothing showing Figure 2.20.

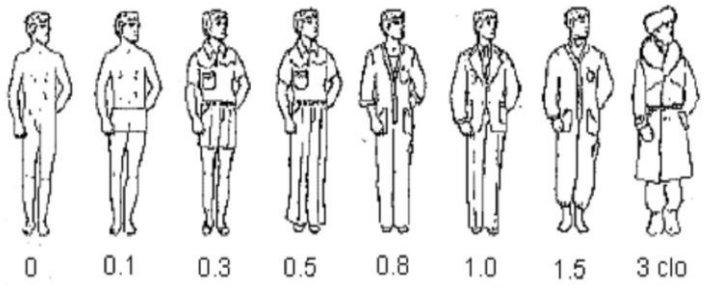


Figure 2.20 Thermal insulation of typical clothing [Li, 2001]

The resistance of fabric offers to the movement of beat through it is of critical importance to its thermal comfort. The thermal resistance to transfer of heat from the body to the surrounding air is the sum of three parameters:

- The thermal resistance to transfer of heat from the surface of the material
- The thermal resistance of the clothing material
- The thermal resistance of the air interlayer [Milenkovic et al., 1999; Oğulata, 2007].

(iii) Thermal Absorptivity

The sensation of coolness or warmth to touch when human body is brought into contact with a fabric surface is transitory heat conduction and this contributes to the perception of comfort of the clothing. The warm-cool feeling is believed to be the result of the rapid transfer of heat flux from the human body skin to the fabric surface immediately. The rate of heat flow, which reaches a peak value, (q_{max}) approximately 0.2 sec after contact with the fabric is related to the warm-cool feeling felt by the wearer [Raj and Sreenivasan, 2009].

The 'warm-cool feeling', is included in the overall assessment of the handle of the fabric surfaces with their low-stress mechanical properties, so it contributes to the fabric handle [Pamuk, 2008]**.** The fabric handle usually perceived by the hands, and this feeling strongly affects the choice of people when buying garments or clothings [Güneşoğlu et al., 2005]**.**

The thermal absorptivity b ($Ws^{1/2}m^{-2}K^{-1}$) is the heat flow q (W/m^2) which passes between the human body and the contacting textile fabric surface. Hes (1987) introduced the thermal absorptiveness to evaluate "warm-cool feeling". This parameter is the objective measurement of warm-cool feeling and to determine the contact temperature of two surfaces [Hes, 1987; Hes, 2000; Frydrych, 2002; Pamuk, 2008; Oğlakcıoğlu and Marmaralı, 2010]. The thermal absorption can be expressed as where (Equation 2.3):

$$b = \sqrt{\lambda * \rho c} \tag{2.3}$$

λ ; the thermal conductivity,

ρ ; the fabric density,

c ; the specific heat of the fabric [Hes, 1987; Hes, 2000; Frydrych, 2002].

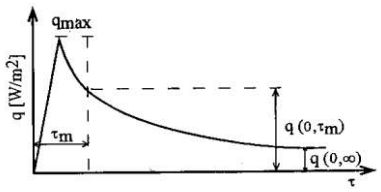


Figure 2.21 Heat flow between human body and clothing [Hes and Martins 1993, Hes et al. 1996]

Kawabata and Yoneda (1982) were the first researchers to state the warm-cool feeling with numerical. They designed the Thermo-Labo, the first instrument which is able to evaluate the thermal contact property objectively and introduced the maximum level of the contact heat flow q_{max} (W/m^2K) as a measure of transient thermal properties. When the ***b*** values or (thermal absorptivity of the fabric) increase the human feels cool (Figure 2.21) [Güneşoğlu and Meriç, 2006; Oğlakcıoğlu and Marmaralı, 2010].

(iv) Heat Transfer

People wear clothing to protect their body from the environment conditions. The clothing has a very important and controllable role for the clothing-body-environment system which includes a great number of parameters having dynamic interactions between each other. The human body-clothing-environment system is

indicated that Figure 2.21 [Li, 2001; Li and Wong, 2006a; Kothari, 2006; Kaplan and Okur, 2012].

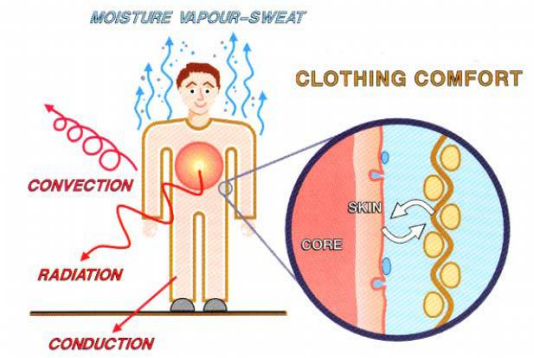


Figure 2.21 The clothing-body-environment system [Li, 2001]

In a regular atmospheric condition and during normal activity levels, the heat can be transferred within clothing by the metabolism is released to the atmosphere by conduction, convection, radiation (sensible heat) and the body sweats in vapour form (latent heat) [Kothari, 2006; Das et al., 2007; Pamuk, 2008; Parkova and Vilumsone, 2011; Kamalha, 2013]. From skin to environment heat transfer diagram shown that in Figure 2.22.

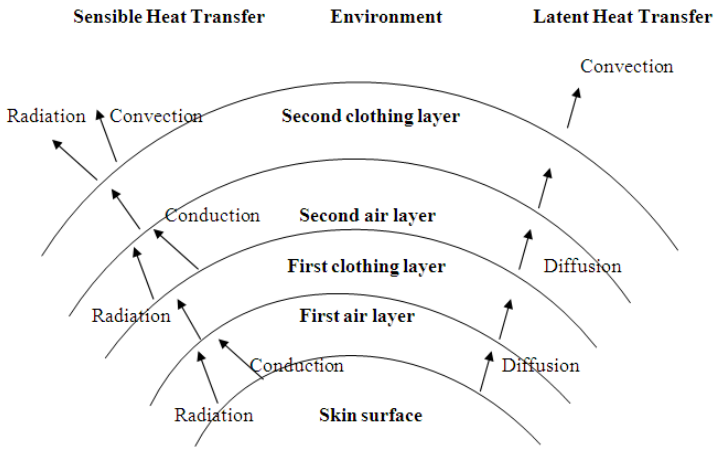


Figure 2.22 From skin to environment heat transfer diagram [McCullough et al., 1989]

Conduction, convection and radiation are dominated by the temperature difference between the human body surface and the environment, and are therefore drouped as dry heat transfer. Besides, the latent heat transfer is acquired by moisture transmission related to water vapour pressure between the human body surface and the environment [Kothari, 2006]. There are two different forms of heat of concern in planning for comfort sensible heat and latent heat [http:// courses.washington. edu/].

Sensible heat transfer; *Conduction* is the process whereby molecular excitation spreads through a substance or from one substance to another by direct contact. *Convection* occurs in fluids and is the process of carrying heat stored in a particle of the fluid to another location where the heat can conduct away. Usually, the response of *radiation* to a material is some combination of transmission, reflection, and absorption [http://courses.washington.edu].

Latent heat; that changes the state of matter from solid to liquid or liquid to gas is called *latent heat.* The *latent heat of vaporization* is the heat need to change a liquid to a gas [http://courses.washington.edu].

Heat is gained by the human body from the sun (indirectly or directly), by physical exercise, by internal metabolism or by involuntary contractions of skeletal muscles in shivering. Excessive heat may be dissipated quickly by vaporization of body water, the human body being used, as a source of latent heat for the purpose and clothing systems that hinder free evaporation to any appreciable extent will thus be not comfortable. The heat loss, by convection, conduction or radiation, depends partly upon the temperature gradient between the human body and the environment, and varying the skin temperature modifies this gradient. In other respect, undesirable heat loss can be protected by increasing the thermal resistance of the barrier between the body and its environment, and the fabric will again result in discomfort for the wearer [Milenkovic et al., 1999].

The human body is in a state of thermal equilibrium with its environment when it loses heat at exactly the same rate as it gains heat. Mathematically, the relationship between the human body's heat production and all its other heat gains and losses is:

Heat production=Heat loss (2.4)

or

$$M = E \pm R \pm C \pm S \quad (2.5)$$

M = the metabolic rate,

E = the rate of heat loss by evaporation, respiration, and elimination,

R = the radiation rate,

C = the conduction and convection rate,

S = the body heat storage rate.

Equation 2.5 is indicated in Figure 2.23. The human body usually produces heat, so the metabolic rate (M) is always positive, varying with the degree of exertion. If the environmental conditions are such that the combined heat loss from conduction, radiation convection, and evaporation is less than the body's rate of heat production, the excess heat must be stored in body tissue. However, the human body heat storage (S) is always small because the body has a limited thermal storage capacity. The heat balance is obtained when the value of *S* is zero. Thus, as its interior becomes warmer, the human body reacts to correct the situation by increasing blood flow to the body surface and increasing perspiration. Concequently, the human body heat loss is increased, thereby maintaining the desired body temperature and the balance expressed by Equation 2.5 [Milenkovic et al., 1999; Oğulata, 2007; Wardiningsih, 2009; http:// courses. washington. edu].

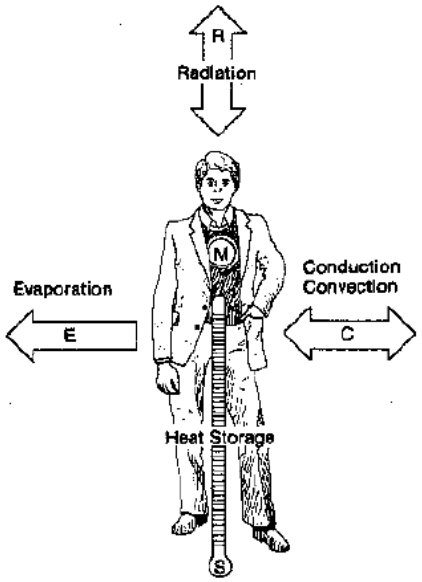


Figure 2.23 Heat balance of the human body interacting with its environment [http://courses.washington.edu/]

For a continuously heated body (by metabolic heat production), a dynemic equilibrium is maintained where generally;

Body Tempe.> Skin Tempe. > Clothing Surface Tempe. > Ambient Tempe. [Kothari, 2006].

(v) Air Permeability

The geometrical properties of the fabrics are very significant factor for evaluating and simulating lots of fabric characteristic properties, one of which is air permeability. The air permeability of the fabric is closely linked to its structural properties [Oğulata, 2006; Havlova, 2013]. The fabric air permeability properties are determined by the rate of air flow through a substrate under a differential pressure between the two fabric surfaces. Therefore, the air permeability of the fabric is affected by various factors such as; fabric construction, types of fabric (woven or knitted), fabric sett-weight-thickness, types of yarns, etc. [Oğulata, 2006].

The air permeability of the fabric can also affect its comfort properties in different ways. In the first case, the textile material that is permeable to air is also, in general, most likely to be permeable to water, in either the vapour phase. Therefore, the moisture-vapour permeability and the liquid-moisture transmission are normally closely related to air permeability. The fabric which has good air permeability, however, does not necessarily have good moisture vapour permeability. In the second case, the thermal resistance of the fabric is strongly depend upon closely still air, and this parameter is in turn affected by the fabric structure properties, as also is the air permeability properties. A very open cloth can inflict serious wind chill problems on the wearer in cold climates with a breeze blowing and may thus affect survival chances in extreme cases. Finally, a highly air-permeable fabric may be sheer or have as very open structure, so that aesthetic factors such as modesty, drape, dimensional stability, drape, etc. may result in discomfort of a physical or psychological nature in the wearer. Although the air permeability in itself is merely another effect, rather than a cause, associated with such manifestations of discomfort, it can nonetheless provide a convenient and readily measured way of quantifying the likely behaviour of a fabric in these other areas [Milenkovic et al., 1999; Wardiningsih, 2009].

The air permeability is a measure of how well air is able to flow through a fabric. It can be measured on either dry or damp fabrics. The air permeability is commonly measured on apparatus designed to force air through the test specimen in a reproducible manner [Milenkovic et al., 1999; Wardiningsih, 2009].

(vi) Water Vapour (Moisture) Permeability

Another significant property of the fabric, from the comfort standpoint, is the way in which it allows water to pass through it. This property is known as "permeability of a fabric to water vapour" [Milenkovic et al., 1999]. The clothing must maintain thermal equilibrium for the wearer's. Therefore, the water vapour permeability of the fabric is a critical parameter of the clothing comfort [Das and Kothari, 2012]. Water vapour can pass through textile material layers by the following theses mechanisms;

- Diffusion of the water vapour through the layers,
- Absorbtion, transmission and desorption of the water vapour by the fibres,
- The adsorption and migration of the water vapour along the fibre surface,
- Transmission of water vapour by forced convection [Das, 2007; Das et al., 2009].

The fabric moisture permeability are influenced some factors such as; different yarn twists, the fabric structure and properties, texturising, finishing treatments, blending, mechanical treatments, etc. [Milenkovic et al., 1999]. Besides, the moisture is influenced by the enviroment as well as human factors such as fabric and garment openings. There are several "human-clothing" system mechanisms ensuring the maintenance of proper body temperature, the most significant of which are as follows:

- Produced metabolic heat should remain on the internal layer of the body skin, which can be achieved through effective sweat circulation,
- To cool the human body, the skin has to produce a certain amount of sweat,
- Produced sweat has to get through the garment layers [Yoo et al., 2000; Parkova and Vilumsone, 2011; Kamalha, 2013].

(vii) Water Absorption and Water Repellence

The water absorption is the capacity of the fabric structure to absorb the sweat (liquid) generated by the human body and the rate at which it is able to do so. To prevent wet clinging, the fabric's absorption should be low at the surface of the fabric which makes contact with the skin [Wardiningsih, 2009].

In considering the movement of liquid, water through the fabric, two comfort aspects may be described. Water from an external source, e.g. rain, should be prevented from reaching the body, an aim that is achieved by using a water-resistant barrier. Besides, water generated at the body surface as perspiration should be removed as quickly and as efficiently as possible if comfort is desired, a process that is encouraged by absorption within a body-covering. Both mechanisms are usually required simultaneously although two requirements are diametrically opposite. For waterproof and water-repellent finishes on textiles various treatments with the chemical compounds are used. For achieving increased absorbency, three methods may be suggested. They are;

- Physical modification of the structure,
- Chemical treatment or modification,
- Coating techniques.

Test methods for evaluating both repellence and absorbency are available [Milenkovic et al., 1999; Wardiningsih, 2009].

(viii) Wicking

The term "wick" is meaning expanded to include the movement of any liquid, including water, along a capillary. "Wicking" is defined as the movement of large amounts of water by capillary action through such interfibre capillaries in the yarns of a fabric [Crow and Dewar, 1993]. When a water drop is put on the fabric, the water enters the yarns in the fabric and wicks out through it (Figure 2.24).

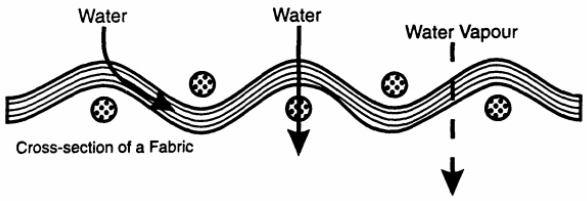


Figure 2.24 Wicking of water through a fabric [Crow and Dewar, 1993]

Wetting is the displacement of a fiber-air interface with a fiber-liquid interface. Wicking is the spontaneous flow of a liquid in a porous substrate. When the fibers in assembly are wetted by a liquid, the resulting capillary forces drive the liguid into the capillaries created by the spaces between fibers in wicking process. Because

capillary forces are caused by wetting, wicking is a result of spontaneous wetting in a capillary system. The wetting and wicking are not different process. The wetting is a prerequisite for the wicking. A liquid that does not wet fibres cannot wick into a fabric. In general, the wicking takes place when a liquid travels along the surface of the fiber but is not absorbed into the fiber structure [Kıssa, 1996; Wiener and Dejlova, 2003; Simile, 2004; Sharabaty et al., 2008].

The behaviour of a given textile structure during its contact with water (or the liquid) is one of the significant properties of textiles [Wiener and Dejlova, 2003]. The liquid general properties such as viscosity, density, surface tension, as well as the surface wetting forces of the fibers are known or can be experimentally determined, but the pore structure of a fibrous medium is complicated and much more difficult to quantify. The complexity of a fabric structure makes it impossible to measure an accurate pore structure. Besides, movement and interaction of a liquid through pores can cause both shifting of fibers and changes in pore structure. Changes in fiber properties caused by wetting can importantly change liquid movement. The wicked moisture spreads throughout the fabric allowing the moisture to easily evaporate [Wiener and Dejlova, 2003; Simile, 2004; Güneşoğlu and Meriç, 2006].

2.3.4 Psychological Comfort

Psychological processes are the most complicated and generally, the psychological comfort focuses on the comfort of individuals in relation to their roles, values and social being. It is concerned with internal self consciousness and the value of life, related to satisfying oneself within choices available. The social-psychological spectrum, involves;

- ***Personal aspects;*** like personality, personal interests political/ cultural/ religious values or beliefs, etc.
- ***Clothing aspects;*** related to details of the fabric and the clothing system such as; style, texture, aesthetics, fashion, suitability, design, color, etc.
- ***Environmental aspects;*** such as occasion, climatic conditions, geographical location, historical importance, social-cultural settings and norms, etc. [Li and Wong, 2006a; Kothari, 2006; Kamalha et al., 2013; Marmaralı and Oğlakcıoğlu, 2013].

The psychological processes of clothing comfort will commonly different from human to human, affected by individual decisions for what they perceive as related to their preferences perception was done, with an argument that psychological comfort involves the brain activity, formulating subjectively, an overall perception of sensory sensations from neurophysiologic sensory signals through evaluation of several perceived sensations, judging by previous experiences and the person's inner wants. The physical stimulations also induce psychological and physiological responses between the wearer and clothing, while, psychological variations also induce physiological responses. These processes are cyclic; the induction of one induces another, accounting for total comfort perceived by the wearer [Li, 2001; Kamalha et al., 2013].

To understand the psychological processes we need measure these perceptions in subjective ways. A subjective measure is the direct measure of the opinion of a person which is the only factor of interest in carring out the measurement [Li, 2001].

Psychological scaling (Figure 2.26 and 2.27) is a type of measurement that consists of assigning numbers to characteristics of objects or events, according to rules which reflect some aspects of reality. In social sciences and marketing research psychological scaling has been widely used to obtain consumers opinions and study their attitudes and preferences [Li, 2001]. Some examples of scale are;

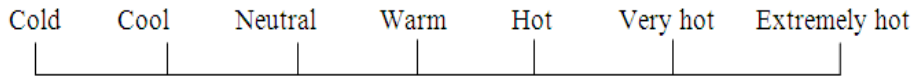


Figure 2.25 Subjective rating scales for thermal sensation [Li, 2001]

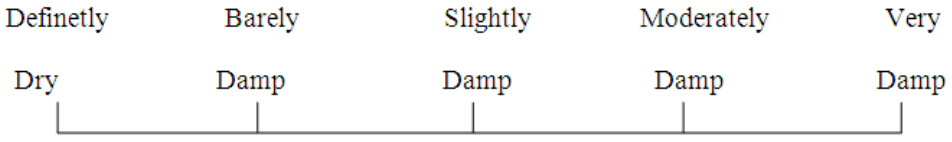


Figure 2.26 Subjective rating scales for dampness sensation [Li, 2001]

2.4 Previous Studies

In the literature, so many studies are existence to the change of denim fabrics performance and apperance properties, coated fabric performance properties and

clothing comfort properties. Some researches are given below in according to the years.

Dascalu et al. (2000) reported that the removal of the indigo color by laser beam denim and investigated the change of the denim fabric diffuse reflectivity after laser beam with different power density and different wavelength. Another research by Morales et al. (2003) analyzed that the comparision of between properties of different types of lasers and parameters denim fading process. They were determined the impressiveness of laser-based technologies and measured the textile properties such as colorfastness, tensile strength, tearing strength and dimensional changes.

Frydrych et al. (2002) analyzed that the thermal insulation properties (thermal resistance, conductivity and absortion) of fabrics made of Cotton and Tencel. For this study, they prepared different weave types (plain, twill and combined) after that finishing processes (desizing, enzymatic finishing and resin finishing) applied samples. As a result of this, the finished fabrics made of tencel yarn indicated lower values of thermal absorption and conductivity than fabrics made of cotton yarn and also higher values of thermal diffusion and resistance.

Cho et al. (2003) investigated that the effect PU concentration and content of coating solution on mechanical properties and water vapour permeability of PU coated fabrics. According to experimental results, PU content is effect on water vapour permeability and also when the concantration of coating solution increase water vapour permeability properties are decreased. On he other hand, mechanical properties of coated fabrics are dependent on PU content, while the influence of coating concentration is insignificant.

Koç and Ayyıldız (2004) investigated that the denim fabric performans properties and determined different fabric properties of weft movement and skew, weft and warp shinkage, elongation, rubbing fastness. They confirmed that the effect of production type of weft yarn on the afore-mentioned parameters.

Ramachandran and Kesavaraja (2004) analyzed that the effect factors for wetting and wicking behaviour on the water repellence and breathable fabrics. They confirmed that the wicking properties are related from the external atmosphere conditions.

Card et al. (2005) reported that the effects of laundering on physical properties of washed denim fabrics and confirmed that the change of denim fabric properties such as pilling and abrasion resistance after pre-washing, stone washing and enzyme washing.

Masteikaite and Saceviciene (2005) analyzed the tensile properties of coated fabrics and laminates. In this study they prepared very wide and diverse samples, these are different fabric structure (knitted, weave), different yarn (CO+PES, CO, PES, Rayon+CO, PAN) and different coated and laminated properties (PU, PVC) and also different fabric weight.

Juciene et al. (2006) investigated that the effect on diffirent types of industrial washing on denim fabric properties. They applied the denim fabrics on simple softening, silicone softening, chlorine washing, enyzme washing and double enzyme washing on the denim fabrics and evaluated that effect of different washing on fabric properties, these are air permeability, shrinkage, extensibility, bending rigidity, breaking strength and elongation. As a result of this study they comfirmed that the silicone softening made the greatest effect on the change of denim fabric properties.

Ghoranneviss et al. (2007) reported an experimental study the comparison between decolorization of denim fabrics with Oxygen and Argon. They compared the influence of low temperature plasma of Ar and O_2 on decolorization of denim fabrics and comfirmed that the better decolorized Ar rather than O_2 when being treated for 15 minutes.

Padleckiene and Petrulis (2008) reported that the properties of air permeability and structure of breathable coated textile materials after cyclic stretching. As a result of this experimental study the air permability values increase after cyclic stretching related the increase number of elongation and stretching cycles. Padleckiene and Petrulis (2009) in the next study of about the influence of abrasion on the air permeability properties of breathable coated fabrics. They analyzed the air permeability and mass loss of different properties coated fabrics after abrasion process and reported that after abrasion tests, air permeability and mass of breathable coated fabrics are changed and its effect the fabric properties.

Padleckiene et al. (2009) investigated the breathability and resistance to water penetration properties of breathable coated fabrics used for as outwear after mechanical tests (strecthing and elongation). They observed when the water vapour permeability values increase the stretching cycles and elongation structure of breathable coated fabrics is also changed.

Aslan and Körlü (2009) observed the change on denim fabric characteristic properties with desizing or no desizing processes after enzymatic washing processes performed in different pH and different process time. In this work shown that these different parameters are influence of the dimensional stability, number of warps and wefts, color, average weight and tear strength. Another study by Khedher et al. (2009) invetigated the effect of industrial washing processes (sanding, brusing, resin treatment, permanganate-spray and softening) on the denim fabric mechanical properties such as breaking strength and tear strength.

Lee et al. (2010) performed that the denim fabric reinforced composites with different numbers of denim layers and according to the experimental results, the PLA (poly-lactic acid) / denim composites had good mechanical properties such as impact strength and tensile strength.

Güney and Üçgül (2010) investigated that the thermal ınsulation features of breathable membrans of protective clothings and concluded breathable membrans and porous structures enable to increasing the comfort properties by allowing vapour and heat transfer.

Rahman (2011) investigated that the influence of industrial enzyme washing on the denim garment properties and the experimental study shown that increase of denim fabric softness and surface density after enzyme washing and whereas decrease of denim fabric tensile strength.

Çoruh et al. (2011) improved a new 19 items scale for the purpose of evaluate the physical comfort of denim jeans and and according to the this study results. This scale is a credible tool which can be used to measure and also utilise the problems of physical comfort who denim jeans users.

Bilişik and Yolacan (2011) intended to determine the tensile and tear strenght properties of newly different developed structural denim fabrics after an abrasion resistance and they reported an experimental study when the abrasion cycles increased the tear and tensile strength properties all denim fabric samples decreased.

Babalık (2012) investigated the effect of the particle size of the silicone softeners on sewing damage at denim jeans. In this study were used three different size sewing needle and three different silicone softeners (macro, semi, micro) on single type of denim samples.

Toksöz and Mezarcıöz (2013) analyzed that the effect of washing process (rinse, enzyme, stone) on different types of fabric constructions (1/1 plain, 3/1 twill) at performance properties (dimensional stability, tensile strength). They observed that the washing process is effected dimensional stability and braking strength on denim fabrics both weave construction and washing type, especially rinse washing.

Matkovic and Skenderi (2013) evaluated that the mechanical properties of polyurethane coated knitted fabrics. In this study were used seven different structure knitted fabrics and observed breaking strength and elongation properties both wale and course direction. As a result of this tests breaking elongation in the course and wale direction of the knitted fabric increases after coating process.

Chinta and Gujar (2013) reported the effect of softeners on the comfort properties of fabrics. They used four different types of bleached fabrics (cotton, heavy cotton, P/V blend, P/C blend), these fabrics treated with eleven softeners (anionic, nonionic, PE emulsion, amino silicone, micro amino silicone, reactive softener, glycerin, micro silicone and hydrophilic silicones like Silkofeel HP 678, Silkofeel HP 387), the softener concentrations applied four different types (10 gpl, 20 gpl, 30 gpl, 40 gpl). As a results of this study the softener and softener concentration influence the moisture properties of fabrics and the fabrics treated with Silkofeel HP 678 has better comfort properties like air permeability, wicking and water absorbency.

Mondal and Khan (2014) reported the effect of process parameters (concentration of enzyme, washing temperature and time) on the physical and mechanical properties of denim fabrics. As a result of this study, the breaking strength, stiffness and color

shade values decrease after cellulase finishing process and also the rate of denim softness, water moisture and absorbtion regain properties increase.

Haq (2014) investigated the mechanical and physical properties of denim (jeans) after an acid washing process via (H_3PO_4 + $KMnO_4$ combine with pumice stone). According to this study, some properties such as tensile strength, GSM, stiffness, color depth were decreased whereas count, dimensional stability, EPI, PPI and soft feeling were increased due to acid washing.

Khalil (2015) evaluated the developments of sustainable enviromental and emerging industrial technologies (ozone, laser and water jet) for the finishing treatments of the denim jeans.

Elamri et al. (2015) intended to analyze mechanical and morphological features of fabric coated with nano-clay composites. Nanoclay solution of concentration prepared from 1 to 5 % and two different resins (PU and PAC) mixed with nano-clay particules and the various composites clay/resin applied 100 % cotton fabrics. After this process, prepared fabric samples tested in terms of tensile strength, tear strength and abrasion resistance. Test results shown that, the maximum clay percetange to improve mechanical properties of coated fabric was between 4 % and 5 %.

Kadem and Ergen (2015) focused that the properties of the comfort on the different membran lamination fabrics. In this sudy samples prepared 100 % PES woven fabric laminated with respect to hot melt method using different membrane materials as PU (hydrophilic), PES (hydrophilic) and PTFE (micro porous structure). After lamination process some comfort tests (air permeability, water vapor transmission, water impermeability) applied to these fabrics. The test results indicated that the 100 % PES woven fabric has the highest air permeability properties, the PTFE membran laminated fabric has the highest water vapour permeability and the PES membrane laminated fabric has the highest water resistance.

CHAPTER 3

MATERIAL AND METHODS

3.1 Materials

The properties of denim fabrics used (before coating process and after coating process) are given Table 3.1.

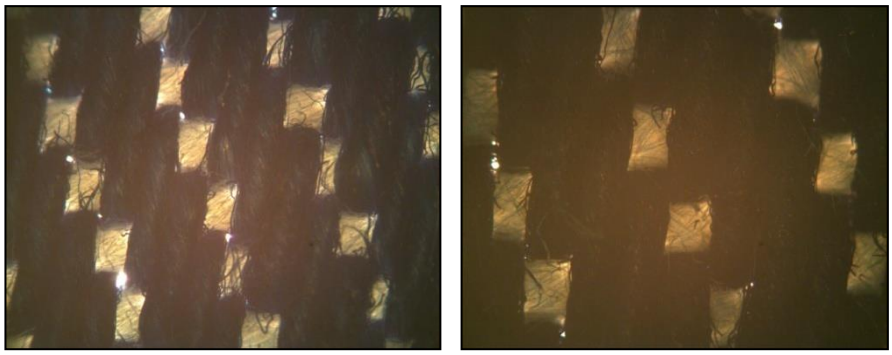
Table 3.1 Structural properties of fabric samples

Fabric Code	Weave Type	Fabric Weight g/m²	Fabric Thickness mm	Fabric Density (weight/ thickness)	Fabric Sett per/cm	
					Warp	Weft
G1*	3/1 Z twill	311	0,532	584,59	38	21
G2**	3/1 Z twill	400	0,692	578,04	26	15
G1PU1***	3/1 Z twill	343	0,55	623,64	38	21
G1PU2****	3/1 Z twill	350	0,56	625	38	21
G2PU1	3/1 Z twill	447	0,696	642,24	26	15
G2PU2	3/1 Z twill	458	0,702	652,42	26	15

*__G1:__ 311 g/m^2 Denim fabric, **__G2:__400 g/m^2 Denim fabric, ***__PU1__:0.2 mm with knife distance made of polyurethane coated, ****__PU2__:0.4 mm with knife distance made of polyurethane coated.

Firstly, untreated denim fabrics (G1 and G2) were measured the comfort properties (air permeability, water vapour permeability and wicking) and mechanical properties (water resistance, breaking strength - elongation and abrasion resistance). These fabric structure views are shown under the microscope in Figure 3.1.

In the second stage, denim fabrics were applied two different knife distance (PU1 and PU2) polyurethane coating (G1PU1 - 0.2 mm with knife distance made of polyurethane coated, G1PU2 - 0.4 mm with knife distance made of polyurethane coated, G2PU1, G2PU2,) in the laboratory conditions and measured the comfort and mechanical performance like untreated denim fabrics (G1, G2).



(a) (b)

Figure 3.1 The fabric structure view under microscope (a) G1, (b) G2.

In the third stage, polyurethane coated denim fabrics; G1PU1, G1PU2, G2PU1, G2PU2 were applied micro-cracking process with three different chemical solution (Acetone, DMF and Ethanol) with two different concentration rate (1/10 and 1/50, organic solution/distilled water) and with two different duration time (5 sec and 10 sec). At the end of this preparation, we have obtained 54 different properties fabric samples.

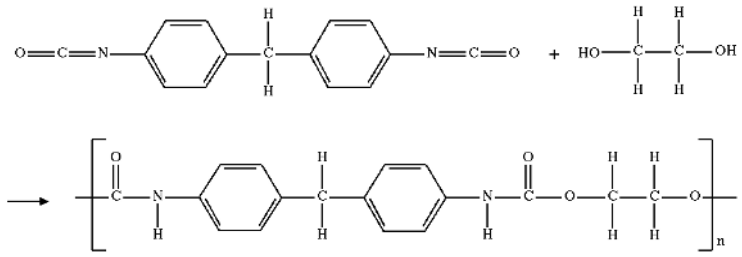
(i) Polyurethane (PU) Coating

Polyurethanes (PU) belong to the group of very durable plastic materials. The main property of polyurethane is wide application. It can be coated to textiles, leather, in solution, dispersion, with a low solvent content or without it, such as powder or granules. It has good washproofness, good adhesion to the fabric, good durability at low temperatures, it is possible to use it without softeners. It has also good viscosity and abrasion resistance, at the same time it has a pleasant and soft touch, a low specific mass, resistance to oils and fats [Dubrovski, 2010; Kovacevic, 2010].

The key parameter for the success of polymer coating is its long durability and versatility. Polyurethane has the property of good adhesion which can be strengthened by addition of cross-linking agents. Hardness or softness can be achieved by variation of polymer structures without using a plasticizer. It is also possible to reduce fragility by the impact of light [Dubrovski, 2010]. Generalized urethane reaction is like below Equation 3.1.

$$R^1 - N = C = O + R^2 - O - H \rightarrow R^1 - (N - H) - (C = O) - O - R^2 \qquad (3.1)$$

Polyurethane synthesis wherein the urethane groups –NH-(C=O)-O- link the molecular units in Eguation 3.2 [https://en.wikipedia.org/wiki/Polyurethane]



(3.2)

To achieve a good material quality, it is very significant to dose the solvent regularly in the binding coating. Too small a quantity of the solvent in the binding coating causes the swelling of the binder instead of its dissolving, resulting in poor bonding of the material to the substrate. Besides, too great a quantity of the solvent in the binding coating causes too rapid dissolving of the binder, resulting in too great penetration of the PU coating into the substrate. When polyurethane is coated directly, the polymer is coated using special coating blades (Figure 3.2). After each coating, the polymer is dried and cooled down [Dubrovski, 2010].

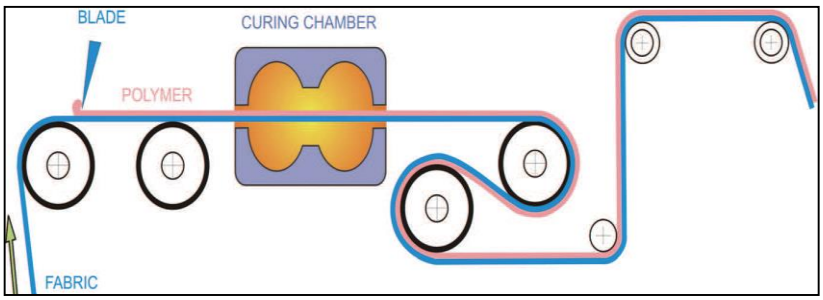


Figure 3.2 Schematic of the process of polyurethane coating a direct coating with one passage [Dubrovski, 2010]

It is another common coating type that can be used for a wide variety of products such as tents, life vests, evacuation slides, flexible fuel storage tanks, and apparel items. Inflatable boats, luggage, rainwear, water storage bags, automotive upholstery, food conveyor belts, and fuel hoses are also made with polyurethane coatings. They provide ultra-violet protection, toughness, and can impart a leather like feel to the fabric [Heller and Pringe, 2001; Dubrovski, 2010; Kovacevic, 2010].

Thereafter, hot-melt lamination membrane was applied on the denim fabric (G1) in the factory in order to comparison of comfort properties (air permeability and water vapour permeability) with polyurethane (PU) coated fabrics after micro-cracking process.

3.2 Methods

Within the scope of this thesis, first of all, fabric samples were conditioned according to "TS EN ISO 139:2008 Textile Fabrics–Standard atmospheres for conditioning and testing" (20±3 °C and 65±5 % RH) before to determine the fabrics structural properties, to apply coating process, to measure the comfort and mechanical properties. After this conditioning, the tests and measurements were performed.

3.2.1 Coating Process

In this study, untreated denim fabrics were subjected to the coating process in the laboratory conditions. The coating process was performed by laboratory type coating machine. Before the coating process, the coating paste was prepared according to the selected recipe. It is given in Table 3.2 coating paste recipe.

Table 3.2 Coating paste recipe

	500 ml/g Coating paste
Polyurethane (RUDOLF 3881)	250 ml/g
Distilled water	215 ml/g
Fixator (RUCO COAT-FX 8011)	25 ml/g
Thickener (TH 821)	10 ml/g

After that, in order to preparation of coating paste according to the recipe, coating chemicals were measured by means of precision balance.

For preparation of coating paste, firstly commercial polyurethane and distilled water were putted into the beaker and than mixed with laboratory type mixer about 2-3 minutes. Than fixator was added in the beaker and again mixed about 5-6 minutes. Lastly thickener was added in the beaker and stirred until homogeneous mixing. Laboratory type mixer (0-3000 m/min) is shown Figure 3.3.

Figure 3.3 Laboratory type mixer

In preparation stage of coating paste, using chemical rate, mixing velocity, viscosity of coating paste and laboratory temperature – humidity values were significantly kept under control.

The denim fabric sample was placed tightly on the coating device frame (Figure 3.4) in order to applied coating paste on the sample surface.

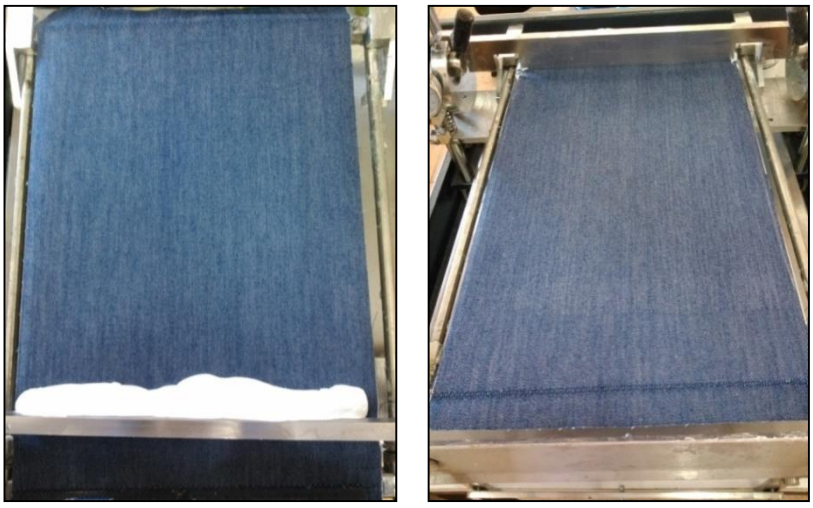
Figure 3.4 Laboratory type coating machine

By using laboratory type coating machine, prepared coating paste was applied on the denim fabric samples with knife coating technique. In this study, two different coating weightsdetermining of denim fabrics were obtained by adjusting the distance

between the knife and cylinders. The blade distances were determined as 0.20 mm and 0.40 mm. The blade distance adjusting apparatus is shown in Figure 3.5.

Figure 3.5 Blade distance adjusting apparatus

And than the coating process was performed with knife coating technique as shown in Figure 3.6 (a) and than this process was completed as indicated in Figure 3.6 (b).



(a) (b)

Figure 3.6 (a) Apply coating paste (b) Coating process

In the final steps of coating process, in order to the fixation of coating paste on the denim fabric surfaces were used the laboratory type stenter machine. Coated denim fabric sample was putted into the stenter machine in the 160 – 165 °C and 2 minutes.The laboratory type stenter device is indicated in Figure 3.7.

Figure 3.7 Laboratory type stenter machine

3.2.2 Micro-Cracking Process

Micro-cracking studies began in the 1970's with observations of the initiation of micro-cracking. Since then there have been numerous papers on the micro-cracking process under a variety of loading and environmental conditions [Nairn, 2000].

The micro-cracking process is used for different purposes in various fields such as industial textile, compozite materials, etc. Within the scope of this thesis, the micro-cracking process applied on the coated denim fabrics which will be used a first time method in this field.

One of the main purpose of the thesis is improvement of clothing comfort properties (air and water vapour permeability) after coating process. For this aim, the micro-cracking process was carried out with some chemicals. With the aid of chemicals, micro porous structure were created to help breahtability on the textile coated surface.

The chemicals used for micro-cracking process;

- Acetone,
- DMF (Dimethylformamide)
- Ethanol.

3.2.2.1 Micro-Cracking Chemicals

(i) Acetone

Acetone is the organic compound with the formula OC $(CH_3)_2$ [Allen et al., 1952]. It is produced directly or indirectly from propylene. Approximately 83 % of acetone is produced via the cumene process; as a result, acetone production is tied to phenol production. In the cumene process, benzene is alkylated with propylene to produce cumene, which is oxidized by air to produce phenol and acetone [Sifniades and Levy, 2005].

The physical properties of acetone, such as colorless, miscible with water, high evaporation rate, low viscosity, and several organic solvents make it suitable for use as a solvent [Krasavage et al. 1982]. Because of its ability to undergo addition, oxidation/reduction, and condensation reactions, acetone is used as a raw material in the chemical synthesis of many commercial products. It is a good solvent for many some synthetic and plastics [http://www.atsdr.cdc.gov].

Although acetone occurs naturally in the environment in plants, trees, volcanic gases, forest fires, and as a product of the breakdown of body fat, the majority of the acetone released into the environment is of industrial origin. It evaporates rapidly, even from water. Once in the atmosphere, it is degraded by UV light with a 22-day half-life [Darwent et al., 1960]. It is a clear, flammable and volatile product. Vapours may form explosive mixtures with air. The most common hazard associated with acetone is its extreme flammability. Acetone is believed to exhibit only slight toxicity in normal use, and there is no strong evidence of chronic health effects if basic precaution sare followed. The product causes irritation of eyes, skin and mucous membranes. It causes headache, drowsiness or other effects to the central nervous system [http://physics.utsa.edu].

(ii) DMF (Dimethylformamide)

Dimethylformamide (DMF) is chemical formula $(CH_3)_2$ NC (O)H. It is a colourless liquid is miscible with water and the majority of organic liquids. DMF is a common solvent for chemical reactions [http://monographs.iarc.fr].

It is also odorless whereas technical grade or degraded samples often have a fishy smell due to impurity of dimethylamine. As a common and cheap reagent, DMF has many uses in the research laboratory. The potential toxicity DMF has received considerable attention. Dimethylformamide (DMF) is primarily used as a solvent in the production of polyurethane products and acrylic fibers. It is also used in the pharmaceutical industry, in the formulation of pesticides, and in the manufacture of synthetic leathers, fibers, films, and surface coatings. DMF may be emitted to the environment as a result of its use in a variety of petro chemical industries [http://oehha.ca.gov].

(iii) Ethanol

Ethanol is a 2-C alcohol. Its molecular formula is CH_3CH_2OH. It is a volatile, colorless liquid that has a slight odor. It burns with a smoke less blue flame that is not always visible in normal light. Ethanol is produced both as a petro chemical, through the hydration of ethylene and, via biological processes, by fermenting sugars with yeast. The physical properties of its hydroxyl group and the shortness of its carbon chain. Ethanol's hydroxyl group is able to participate in hydrogen bonding, rendering it more viscous and less volatile than less polar organic compounds of similar molecular weight, such as propane. Ethanol is a versatile solvent, miscible with water [Lide, 2012]. The Table 3.3 generally given an information about these using chemical for the micro-cracking process.

Table 3.3 General properties of the chemicals

Chemicals / Properties	**Acetone**	**DMF**	**Ethanol**
Chemical formula	C_3H_6O	C_3H_7NO	CH_3CH_2OH
Appearance	Colorless	Colorless	Colorless
Density (g/ml^{-1})	0.791	0.948	0.789
Molar mass (g/mol^{-1})	58.08	73.10	46.07
Vapor Pressure (kPa) at 20°	24.46	0.3	7.91
Viscosity (mPa s) at 20°	0.32	0.92	1.08

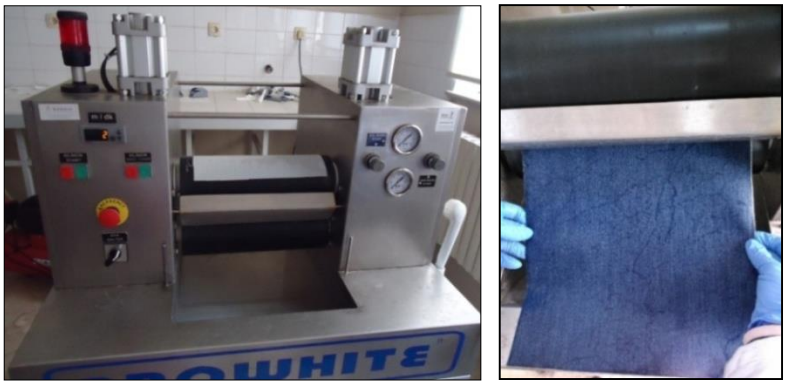
3.2.2.2 Preparation of Micro-Cracking Process

In this study, in order to improve the comfort properties of polyurethane (PU) coated denim fabrics, in other words to creation of micro-cracking on the coated denim

fabric samples surface (G1PU1, G1PU2, G2PU1, G2PU2) with using organic solvents (Acetone, DMF, Ethanol) with two different concentration rate (1/10, 1/50) and also two different duration time (5 sec, 10 sec) were carried out in the coagulation bath (Figure 3.8).

Figure 3.8 Micro-cracking coagulation bath

After the coagulation bath, coated denim fabric samples were applied extraction process with laboratory type pad machine (Figure 3.9 (a-b)).The extrusion velocity 2 m/min and extrusion pressure 3 bars were applied. At the end of the micro-cracking processes, the samples were allowed to drying freely at the laboratory condition for 24 hours.



(a) (b)

Figure 3.9 Laboratory type fluart (a) general view of machine, (b) expression rollers

3.2.3 Fabric Structural Properties

3.2.3.1 Fabric Weight

In order to determine the fabric samples weight after the coating process, samples weight were measured according to the "TS EN 12127:1999 Textile Fabrics-Determination of mass per unit area using small samples".

All of denim fabric sample weights were measured before the coating process and after the coating process. Five specimens were cut with specimen cutter from each fabric samples (100 cm²) and calculated the average value and results were reported in grams per square meters (g/m²). The sensitive scale and specimen cutter are shown in Figure 3.10.

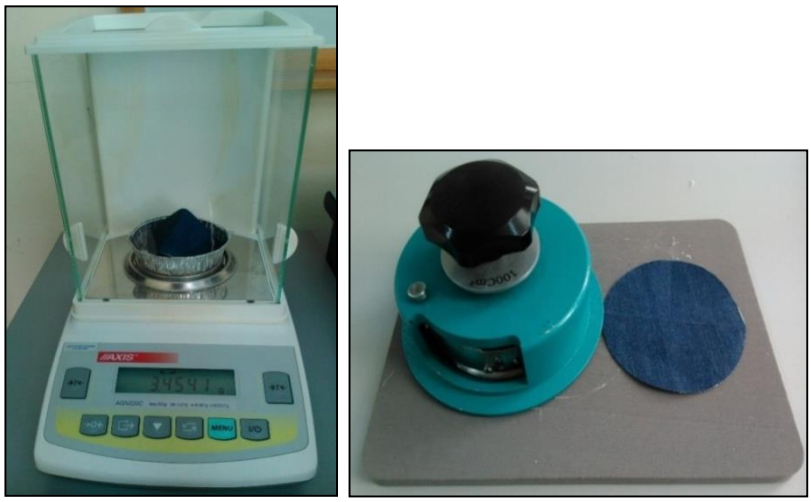


Figure 3.10 Testing instruments for measuring weight

3.2.3.2 Fabric Thickness

The fabric samples thickness were measured according to "TS EN ISO 5084: 1998 Textile Fabrics-Determination of thickness of textiles and textile products".

Thickness values were measuredby using digital fabric thickness measurement device. In this thickness instrument 10 g/cm² pressure was applied on the sample and measured with 0.01 mm precision. The average of five sample values were received expressed in (mm). Schmidt digital thickness measurement is indicated in Figure 3.11.

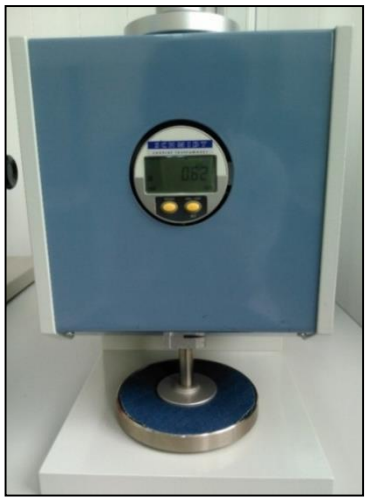


Figure 3.11 Digital thickness tester

3.2.4 Comfort Related Fabric Properties and Measurement

3.2.4.1 Air Permeability

Air permeability is a substantial factor in the comfort and performance properties of textile materials. The air permeability is the rate of air flow passing through a certain area under a specified air pressure differential between the two surfaces of a textile material.

The specimen is placed on the machine testing area and is clamped into the tester and through the use of a vacuum. Air flow will take place from the one side with higher air pressure through the fabric, to the other side with the lower air pressure (Figure 3.12). The rate of air flow, the air permeability of the fabric is identified.

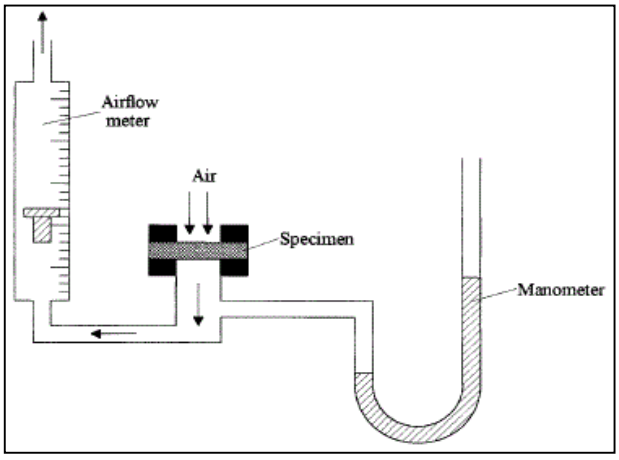


Figure 3.12 Working principle of air permeability tester [Saville,1999]

Untreated denim fabric samples, before micro-cracking and after micro-cracking coated denim fabric samples were measured in order to determine the air permeability properties according to the "TS 391 EN ISO 9237: 1999 Textile Fabrics-Determination of permeability of fabrics to air".

SDL Atlas air permeability tester was used and all of the samples were measured with 20 cm^2 test head and at 100 Pa pressure. Three measurements were taken from each fabric sample types. Test results were recorded and calculated average value.

Obtaining the average of the air permeability results were determined by in terms of dm^3/sec. SDL Atlas air permeability tester is indicated in Figure 3.13.

Figure 3.13 Digital air permeability tester

3.2.4.2 Permetest Water Vapour Permeability

Hes (1998) has improved a new system, the PERMETEST, for measuring of water vapour permeability of textile surfaces such as garments, nonwoven webs etc. The Permetest instrument is called skin model, which simulates dry and wet human skin in terms of its thermal feeling. It works on the principle of heat flux sensing. The temperature of the measuring head is maintained at room temperature for isothermal conditions. The heat supplied to maintain the temperature of the measuring head, from where the supplied water gets evaporated, is measured. The heat supplied to maintain a constant temperature with and without the fabric mounted on the plate is measured (Figure 3.14).

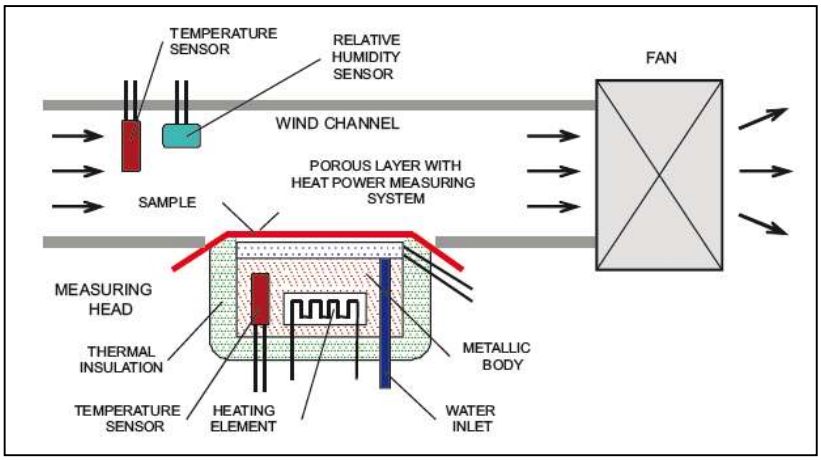


Figure 3.14 Water vapour permeability principle of permetest device [Boguslavska-Baczek&Hes, 2013]

In this method, the steady state water vapour permeability is also measured. The relative water vapour permeability (P) of the sample is calculated comparing it with a reference fabric and its express Equation 3.3;

$$\text{Relative water vapour permeability (\%)} = \frac{(WVP)_f}{(WVP)_r} \times 100 \qquad (3.3)$$

$(WVP)_f$; the water vapour permeability of the test fabric,
$(WVP)_r$; the water vapour permeability of the reference fabric.

Water vapour resistance R_{et} (as defined in ISO 11092) expresses the following Equation 3.4;

$$\text{Water vapour permeability}(m^2Pa/W) = (P_m - P_a)(q_s^{-1} - q_o^{-1}) \qquad (3.4)$$

P_m and P_a ; the water vapour saturate partial pressure in Pascals,
q_s; heat flow with a sample,
q_o; heat flow without a sample.

The instrument provides all kinds of measurements according to ISO Standard 11092 with 0,92 correlation rate. The differences in relation to this standard depend in smaller sample, application the 20-22 ºC isothermal laboratory temperature instead of 35ºC (at the water-vapour resistance measurements) and by the application of the

laboratory (environmental) water-vapour concentration (humidity) of the parallel air flow 45 – 60 %, instead of the air humidity level of 40 %.

This test method is very short time within 2-3 minutes. The test specimens were prepared 15*15 cm (sample area 100 mm). Test results were presented in digital form both on the instrument display and on the screen of computer. Each of samples water vapourpermeability was repeated 3 times.

The permetest instrument is shown in Figure 3.15.

Figure 3.15 Permetest, water vapour permeability tester

3.2.4.3 Wicking

The wicking test had conducted using a vertical wicking tester according to DIN 53924 standard. Before the testing, the specimens were conditioned at 20°C temperature and 65 % relative humidity at 24 hours.

Vertical wicking tests were carried out on the apparatus indicated in Figure 3.15. Three specimens of 200 × 25 mm (1 x 8 inch) cut along the warp and weft directions were prepared. The fabric sample was hung vertically with the sample holder and than the pin penetrated the sample on the beaker centre line in the distilled water. In order to ensure that the bottom ends of the samples could be immersed vertically at a depth of 10 mm into the water, the bottom end of each sample was clamped with a 1 g clip, as indicated in Figure 3.16. The wicking heights were measured every minute for 2, 5, 10, 15, 20, 25, 30 minutes and recorded (mm) for height of water rise the fabric samples of wicking ability.

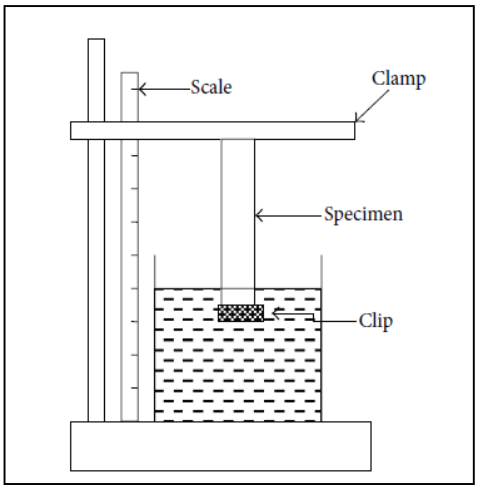


Figure 3.16 Wicking test system – vertical line [Chatterjee& Singh, 2014]

3.2.5 Coating Performance Related Fabric Properties

3.2.5.1 Water Resistance

The hydrostatic head supported by a fabric is a measure of the opposition to the passage of water through the fabric (Figure 3.17).

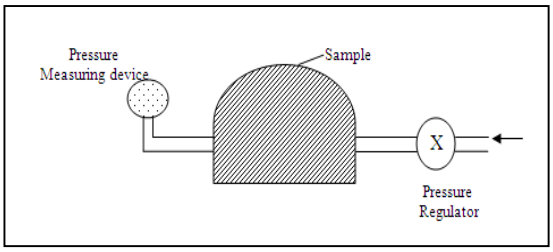


Figure 3.17 Hydrostatic head tester working principle [Saville,1999]

This test was applied with according to "TS 257 EN 20811:1996, Textile Fabrics-Determination of resistance to water penetration-Hydrostatic pressure test".

The test specimens were prepared 15*15 cm. Firstly, the tests mode (dynamic) and pressure unit (mbar) was selected. The testing part of the hydrostatic head tester instrument, the specimen was positioned no air space between the distilled water. After that the clamp was compressed, the specimen does not slip in the clamp and no leakage of water take place at the clamp during the test period. When seen 3 drops of water on the fabric surface, the test was completed and than the result of pressure

was recorded on the digital screen. 4 measurements were performed for each of fabric samples.The hydrostatic head tester instrument is indicated in Figure 3.18.

Figure 3.18 Hydrostatic head tester

3.2.5.2 Breaking Strength and Elongation

Fabric breaking strength and elongation tests were carried out all of samples according to "ASTM-D5035-11 Breaking force and elongation of textile fabrics-Strip method" by using Titan strength tester (Figure 3.19).

Each type of fabric samples was prepared diagonally; five warp and weft direction of specimens and each specimen was cut 50*150 mm. The results obtained by taking the average of breaking strength (N) and breaking elongation (%) were determined.

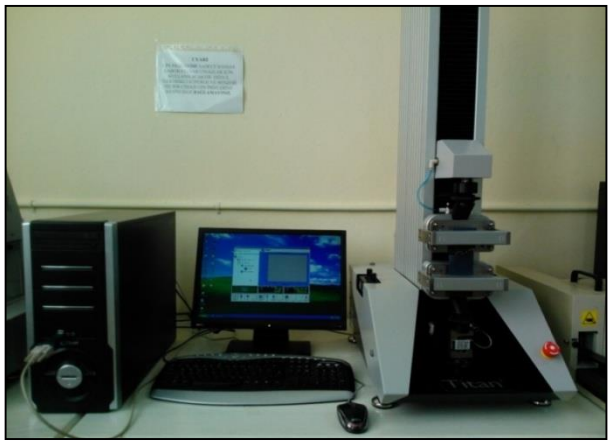


Figure 3.19 Titan, breaking strength tester

The specimen is placed on the testing machine apparatus like Figure 3.20.

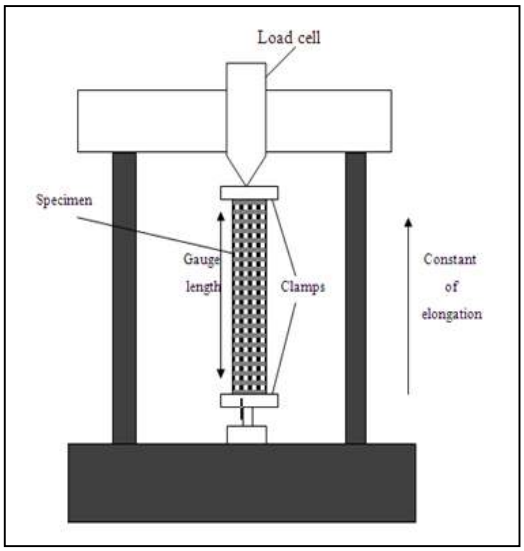


Figure 3.20 Fabric breaking strength and elongation system [Saville, 1999]

3.2.5.3 Martindale Abrasion Resistance

In this study, in order to investigate and compare the samples of properties after micro-cracking chemical processes, all fabric samples (untreated or no PU coated denim fabrics, before micro-cracking and after micro-cracking) were tested abrasion resistances according to "TS EN ISO 12947-3: 2001 Textile Fabrics-Determination of the abrasion resistance of fabrics by the martindale method-Part 3: determination of mass loss" (Figure 3.21).

Figure 3.21 Martindale, abrasion tester

For this test, four specimens were cut circular 38 mm diameter by using the cutter apparatus and then the specimens were placed in the specimens holders with the standard foam. It is shown in Figure 3.22.

Figure 3.22 Description of abrasion holder apparatus

The abradant fabrics were mounted under plate of the martindale abrasion device (Figure 3.21). It is generally used woven wool fabric (1/1 plain weave). The test specimen holders are mounted on the machine with the fabric under test next to the abradant. A spindle is inserted through the top plate and the weights (12 kPa) are placed on top of this (Figure 3.23). The specimens weight were measured before testing by using sensitive scale and after 5000 and 10000 cycles were measured the weight of specimens. For each fabric samples, four replicates abrasion test was performed and average value was calculated according to % mass loss (Equation 3.5).

$$\text{Mass loss } \% = \frac{\text{Fabric mass before abrasion cycles}}{\text{Fabric mass loss after abrasion cycles}} \times 100 \qquad (3.5)$$

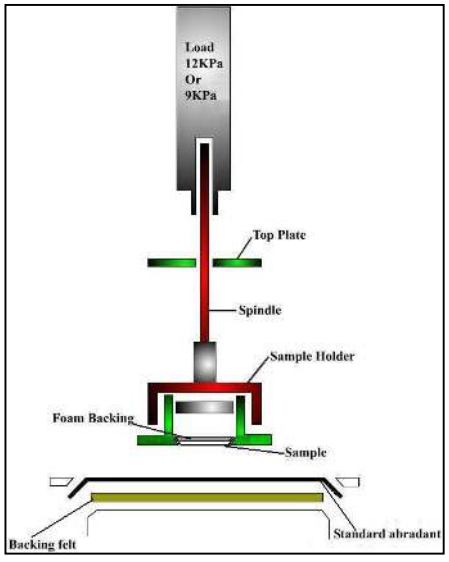


Figure 3.23 Description of abrasion apparatus [Saville, 1999]

CHAPTER 4

RESULT AND DISCUSSION

Within the scope of this thesis, untreated denim fabric samples (G1 and G2), PU coated denim fabric samples in other words before micro-cracking coated denim fabric samples (G1PU1, G1PU2, G2PU1 and G2PU2) and after micro-cracking coated denim fabric samples test results were represented graphically. Furthermore, all the test result (air permeability, water vapour permeability, water vapour resistance (RET), wicking, water resistance, breaking strength and elongation and abrasion resistance) are given in Appendix A.

There after in this study, 3 factor analysis of variance using the program statistical software package SPSS 17.0 was used to interpret the experimental data. In order to understand the statistical importance of different type on fabric properties analysis of variance (ANOVA) was performed and Tukey Tables were used to determine the best fabric types for air permeability, water vapour permeability, wicking, water resistance, breaking strength and elongation and abrasion resistance properties.

Variations source as solvent (chemical) type, concentration rate, and duration time are chosen. Variation of source and interaction of effect were interpreted by examining F statistic and Partial Eta Square statistic values. While, F statistics value and Partial Eta Square statistics value increase it is indicated that a strong in the contribution of the sources of variation. Furthermore, Tukey Tables are demonstrated that, the sources of variation are displayed between similarity or dissimilarty each other. All test results were appraised at significance levels of $\alpha \leq 0{,}05$ and $\alpha \leq 0{,}01$. Besides, the details of statistical analysis results are given in Appendix B.

54 different denim fabric samples were used for this experimental study.

4.1 Test Results of Comfort Related Fabric Properties

4.1.1 Air Permeability

All the samples air permeability test results are demonstrate in Appendix Table A.1. fabric samples have been measured the air permeability values before PU coating process and after PU coating process. The results are expressed with graphical representation like in Figure 4.1

As it is expected, (Figure 4.1) the air permeability values are significant decrease after coating process. For G1 fabric samples in PU1 coated thickness, the air permeability values approximately diminish 92.75 %, in PU2 coated thickness 95.5 % and for G2 fabric samples in PU1 coated thickness, the air permeability values approximately diminish 93.1 %, in PU2 coated thickness 94.83 %.

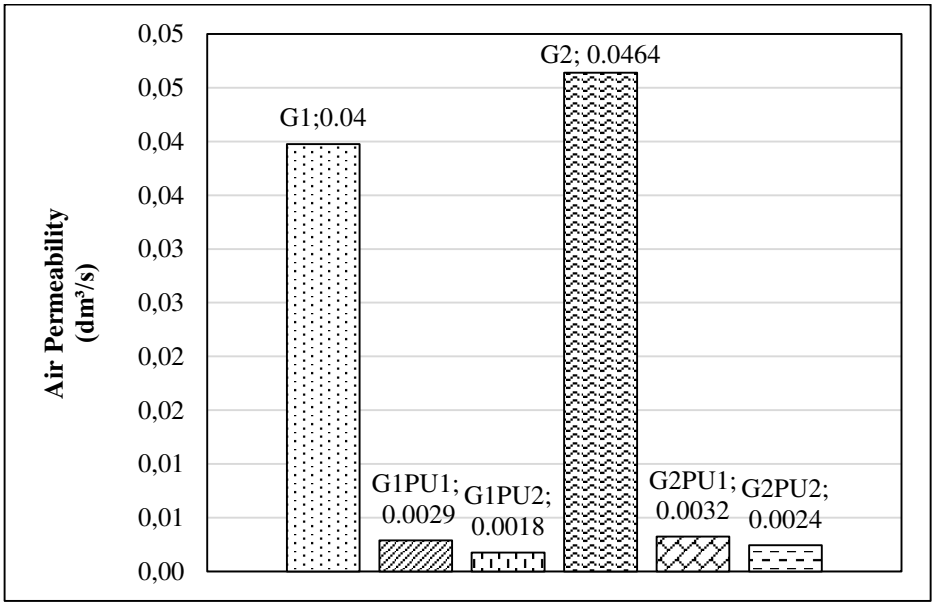
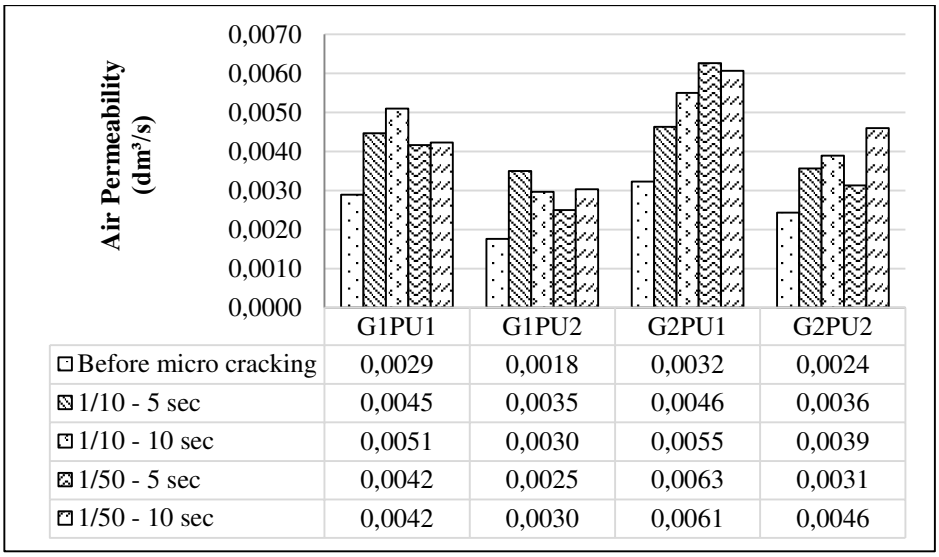


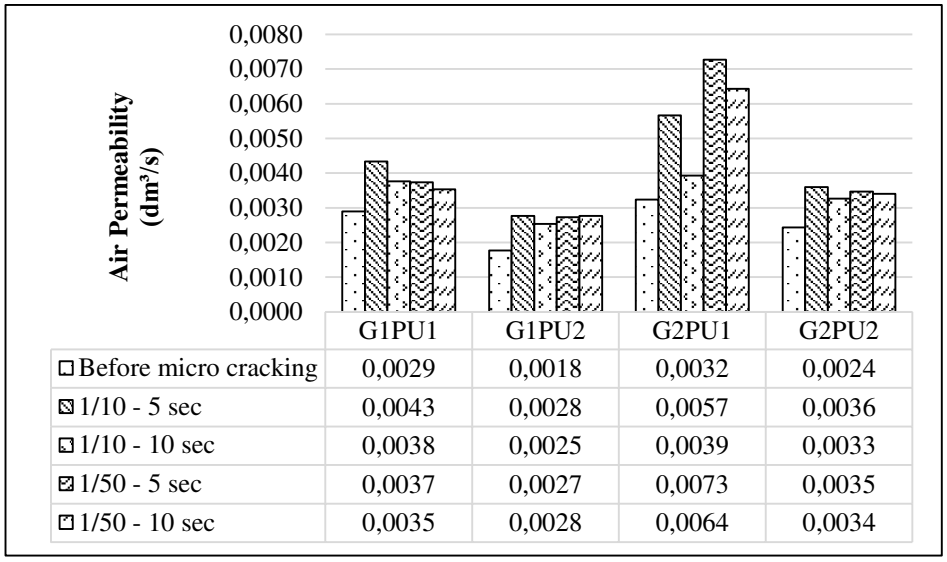
Figure 4.1 Air permeability test result before PU coating process and after PU coating process

The air permeability values of coated fabric samples are shown according to chemical (solvent) type in (Figure 4.2, Figure 4.3 and Figure 4.4), before micro-cracking and after micro-cracking process. According to these figures, it can be clearly seen that the air permeability values increase after micro-cracking process all the fabric samples. On the other hand, chemical type, concentration rate and duration time are influence differently on the samples.



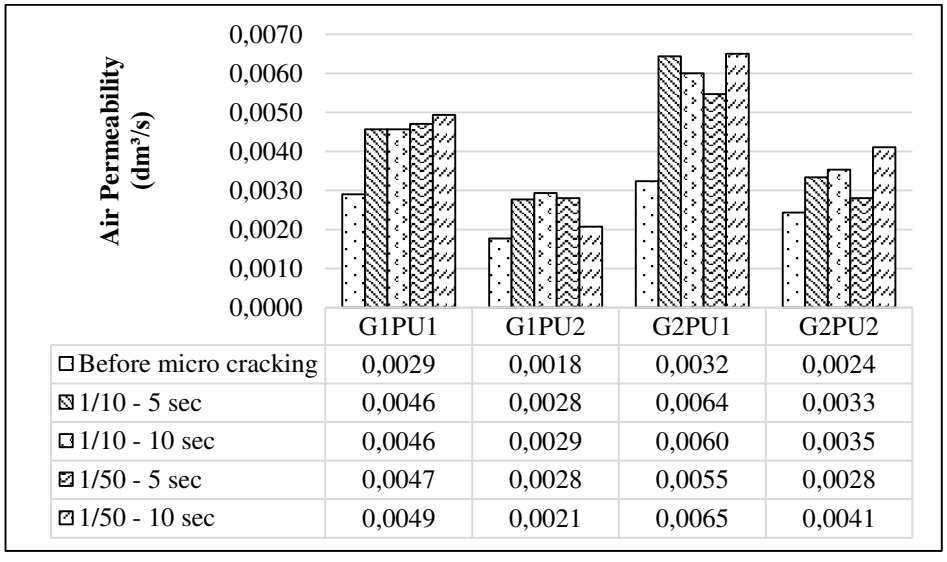
	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	0,0029	0,0018	0,0032	0,0024
1/10 - 5 sec	0,0045	0,0035	0,0046	0,0036
1/10 - 10 sec	0,0051	0,0030	0,0055	0,0039
1/50 - 5 sec	0,0042	0,0025	0,0063	0,0031
1/50 - 10 sec	0,0042	0,0030	0,0061	0,0046

Figure 4.2 Air permeability test results after micro-cracking with Acetone



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	0,0029	0,0018	0,0032	0,0024
1/10 - 5 sec	0,0043	0,0028	0,0057	0,0036
1/10 - 10 sec	0,0038	0,0025	0,0039	0,0033
1/50 - 5 sec	0,0037	0,0027	0,0073	0,0035
1/50 - 10 sec	0,0035	0,0028	0,0064	0,0034

Figure 4.3 Air permeability test results after micro-cracking with DMF



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	0,0029	0,0018	0,0032	0,0024
1/10 - 5 sec	0,0046	0,0028	0,0064	0,0033
1/10 - 10 sec	0,0046	0,0029	0,0060	0,0035
1/50 - 5 sec	0,0047	0,0028	0,0055	0,0028
1/50 - 10 sec	0,0049	0,0021	0,0065	0,0041

Figure 4.4 Air permeability test results after micro-cracking with Ethanol

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.1 and Table 4.2 for G1PU1 fabric samples.

Table 4.1 ANOVA values of air permeability test results (G1PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	15,379	,000	,542
Concentration Rate	3,650	,067	,123
DurationTime	,045	,834	,002
Chemical * concentration	3,785	,036	,226
Chemical * time	2,733	,084	,174
Concentration * time	,002	,966	,000
Chemical * concentration * time	1,240	,306	,087

Generally, when the concentration rate decrease and duration time increase higher air permeability values are measured for all G1PU1 fabric samples. After micro-cracking process, the chemical type is found that the most effective factor according to Table 4.1 in partial eta squared value (,542). Besides, acetone and ethanol are more influence than DMF (Table 4.2). However, acetone and ethanol have no statistically different effect on fabric samples. Otherwise, concentration rate (1/10, 1/50) and duration time (5 s, 10 s) have statistically significant effect on the air permeability properties of G1PU1 fabric samples before micro-cracking whereas there is no statistical different effect between them after micro-cracking process.

Table 4.2 Tukey values of air permeability test results (G1PU1)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
None (Untreated samples)	,002900		
DMF		,003842	
Acetone			,004492
Ethanol			,004692
Sig.	1,000	1,000	,782

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None (Untreated samples)	,002900		None	,002900	
1:10		,004467	5 s		,004328
1:50		,004217	10 s		,004356
Sig.	1,000	,481	Sig.	1,000	,991

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.3 and Table 4.4 for G1PU2 fabric samples.

Table 4.3 ANOVA values of air permeability test results (G1PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	4,873	,016	,273
Concentration Rate	6,741	,015	,206
DurationTime	1,614	,215	,058
Chemical * concentration	3,244	,055	,200
Chemical * time	,681	,515	,050
Concentration * time	,516	,479	,019
Chemical * concentration * time	8,059	,002	,383

Statistical analysis results are shown that the air permability values increase with micro-cracking and this increment originate by chemical type (,273), concentration rate (,206) in Table 4.3. On the other hand, the chemicals (acetone, DMF, ethanol) concentration rate (1/10, 1/50) and duration time (5 s, 10 s) have statistically different influence on the air permeability properties of G1PU2 fabric samples before micro-cracking but there is no statistical different effect between them after micro-cracking process according to Tukey values (Table 4.4).

G1PU2 fabric samples air permeability values increase with micro-cracking process however, the coating rate or coating thickness value is higher than G1PU1 fabric samples. Thus, G1PU2 fabric samples air permeability values are lower than G1PU1.

Table 4.4 Tukey values of air permeability test results (G1PU2)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	,001767	
Ethanol		,002642
DMF		,002700
Acetone		,003000
Sig.	1,000	,150

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	,001767		None	,001767	
1:10		,002911	5 s		,002844
1:50		,002650	10 s		,002717
Sig.	1,000	,268	Sig.	1,000	,720

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.5 and Table 4.6 for G2PU1 fabric samples.

Table 4.5 ANOVA values of air permeability test results (G2PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	1,953	,162	,131
Concentration Rate	38,662	,000	,598
DurationTime	2,712	,112	,094
Chemical * concentration	13,713	,000	,513
Chemical * time	9,477	,001	,422
Concentration * time	2,712	,112	,094
Chemical * concentration * time	6,555	,005	,335

According to Table 4.5 for G2PU1 fabric samples, the concentration rate is found that the most effective factor (,598) and in addition to this the chemical*concentration rate intersection is influenced the air permeability values (,513). The chemical types have no statistically different effect between each other in Table 4.6. On the other hand the concentration rate (1/10 and 1/50) have statistically different effect on the G2PU1 fabric sample air permeability properties.

On the other hand (Table 4.6), the chemicals (acetone, DMF, ethanol) and duration time (5 s, 10 s) have statistically different effect before micro-cracking whereas, there is no statistical different effect between them after micro-cracking process.

Table 4.6 Tukey values of air permeability test results (G2PU1)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	,003233	
Acetone		,005617
DMF		,005825
Ethanol		,006017
Sig.	1,000	,456

a

Concentration Rate	Subset		
	3	2	1
None	,003233		
1:10		,005306	
1:50			,006333
Sig.	1,000	1,000	1,000

Duration Time	Subset	
	2	1
None	,003233	
5 s		,005956
10 s		,005683
Sig.	1,000	,578

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.7 and Table 4.8 for G2PU2 fabric samples.

Table 4.7 ANOVA values of air permeability test results (G2PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	1,918	,167	,129
Concentration Rate	,082	,777	,003
DurationTime	7,670	,010	,228
Chemical * concentration	,058	,944	,004
Chemical * time	3,895	,033	,231
Concentration * time	5,700	,025	,180
Chemical * concentration * time	,660	,525	,048

G2PU2 fabric samples air permeability properties are shown that much the same with G1PU2 fabrics samples. On the other words, G2PU2 fabric samples air permeability values increase with micro-cracking however this increment is lower than G2PU1 after micro-cracking process. Statistical analysis results are shown that the air permability values increase with micro-cracking process and this increment originate by duration time (,228), and intersection of chemical*duration time (,231) in Table 4.7.

According to Table 4.8 the chemicals (acetone, DMF, ethanol) concentration rate (1/10, 1/50) and duration time (5 s, 10 s) have statistically significant effect on the air permeability properties of G2PU2 fabric samples before micro-cracking but there is no statistical different effect between them after micro-cracking process.

Table 4.8 Tukey values of air permeability test results (G2PU2)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	,002433	
DMF		,003433
Ethanol		,003442
Acetone		,003800
Sig.	1,000	,573

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	,002433		None	,002433	
1:10		,003533	5 s		,003317
1:50		,003583	10 s		,003800
Sig.	1,000	,983	Sig.	1,000	,226

b

As a concequence of these experimental and statistical results, generally the air permeability values decrease both not only G1 fabric samples but also G2 fabric samples after coating process. However, the micro-cracking process provides to increase the air permeability values all coated fabric sample types.

4.1.2 Water Vapour Permeability (WVP)

All the samples water vapour permeability test results are demonstrate in Appendix Table A.2. Fabric samples have been measured the water vapour permeability values before PU coating process and after PU coating process. The results are expressed with graphical represantation in Figure 4.5.

As it is expected, (Figure 4.5) the water vapour permeability values are noteworthy decrease after coating process. For G1 fabric samples water vapour permeability values decrease respectively 63.7 %, 72.22 %, and for G2 fabric samples water vapour permeability values decrease respectively 42.77 %, 63.25 %. Moreover, when the coating rate increases, the water vapour permeability values decrease.

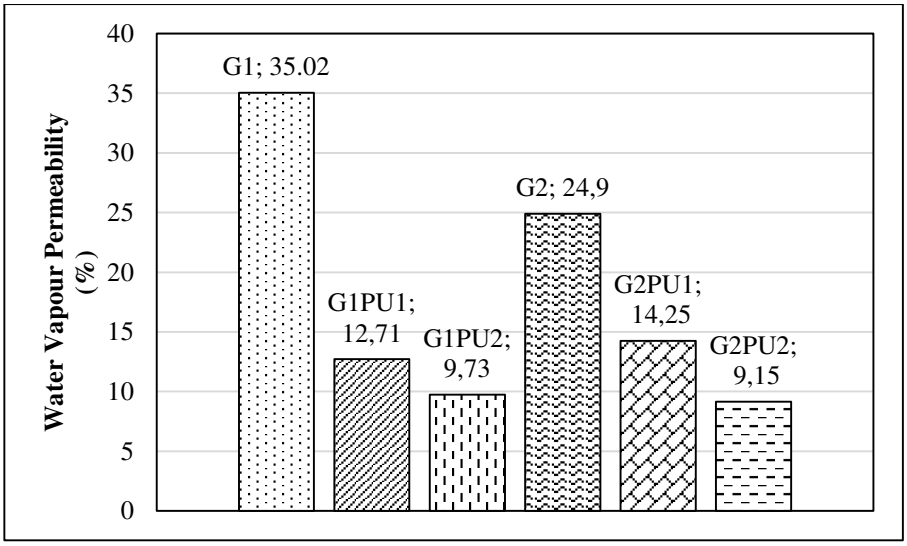
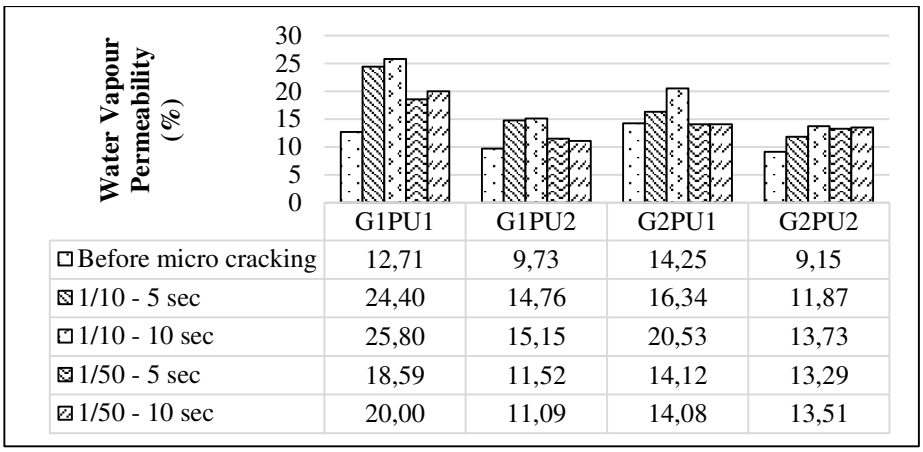


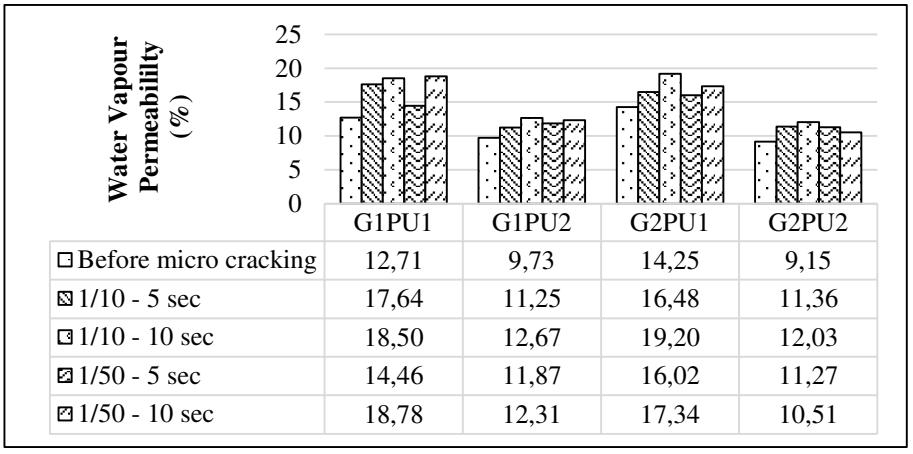
Figure 4.5 Water vapour permeability test result before PU coating process and after PU coating process

The water vapour permeability values of coated fabric samples are shown according to chemical type in (Figure 4.6, Figure 4.7 and Figure 4.8), before micro-cracking and after micro-cracking process. According to these figures, it can be clearly seen that the water vapour permeability values increase after micro-cracking process all the fabric samples.



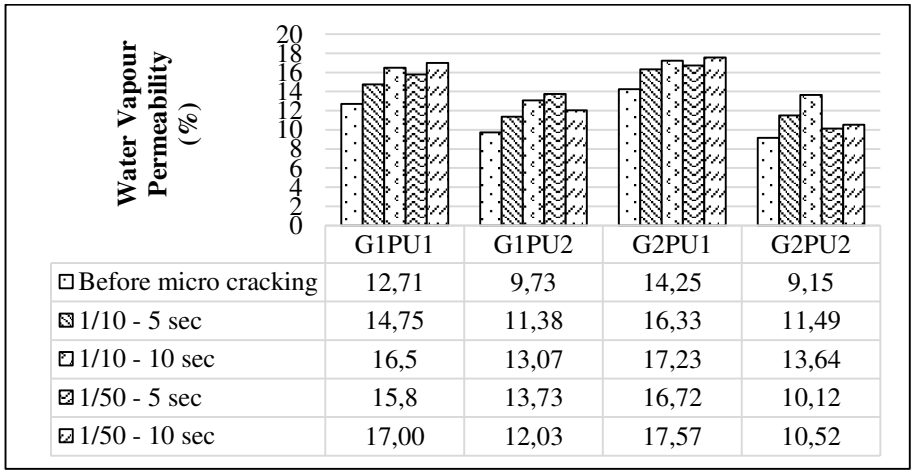
	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	12,71	9,73	14,25	9,15
1/10 - 5 sec	24,40	14,76	16,34	11,87
1/10 - 10 sec	25,80	15,15	20,53	13,73
1/50 - 5 sec	18,59	11,52	14,12	13,29
1/50 - 10 sec	20,00	11,09	14,08	13,51

Figure 4.6 Water vapour permeability test results after micro-cracking with Acetone



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	12,71	9,73	14,25	9,15
1/10 - 5 sec	17,64	11,25	16,48	11,36
1/10 - 10 sec	18,50	12,67	19,20	12,03
1/50 - 5 sec	14,46	11,87	16,02	11,27
1/50 - 10 sec	18,78	12,31	17,34	10,51

Figure 4.7 Water vapour permeability test results after micro-cracking with DMF



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	12,71	9,73	14,25	9,15
1/10 - 5 sec	14,75	11,38	16,33	11,49
1/10 - 10 sec	16,5	13,07	17,23	13,64
1/50 - 5 sec	15,8	13,73	16,72	10,12
1/50 - 10 sec	17,00	12,03	17,57	10,52

Figure 4.8 Water vapour permeability test results after micro-cracking with Ethanol

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.9 and Table 4.10 for G1PU1 fabric samples.

Table 4.9 ANOVA values of water vapour permeability test results (G1PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	51,266	,000	,798
Concentration Rate	16,942	,000	,395
DurationTime	12,073	,002	,317
Chemical * concentration	13,564	,000	,511
Chemical * time	,539	,590	,040
Concentration * time	,858	,363	,032
Chemical * concentration * time	1,427	,258	,099

It is clear from the statistical and experimental results the water vapour permeability (WVP) of fabric samples increase after micro-cracking process. According to the ANOVA test results (Table 4.9), the chemical type is noteworthy effect (,798) on the fabric water vapour permeability properties. In addition to from Tukey test, acetone is higher influence than DMF and ethanol (Table 4.10-a). However, DMF and ethanol have no statistically different effect on fabric samples. On the other hand (Table 4.10-b), the concentration rate has statistically different effect on fabric samples. The duration time (5 s, 10 s) have statistically significant effect before micro-cracking but there is no statistical different effect between them after micro-carcking process.

Table 4.10 Tukey values of water vapour permeability test results (G1PU1)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	1	2	3
None	12,7133		
Ethanol		16,0133	
DMF		17,3450	
Acetone			22,1975
Sig.	1,000	,415	1,000

a

Concentration Rate	Subset			Duration Time	Subset	
	3	2	1		2	1
None	12,7133			None	12,7133	
1:50		17,4383		5 s		17,6076
1:10			19,5989	10 s		19,4306
Sig.	1,000	1,000	1,000	Sig.	1,000	,104

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.11 and Table 4.12 for G1PU2 fabric samples.

Table 4.11 ANOVA values of water vapour permeability test results (G1PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	,956	,397	,069
Concentration Rate	2,132	,156	,076
DurationTime	,209	,651	,008
Chemical * concentration	4,326	,024	,250
Chemical * time	,229	,797	,017
Concentration * time	1,752	,197	,063
Chemical * concentration * time	,407	,670	,030

According to the ANOVA and Tukey test results (Table 4.11 and Table 4.12), the chemical types, concentration rate and duration times have no statistically different effect on the WVP of the G1PU2 fabric samples. On the other hand, each of the chemical type are increased the WVP values in comparison with before micro-cracking process. In other respects, the duration time has no statictically different effect on the WVP properties of the fabric samples.

This situation is indicated that, when the coating rate increases, the water vapour permeability properties affect negatively on the fabric.

Table 4.12 Tukey values of water vapour permeability test results (G1PU2)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	9,7333	
DMF	12,0250	12,0250
Ethanol	12,5525	12,5525
Acetone		13,1300
Sig.	,059	,725

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	9,7333		None	9,7333	
1:50	12,0928	12,0928	5 s		12,4200
1:10		13,0456	10 s		12,7183
Sig.	,088	,649	Sig.	1,000	,958

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.13 and Table 4.14 for G2PU1 fabric samples.

Table 4.13 ANOVA values of water vapour permeability test results (G2PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	2,344	,116	,153
Concentration Rate	19,818	,000	,433
DurationTime	18,626	,000	,417
Chemical * concentration	13,034	,000	,501
Chemical * time	1,048	,365	,075
Concentration * time	6,068	,021	,189
Chemical * concentration * time	2,565	,096	,165

From Table 4.13 as it can be seen that, the concentration rate (,433) has statistically more influence factor than the duration time (,417) and the chemical type (,153) on the G2PU1 fabric samples.

The obtained of analysis results demonstrated that (Table 4.14), the chemical type has no statictically different effect and it means that, it can be used acetone, DMF and ethanol chemicals. However the concentration rate and the duration time have statistically different effect on the WVP on the G2PU1 fabric samples.

Table 4.14 Tukey values of water vapour permeability test results (G2PU1)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	14,2500	
Acetone		16,2683
Ethanol		16,9608
DMF		17,2608
Sig.	1,000	,398

a

Concentration Rate	Subset		
	3	2	1
None	14,2500		
1:50		15,9756	
1:10			17,6844
Sig.	1,000	1,000	1,000

Duration Time	Subset		
	3	2	1
None	14,2500		
5 s		16,0017	
10 s			17,6583
Sig.	1,000	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.15 and Table 4.16 for G2PU2 fabric samples.

Table 4.15 ANOVA values of water vapour permeability test results (G2PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	2,340	,116	,153
Concentration Rate	1,158	,292	,043
DurationTime	,996	,327	,037
Chemical * concentration	1,179	,324	,083
Chemical * time	,289	,752	,022
Concentration * time	1,123	,299	,041
Chemical * concentration * time	,004	,996	,000

From the ANOVA (Table 4.15) and Tukey (Table 4.16) test results are indicated that, the chemical type (,153), concentration rate (,043) and duration times (,037) have no statistically different effect on the water vapour properties. The Table 4.16 shown that the tukey values the most effective chemical is acetone and 1/10 concentration rate and 10 s duration time.

Table 4.16 Tukey values of water vapour permeability test results (G2PU2)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	9,1500	
DMF	11,2933	11,2933
Ethanol	11,4417	11,4417
Acetone		13,1008
Sig.	,266	,468

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	9,1500		None	9,1500	
1:50	11,5378	11,5378	5 s	11,5672	11,5672
1:10		12,3528	10 s		12,3233
Sig.	,150	,789	Sig.	,144	,815

b

As a concequence of that, it can be said that, when the coating rate increase independently of denim fabric weight, the micro-cracking process is affected on the water vapour permeability but the effect is attenuation on the fabric samples.

4.1.3 Water Vapour Resistance (RET)

All the samples water vapour resistance (RET) test results are demonstrate in Appendix Table A.2. Fabric samples have been measured the water vapour permability (RET) values before PU coating process and after PU coating process. The results are expressed with graphical represantation in Figure 4.9.

On the basis of the results (Figure 4.9), it can be seen that the coated fabric samples have more resistance to water vapour. As a conclusion of the test results shown that the water vapour resistance (RET) values are increase on G1 fabric samples respectively PU1 3.5 and PU2 4.7 times and on G2 fabric samples respectively PU1 3.5 and PU2 6.5 times. When the coating rate increases, the fabric water vapour resistance (RET) values also increase.

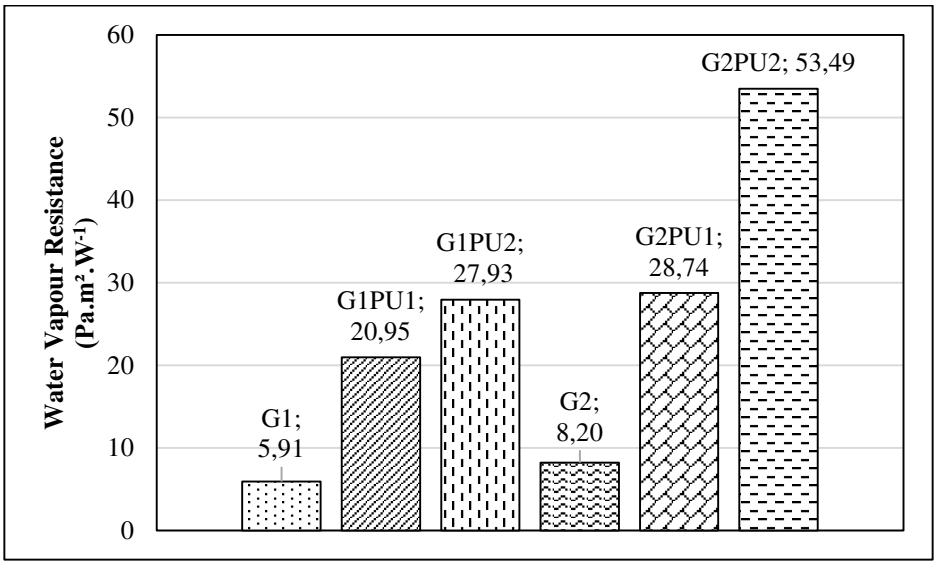
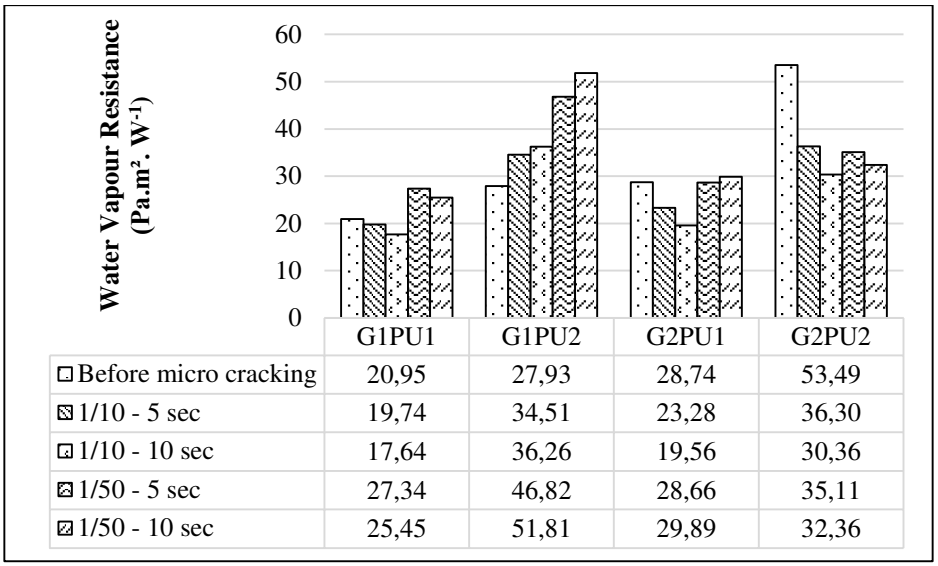


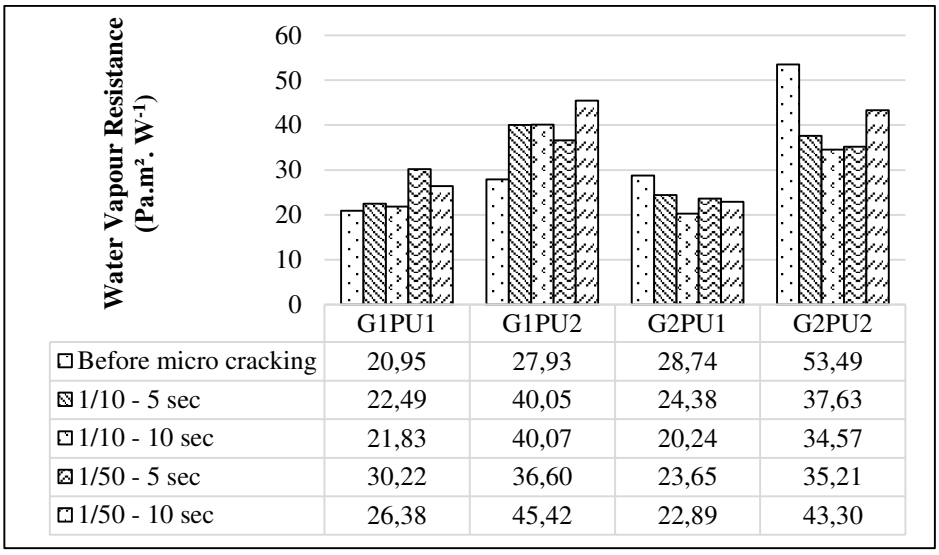
Figure 4.9 Water vapour resistance test result before PU coating process and after PU coating process

The water vapour resistance (RET) values of coated fabric samples are shown according to the chemical type in (Figure 4.10, Figure 4.11 and Figure 4.12), before micro-cracking and after micro-cracking process.



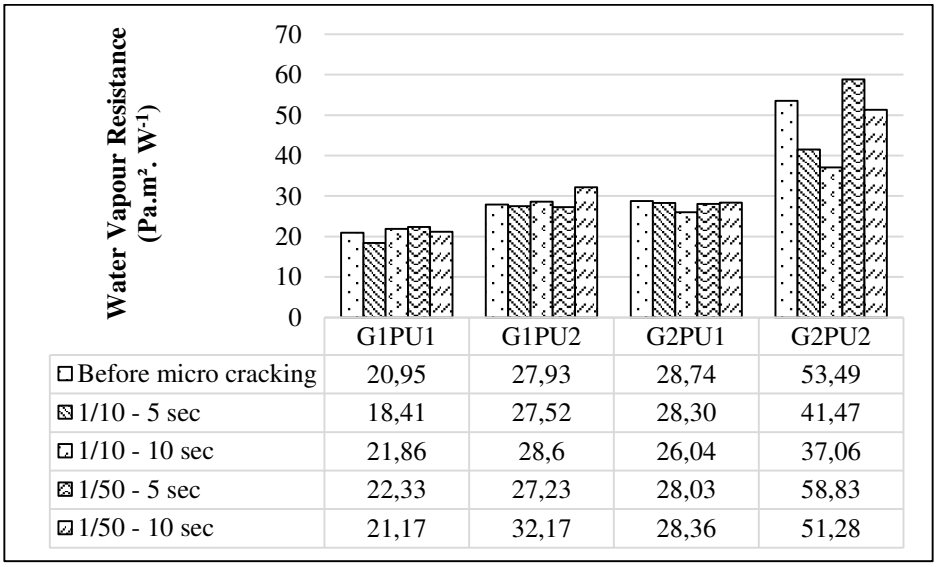
	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	20,95	27,93	28,74	53,49
1/10 - 5 sec	19,74	34,51	23,28	36,30
1/10 - 10 sec	17,64	36,26	19,56	30,36
1/50 - 5 sec	27,34	46,82	28,66	35,11
1/50 - 10 sec	25,45	51,81	29,89	32,36

Figure 4.10 Water vapour resistance test result after micro-cracking with Acetone



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	20,95	27,93	28,74	53,49
1/10 - 5 sec	22,49	40,05	24,38	37,63
1/10 - 10 sec	21,83	40,07	20,24	34,57
1/50 - 5 sec	30,22	36,60	23,65	35,21
1/50 - 10 sec	26,38	45,42	22,89	43,30

Figure 4.11 Water vapour resistance test result after micro-cracking with DMF



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	20,95	27,93	28,74	53,49
1/10 - 5 sec	18,41	27,52	28,30	41,47
1/10 - 10 sec	21,86	28,6	26,04	37,06
1/50 - 5 sec	22,33	27,23	28,03	58,83
1/50 - 10 sec	21,17	32,17	28,36	51,28

Figure 4.12 Water vapour resistance test result after micro-cracking with Ethanol

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.17 and Table 4.18 for G1PU1 fabric samples.

Table 4.17 ANOVA values of water vapour resistance (RET) test results (G1PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	14,957	,000	,535
Concentration Rate	63,402	,000	,709
DurationTime	2,558	,122	,090
Chemical * concentration	7,956	,002	,380
Chemical * time	2,843	,076	,179
Concentration * time	3,822	,061	,128
Chemical * concentration * time	1,226	,310	,086

As it can be seen clearly from Table 4.17 the concentration rate is more effect on the water vapour resistance (RET) values of the G1PU1 fabric samples than the other factors. Besides, the chemical type has an effect on the RET values of fabric samples. On the other hand, from the Tukey test (Table 4.18), ethanol is more influence with compare to acetone and DMF.

The concentration rates have statistically different effect whereas the duration times have no statistically effect on the RET values (Table 4.18). The most effective process is found that DMF with 1/50 – 10 sec or 5 sec.

Table 4.18 Tukey values of water vapour resistance (RET) test results (G1PU1)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
Ethanol	20,9425	
None	20,9467	
Acetone	22,5417	22,5417
DMF		25,2292
Sig.	,437	,073

a

Concentration Rate	Subset		Duration Time	Subset
	2	1		1
1:10	20,3294		None	20,9467
None	20,9467		5 s	23,4217
1:50		25,4794	10 s	22,3872
Sig.	,830	1,000	Sig.	,067

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.19 and Table 4.20 for G1PU2 fabric samples.

Table 4.19 ANOVA values of water vapour resistance (RET) test results (G1PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	15,379	,000	,542
Concentration Rate	6,547	,017	,201
DurationTime	2,795	,107	,097
Chemical * concentration	3,837	,035	,228
Chemical * time	,039	,962	,003
Concentration * time	1,518	,229	,055
Chemical * concentration * time	,168	,847	,013

Table 4.19 is shown that the ANOVA test results of G1PU2 fabric samples water vapour resistance values and it can be seen clearly that,the chemical type (,542) is the more effective factor. Besides, (Table 4.20 a) Acetone and DMF chemicals are similarly influence on the RET values of the G1PU2 fabric samples, whereas ethanol chemical has no statistically effect upon the water vapour resistance differently from other chemical types. According to Table 4.20-b, the concentration rate (1/10, 1/50) and duration time (5 s, 10 s) Tukey statistical test results are obtained close values.

Table 4.20 Tukey values of water vapour resistance (RET) test results (G1PU2)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	27,9333	
Ethanol	28,8792	
DMF		40,5350
Acetone		42,3508
Sig.	,993	,953

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	27,9333		None	27,9333	
1:10	34,5011	34,5011	5 s	35,4556	35,4556
1:50		40,0089	10 s		39,0544
Sig.	,168	,278	Sig.	,101	,569

b

Our findings indicate that, when the coating thickness increase from 0,2 (PU1) to 0,4 (PU2), the water vapour resistance values are also increase.

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.21 and Table 4.22 for G2PU1 fabric samples.

Table 4.21 ANOVA values of water vapour resistance (RET) test results (G2PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	13,051	,000	,501
Concentration Rate	17,603	,000	,404
DurationTime	3,949	,058	,132
Chemical * concentration	8,564	,001	,397
Chemical * time	,339	,715	,025
Concentration * time	5,415	,028	,172
Chemical * concentration * time	,198	,822	,015

From Table 4.21, it can be seen that in general, the chemical type (,501) and concentration rate (,404) have an impact statistical inference on the RET values of G2PU1 fabric samples. Acetone and DMF chemicals are similary effect on the water vapour resistance properties from Table 4.22, but DMF is more influence on the RET values. Furthermore, the concentration rate (1:10) has statistically different effect and also the duration time (10 sec) has an impact on the G2PU1 fabric sample RET values. The most effective process is found that DMF with 1/10 – 10 sec.

Table 4.22 Tukey values of water vapour resistance (RET) test results (G2PU1)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
DMF	22,7917	
Acetone	25,3467	25,3467
Ethanol		27,6825
None		28,7433
Sig.	,208	,057

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
1:10	23,6333		10 s	24,4967	
1:50		26,9139	5 s	26,0506	26,0506
None		28,7433	None		28,7433
Sig.	1,000	,339	Sig.	,454	,108

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.23 and Table 4.24 for G2PU2 fabric samples.

Table 4.23 ANOVA values of water vapour resistance (RET) test results (G2PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	5,836	,008	,310
Concentration Rate	3,730	,064	,125
DurationTime	,607	,443	,023
Chemical * concentration	2,013	,154	,134
Chemical * time	,606	,553	,045
Concentration * time	,312	,581	,012
Chemical * concentration * time	,384	,685	,029

According to the ANOVA results (Table 4.23), the chemical type has more impact statistically on the water vapour resistance properties of G2PU2 fabric samples. From Table 4.24 a-b the chemicals (acetone, DMF, ethanol) concentration rate (1/10, 1/50) and duration time (5 s, 10 s) have statistically significant effect before micro-cracking whereas there is no statistical different effect between them after micro-cracking process.

Table 4.24 Tukey values of water vapour resistance (RET) test results (G2PU2)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
Acetone	33,5317	
DMF	37,6767	
Ethanol	47,1608	47,1608
None		53,4933
Sig.	,080	,650

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
1:10	36,2317		10 s	38,1556	
1:50	42,6811	42,6811	5 s	40,7572	40,7572
None		53,4933	None		53,4933
Sig.	,474	,137	Sig.	,883	,068

b

All the results are evaluated that, G2 fabric samples have more strong effect which is influence on the water vapour resistance after micro-cracking process. When the coating rate increases on the fabric samples, the effect of the micro-cracking process

decreases the water vapour resistance (RET) properties both of denim fabric types (G1 and G2). The most influential micro-cracking process is determined that DMF with 1/10 – 10 sec.

4.1.4 Wicking

All the samples wicking test results are demonstrate in Appendix Table A.3. Fabric samples have been measured the wicking values before PU coating process and after PU coating process. The results are expressed with graphical represantation in Figure 4.13.

As it is expected, (Figure 4.13) the wicking values are substantial decrease after coating process. For G1 fabric samples in PU1 coated thickness, the wicking warp and weft direction values diminish respectively 53.17 %, 44.73 %, in PU2 coated thickness 58.09 %, 53.94 %. For G2 fabric samples in PU1 coated thickness, the wicking warp and weft direction values diminish respectively 50.92 %, 39.19 %, in PU2 coated thickness 53.70 %, 43.24 %.

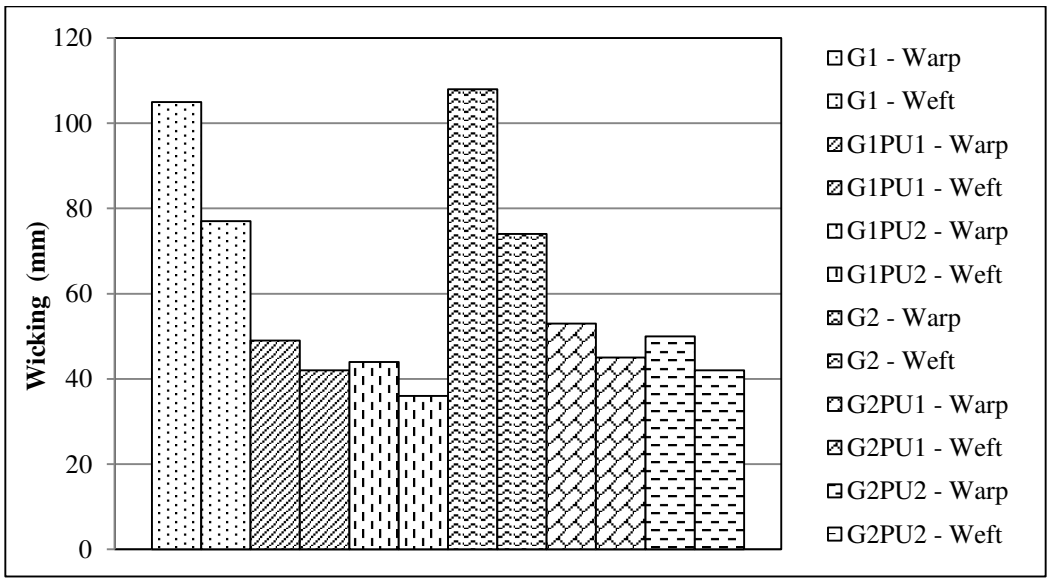


Figure 4.13 Wicking test result before PU coating process and after PU coating process, Warp-Weft

The wicking values (warp and weft directions) of coated fabric samples are shown according to chemical type in (Figure 4.14, Figure 4.15 and Figure 4.16), before micro-cracking and after micro-cracking process.

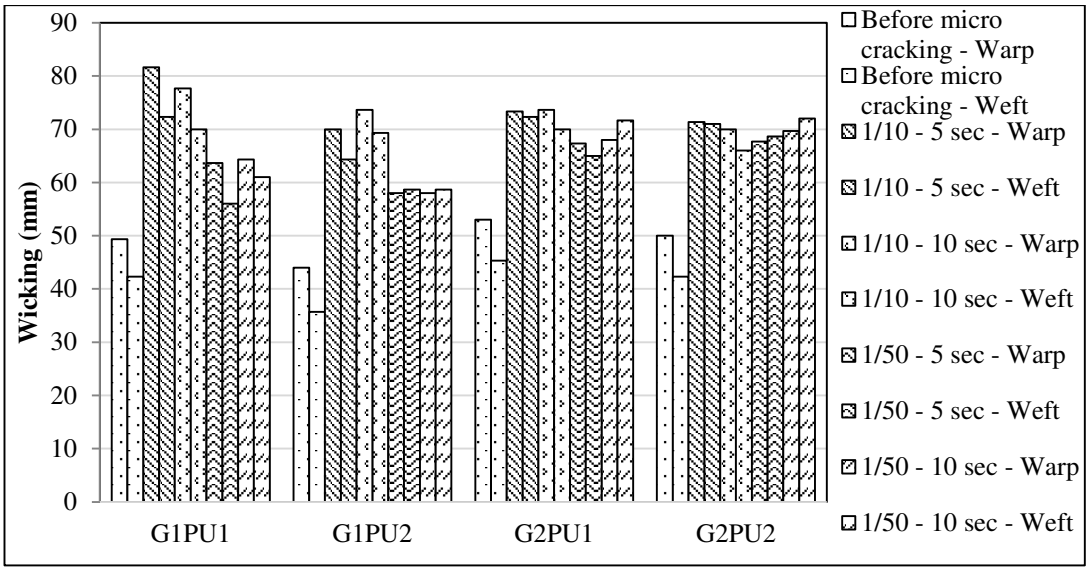


Figure 4.14 Wicking test result after micro-cracking with Acetone, Warp-Weft

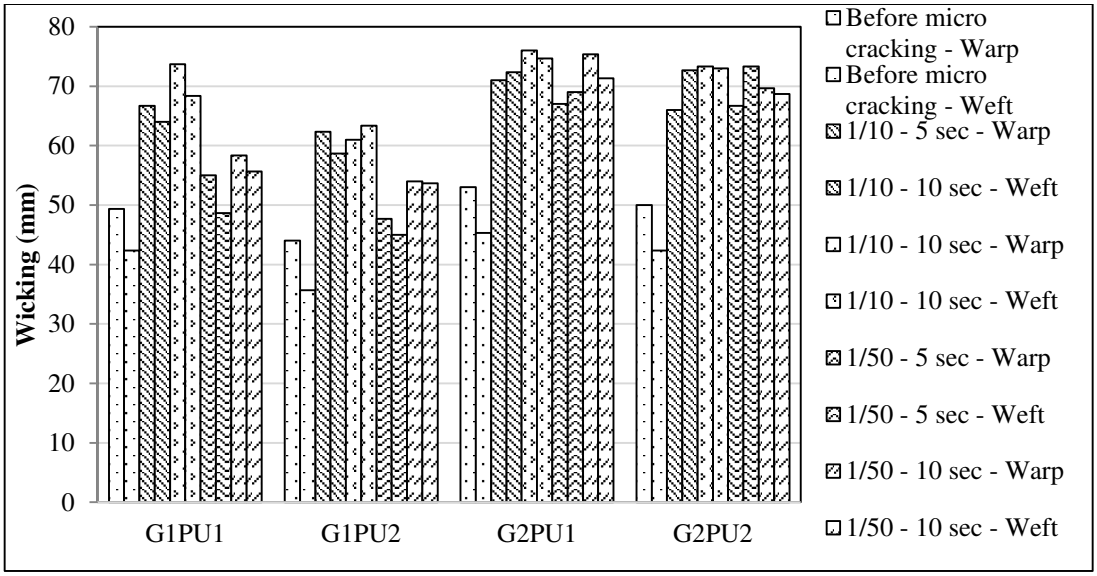


Figure 4.15 Wicking test result after micro-cracking with DMF, Warp-Weft

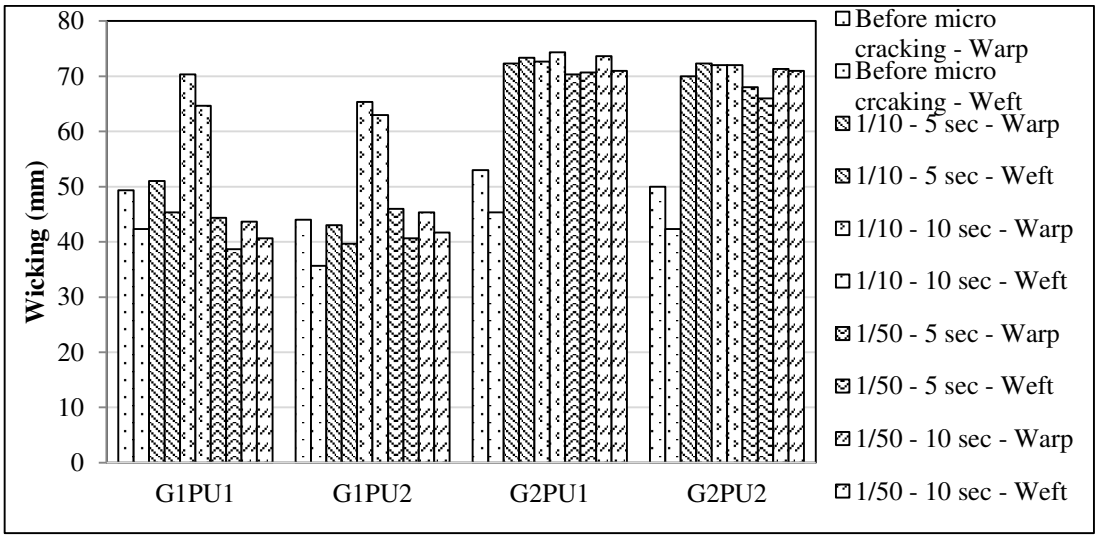


Figure 4.16 Wicking test result after micro-cracking with Ethanol, Warp-Weft

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.25 and Table 4.26 for G1PU1 fabric samples.

Table 4.25 ANOVA values of wicking test results (G1PU1-Warp)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	214,194	,000	,943
Concentration Rate	391,996	,000	,938
DurationTime	30,732	,000	,542
Chemical * concentration	1,467	,249	,101
Chemical * time	17,266	,000	,570
Concentration * time	16,841	,000	,393
Chemical * concentration * time	22,035	,000	,629

According to the ANOVA test results (Table 4.25), the chemical type (,943) the concentration rate (,938) and the duration time (,542) have an impact on the vertical wicking performance of the G1PU1 fabric samples warp direction. The chemical type is exhibited the most significant effect. In addition, interseption of the factors have statistically different effect on the wicking test. Table 4.26 (Tukey) indicated that, acetone, DMF and ethanol have statistically different effect. Furthermore, 1/10 concentration rate has more effective than 1/50 concentration rate and 10 s duration time has more influential than 5 s duration time. On the other hand, the Tukey test (Table 4.26) are illustrated that the most influential chemical is acetone and the most effective concentration rate is 1:10 and also the duration time is 10 sec.

Table 4.26 Tukey values of wicking test results of (G1PU1- Warp)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
None	49,3333		
Ethanol	52,3333		
DMF		63,4167	
Acetone			71,8333
Sig.	,102	1,000	1,000

a

Concentration Rate	Subset			Duration Time	Subset		
	3	2	1		3	2	1
None	49,3333			None	49,3333		
1:50		54,8889		5 s		60,3889	
1:10			70,1667	10 s			64,6667
Sig.	1,000	1,000	1,000	Sig.	1,000	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.27 and Table 4.28 for G1PU1 fabric samples.

Table 4.27 ANOVA values of wicking test results (G1PU1-Weft)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	170,385	,000	,929
Concentration Rate	314,137	,000	,924
DurationTime	55,581	,000	,681
Chemical * concentration	,950	,400	,068
Chemical * time	11,654	,000	,473
Concentration * time	2,394	,134	,084
Chemical * concentration * time	22,933	,000	,638

The results of G1PU1 fabric samples weft direction are exhibited totally harmony with the warp direction of G1PU1 fabric samples. According to the ANOVA test results (Table 4.27), the chemical type (,929) the concentration rate (,924) and the duration time (,681) have an impact on the vertical wicking performance of the G1PU1 fabric samples on the weft direction. Table 4.28 indicated that, acetone, DMF and ethanol have different effect on the G1PU1 fabric samples weft direction. Furthermore, 1/10 concentration rate has more effective than 1/50 concentration rate and 10 s duration time has more influential than 5 s duration time. Besides, the Tukey test (Table 4.28) are illustrated that the most efficient chemical is acetone and the most effective concentration rate is 1:10 and also the duration time is 10 sec.

Table 4.28 Tukey values of wicking test results (G1PU1-Weft)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset			
	4	3	2	1
None	42,3333			
Ethanol		47,3333		
DMF			59,1667	
Acetone				64,8333
Sig.	1,000	1,000	1,000	1,000

a

Concentration Rate	Subset			Duration Time	Subset		
	3	2	1		3	2	1
None	42,3333			None	42,3333		
1:50		50,1111		5 s		54,1667	
1:10			64,1111	10 s			60,0556
Sig.	1,000	1,000	1,000	Sig.	1,000	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.29 and Table 4.30 for G1PU2 fabric samples.

Table 4.29 ANOVA values of wicking test results (G1PU2- Warp)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	143,445	,000	,917
Concentration Rate	231,898	,000	,899
DurationTime	48,492	,000	,651
Chemical * concentration	4,521	,021	,258
Chemical * time	15,905	,000	,550
Concentration * time	19,026	,000	,423
Chemical * concentration * time	38,016	,000	,745

It can be seen clearly from Table 4.29 (ANOVA), the chemical type (,917) the concentration rate (,899) and the duration time (,651) have an effect on the vertical wicking performance of the G1PU2 fabric samples warp direction.

From Tukey (Table 4.30 a-b) test results are indicated that, the chemical type (acetone, DMF, ethanol), the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have statistically different impact on the G1PU2 fabric samples warp direction. Besides, according to Table 4.30 (Tukey) the acetone and 1:10 concentration rate with 10 sec duration time are shown that more impact on the wicking properties of the G1PU2 fabric samples warp direction.

Table 4.30 Tukey values of wicking test results (G1PU2- Warp)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset			
	4	3	2	1
None	44,0000			
Ethanol		49,9167		
DMF			56,2500	
Acetone				64,9167
Sig.	1,000	1,000	1,000	1,000

a

Concentration Rate	Subset			Duration Time	Subset		
	3	2	1		3	2	1
None	44,0000			None	44,0000		
1:50		51,5000		5 s		54,5000	
1:10			62,5556	10 s			59,5556
Sig.	1,000	1,000	1,000	Sig.	1,000	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.31 and Table 4.32 for G1PU2 fabric samples.

Table 4.31 ANOVA values of wicking test results (G1PU2-Weft)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	298,342	,000	,958
Concentration Rate	328,037	,000	,927
DurationTime	165,882	,000	,864
Chemical * concentration	3,371	,050	,206
Chemical * time	25,706	,000	,664
Concentration * time	49,973	,000	,656
Chemical * concentration * time	48,973	,000	,790

According to the ANOVA test results (Table 4.31), the chemical type (,958) the concentration rate (,927) and the duration time (,864) have an effect on the vertical wicking performance. In the same way, G1PU2 fabric samples weft direction influence the micro-cracking process with all types of variations such as the chemical type variations (acetone, DMF, ethanol), the concentration type variations (1/10, 1/50) and the duration time variations (5 s, 10 s). Furthermore, the Tukey test (Table 4.32 a-b) are illustrated that the most influential chemical is acetone and the most influential concentration rate is 1:10 and also the duration time is 10 sec.

Generally, the experimental and statistical results demonstrate that, when the coating rate increase the fabric sample wicking values decrease both warp and weft direction. On the other hand, it can be clearly seen that the results this decrement is increase after the micro-cracking process.

Table 4.32 Tukey values of wicking test results (G1PU2-Weft)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset			
	4	3	2	1
None	35,6667			
Ethanol		46,2500		
DMF			55,1667	
Acetone				62,7500
Sig.	1,000	1,000	1,000	1,000

a

Concentration Rate	Subset			Duration Time	Subset		
	3	2	1		3	2	1
None	35,6667			None	35,6667		
1:50		49,7222		5 s		51,1667	
1:10			59,7222	10 s			58,2778
Sig.	1,000	1,000	1,000	Sig.	1,000	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.33 and Table 4.34 for G2PU1 fabric samples.

Table 4.33 ANOVA values of wicking test results (G2PU1- Warp)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	3,932	,032	,232
Concentration Rate	25,253	,000	,493
DurationTime	27,233	,000	,512
Chemical * concentration	7,406	,003	,363
Chemical * time	10,619	,000	,450
Concentration * time	3,736	,064	,126
Chemical * concentration * time	,682	,515	,050

The obtained ANOVA statistical results (Table 4.33) shown that, the concentration rate (,493) and the duration time (,512) have more statistically effect than the chemical type (,232) on the wicking properties of the G2PU1 fabric samples warp direction. From the Tukey test (Table 4.34), the chemical types have no statistically different effect between each other. Otherwise, the most effective factor is obtained that the concentration rate (1:10) and the duration time (10 sec) on the wicking performance of G2PU1 fabric samples on the warp direction.

Table 4.34 Tukey values of wicking test results (G2PU1- Warp)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	53,0000	
Acetone		70,5833
Ethanol		72,2500
DMF		72,3333
Sig.	1,000	,261

a

Concentration Rate	Subset			Duration Time	Subset		
	3	2	1		3	2	1
None	53,0000			None	53,0000		
1:50		70,2778		5 s		70,2222	
1:10			73,1667	10 s			73,2222
Sig.	1,000	1,000	1,000	Sig.	1,000	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.35 and Table 4.36 for G2PU1 fabric samples.

Table 4.35 ANOVA values of wicking test results (G2PU1-Weft)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	10,459	,000	,446
Concentration Rate	39,013	,000	,600
DurationTime	12,394	,002	,323
Chemical * concentration	,090	,914	,007
Chemical * time	1,174	,325	,083
Concentration * time	8,061	,009	,237
Chemical * concentration * time	10,150	,001	,438

On the basis of the ANOVA results are presented in Table 4.35 it can be seen that, the concentration rate (,600) have more statistically influence than the chemical type (,446) and the duration time (,323) on the wicking performance of G2PU1 fabric samples on the weft direction. From Tukey test results (Table 4.36) it can be clearly seen that, the chemical types are shown different effect among each other (acetone, DMF, ethanol) and have statistically significant effect before micro-cracking but there is no statistical different effect between them after micro-cracking process. The concentration rate 1/10 has more impact than 1/50. Besides, the duration time has no statistically different influence between each other 5 s and 10 s.

Table 4.36 Tukey values of wicking test results (G2PU1-Weft)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
None	45,3333		
Acetone		69,7500	
DMF		71,8333	71,8333
Ethanol			72,3333
Sig.	1,000	,064	,921

a

Concentration Rate	Subset			Duration Time	Subset	
	3	2	1		2	1
None	45,3333			None	45,3333	
1:50		69,7778		5 s		70,4444
1:10			72,8333	10 s		72,1667
Sig.	1,000	1,000	1,000	Sig.	1,000	,098

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.37 and Table 4.38 for G2PU2 fabric samples.

Table 4.37 ANOVA values of wicking test results (G2PU2- Warp)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	1,851	,177	,125
Concentration Rate	7,174	,013	,216
DurationTime	20,481	,000	,441
Chemical * concentration	,111	,895	,008
Chemical * time	5,383	,011	,293
Concentration * time	,009	,927	,000
Chemical * concentration * time	3,642	,040	,219

According to the Table 4.37, the duration time has statistically different effect on the on the wicking performance of G2PU2 fabric samples warp direction.

From the Table 4.38, the chemical types have no statistically different effect among each other. And also, the concentration rate has no different impact between each other. However the duration time (10 sec) is exhibited more influence on the wicking performance.

Table 4.38 Tukey values of wicking test results (G2PU2- Warp)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	50,0000	
DMF		68,9167
Acetone		69,6667
Ethanol		70,3333
Sig.	1,000	,479

a

Concentration Rate	Subset		Duration Time	Subset		
	2	1		3	2	1
None	50,0000		None	50,0000		
1:50		68,8333	5 s		68,2778	
1:10		70,4444	10 s			71,0000
Sig.	1,000	,247	Sig.	1,000	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.39 and Table 4.40 for G2PU2 fabric samples.

Table 4.39 ANOVA values of wicking test results (G2PU2-Weft)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	11,342	,000	,466
Concentration Rate	7,944	,009	,234
DurationTime	,263	,613	,010
Chemical * concentration	13,903	,000	,517
Chemical * time	9,471	,001	,421
Concentration * time	11,096	,003	,299
Chemical * concentration * time	21,683	,000	,625

Based on the ANOVA test results (Table 4.39), it is clear that the chemical type (,466) and the concentration rate (,234) have statistically different effect on the wicking performance of G2PU2 fabric samples the weft direction. As can be seen from (Table 4.40) Tukey test results are indicated that the chemical types have statistically different effect before micro-cracking but there is no statistical different effect between them after micro-cracking process on the G2PU2 fabric samples weft direction. And also the most effective chemical is found that DMF. On the other hand, the concentration rate and the duration time have no statistically different effect each other. Generally, these findings suggest that the wicking values of PU coated denim fabric samples enhance after the micro-cracking process.

Table 4.40 Tukey values of wicking test results (G2PU2-Weft)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
None	42,3333		
Acetone		69,4167	
Ethanol		70,3333	70,3333
DMF			71,9167
Sig.	1,000	,568	,135

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	42,3333		None	42,3333	
1:50		69,9444	5 s		70,6667
1:10		71,1667	10 s		70,4444
Sig.	1,000	,215	Sig.	1,000	,947

b

4.2 Test Results of Coating Performance Related Fabric Properties

4.2.1 Water Resistance

All the samples water resistance test results are demonstrate in Appendix Table A.4. Fabric samples have been measured the water resistance values before PU coating process and after PU coating process. The results are expressed with graphical represantation in Figure 4.17.

It is seen clear from Figure 4.17 that, the water resistance values are increase after the coating process, on G1 fabric samples respectively PU1 3.6 and PU2 4.2 times and on G2 fabric samples respectively PU1 13.3 and PU2 20 times. Besides, this increment generally is shown that the lower weight of fabric samples (G1) and higher coating rate (PU2).

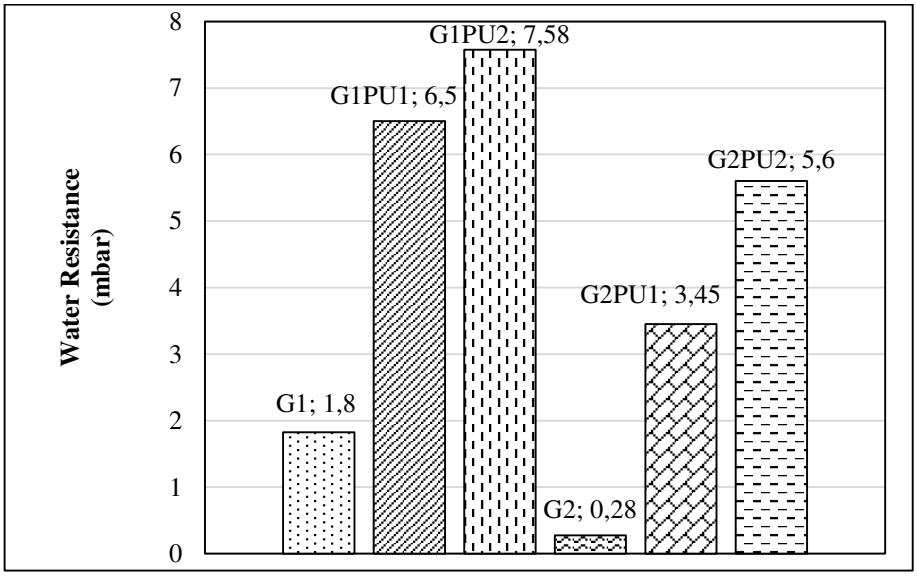
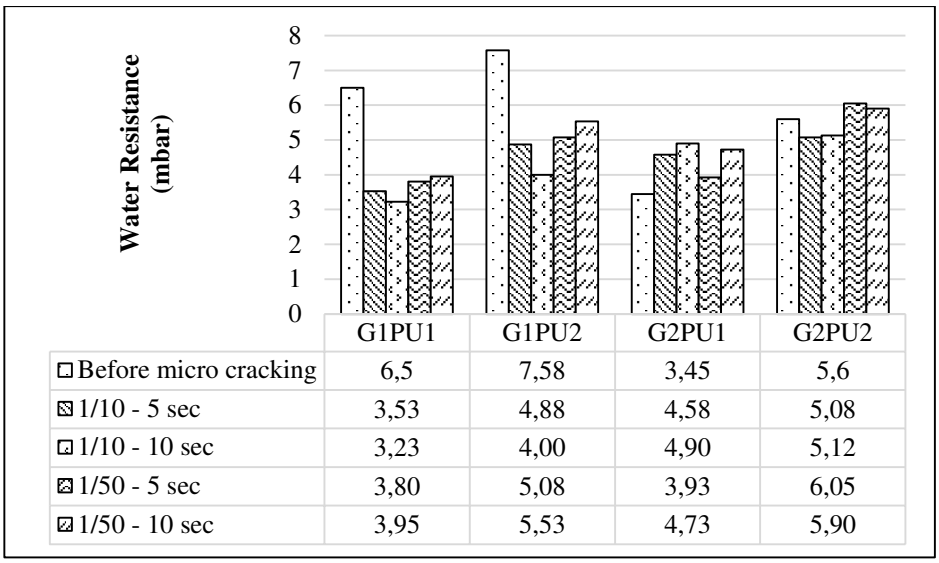


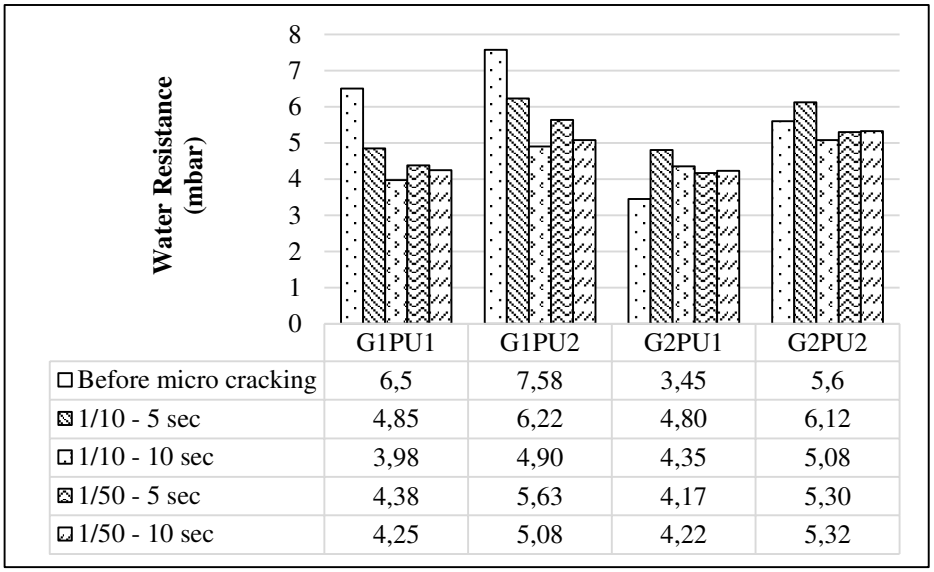
Figure 4.17 Water resistance test result before PU coating process and after PU coating process

The water resistance values of coated fabric samples are shown according to the chemical type in (Figure 4.18, Figure 4.19 and Figure 4.20), before micro-cracking and after micro-cracking process. According to these figures generally, it can be clearly seen that the water resistance values decrease after micro-cracking process but not all sample types.



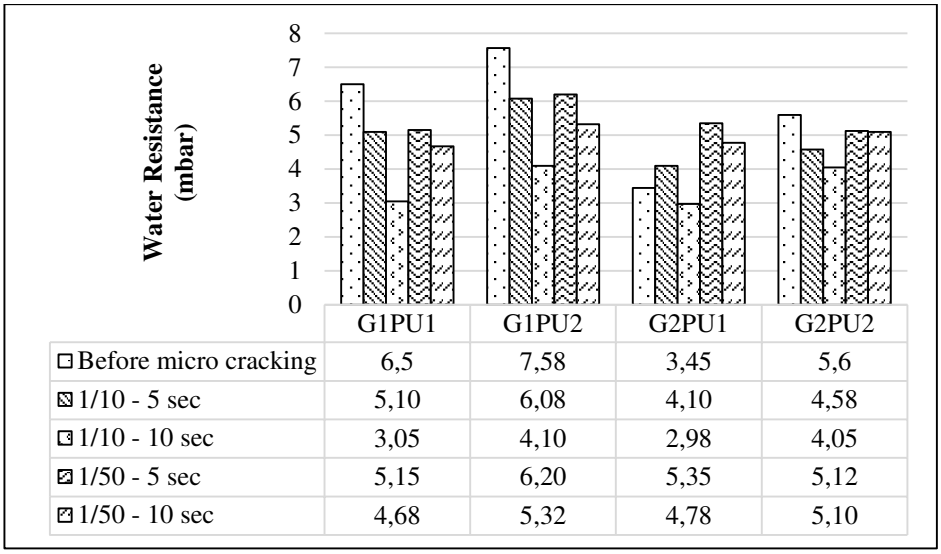
	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	6,5	7,58	3,45	5,6
1/10 - 5 sec	3,53	4,88	4,58	5,08
1/10 - 10 sec	3,23	4,00	4,90	5,12
1/50 - 5 sec	3,80	5,08	3,93	6,05
1/50 - 10 sec	3,95	5,53	4,73	5,90

Figure 4.18 Water resistance test result after micro-cracking with Acetone



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	6,5	7,58	3,45	5,6
1/10 - 5 sec	4,85	6,22	4,80	6,12
1/10 - 10 sec	3,98	4,90	4,35	5,08
1/50 - 5 sec	4,38	5,63	4,17	5,30
1/50 - 10 sec	4,25	5,08	4,22	5,32

Figure 4.19 Water resistance test result after micro-cracking with DMF



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	6,5	7,58	3,45	5,6
1/10 - 5 sec	5,10	6,08	4,10	4,58
1/10 - 10 sec	3,05	4,10	2,98	4,05
1/50 - 5 sec	5,15	6,20	5,35	5,12
1/50 - 10 sec	4,68	5,32	4,78	5,10

Figure 4.20 Water resistance test result after micro-cracking with Ethanol

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.41 and Table 4.42 for G1PU1 fabric samples.

Table 4.41 ANOVA values of water resistance test results (G1PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	11,737	,000	,474
Concentration Rate	5,566	,026	,176
DurationTime	12,523	,002	,325
Chemical * concentration	2,247	,126	,147
Chemical * time	5,312	,012	,290
Concentration * time	7,704	,010	,229
Chemical * concentration * time	,579	,568	,043

According to the ANOVA statistical test results (Table 4.41) the efficient factor is found that the chemical type on the water resistance performance of the G1PU1 fabric samples.

Additionally, acetone has more impact than DMF and ethanol (Table 4.42). So, the water resistance properties of G1PU1 coated denim fabric samples are lower after the micro-cracking process. On the other hand, when the concentration rate (1:10) and the duration time (10 sec) increase, the water resistance properties decrease after micro-cracking process. According to the Tukey test, the statistical defference is obtained before micro-cracking, however there is no statistical difference between

them (1/10, 1/50 and 5 s, 10 s) after micro-cracking process. The water resistance of the G1PU1 fabric samples decrease after the micro-cracking process.

Table 4.42 Tukey values of water resistance test results (G1PU1)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
Acetone	3,6750		
DMF	4,3500	4,3500	
Ethanol		4,5917	
None			6,6667
Sig.	,068	,788	1,000

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
1:10	4,0167		10 s	3,9222	
1:50	4,3944		5 s	4,4889	
None		6,6667	None		6,6667
Sig.	,333	1,000	Sig.	,096	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.43 and Table 4.44 for G1PU2 fabric samples.

Table 4.43 ANOVA values of water resistance test results (G1PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	4,962	,015	,276
Concentration Rate	10,326	,003	,284
DurationTime	43,769	,000	,627
Chemical * concentration	6,763	,004	,342
Chemical * time	2,355	,115	,153
Concentration * time	12,361	,002	,322
Chemical * concentration * time	,978	,390	,070

According to the ANOVA test results (Table 4.43), the duration time have more effective than the other factors on the water resistance of the G1PU2 fabric samples.

The fact remains that, the Table 4.44 (Tukey) explain the chemical types (acetone, DMF, ethanol), the concentration rate (1/10, 1/50) have no statistically different impact among each other. However, the duration time (5 s, 10 s) has statistically different effect each other. On the other hand, generally the micro-cracking process

has statistically different properties comparing to the untreated or no micro-cracking process fabric samples (none).

Table 4.44 Tukey values of water resistance test results (G1PU2)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	**1**
Acetone	4,9583	
Ethanol	5,3917	
DMF	5,4917	
None		7,5667
Sig.	,139	1,000

a

Concentration Rate	Subset		Duration Time	Subset		
	2	**1**		**3**	**2**	**1**
1:10	5,0444		10 s	4,7944		
1:50	5,5167		5 s		5,7667	
None		7,5667	None			7,5667
Sig.	,140	1,000	Sig.	1,000	1,000	1,000

b

The experimental and statistical test results are illustrated that, the coating thickness rate is lower on the fabric surface, in terms of reduction in the water resistance increased the effectiveness of micro-cracking process.

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.45 and Table 4.46 for G2PU1 fabric samples.

Table 4.45 ANOVA values of water resistance test results (G2PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	,797	,461	,058
Concentration Rate	,472	,498	,018
DurationTime	2,249	,146	,080
Chemical * concentration	10,143	,001	,438
Chemical * time	2,234	,127	,147
Concentration * time	2,440	,130	,086
Chemical * concentration * time	,212	,811	,016

Results of ANOVA and Tukey test (Table 4.45 and Table 4.46) are indicated that the chemical type, the concentration rate and the duration times have no statistically different effect on the water resistance of G2PU1 fabric samples. Nevertheless,

intersection of chemical type*concentration rate (,438) has an influence on the water resistance properties of the fabric samples.

Table 4.46 Tukey values of water resistance test results (G2PU1)

Chemical Type	Subset 1	Concentration Rate	Subset 1	Duration Time	Subset 2	Subset 1
None	3,7333	None	3,7333	None	3,7333	
Ethanol	4,2417	1:10	4,3167	10 s	4,2444	4,2444
DMF	4,3750	1:50	4,4389	5 s		4,5111
Acetone	4,5167					
Sig.	,053	Sig.	,056	Sig.	,203	,634

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.47 and Table 4.48 for G2PU2 fabric samples.

Table 4.47 ANOVA values of water resistance test results (G2PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	14,228	,000	,523
Concentration Rate	11,893	,002	,314
DurationTime	8,592	,007	,248
Chemical * concentration	11,686	,000	,473
Chemical * time	1,630	,215	,111
Concentration * time	3,597	,069	,122
Chemical * concentration * time	,559	,578	,041

Based on the statistical results (Table 4.47), it is clear that the chemical type is the more effective factor than other factors (,523) and also, (Table 4.48) ethanol has more influence on the fabric samples compare with acetone and DMF chemicals. On the oher hand, the concentration rate and the duration time have no statistically different effect on the water resistance of the G2PU2 fabric samples.

Table 4.48 Tukey values of water resistance test results (G2PU2)

Chemical Type	Subset 2	Subset 1	Concentration Rate	Subset 1	Duration Time	Subset 1
Ethanol	4,6917		1:10	4,9556	10 s	4,9889
DMF		5,4167	1:50	5,4000	5 s	5,3667
Acetone		5,4250	None	5,4333	None	5,4333
None		5,4333				
Sig.	1,000	1,000	Sig.	,078	Sig.	,107

According to the experimental and statistical results, it can be conclude that generally, the micro-cracking process is influenced the water resistance of the PU coated denim fabric samples, especially thinner coating.

4.2.2 Breaking Strength and Elongation

All the samples breaking strength and elongation test results are demonstrate in Appendix Table A.5. Fabric samples have been measured the breaking strength and elongation values before PU coating process and after PU coating process. The results are expressed with graphical represantation in Figure 4.21 and Figure 4.22.

As it is expected, (Figure 4.21) the breaking strength values are significantly increase not only warp direction but also weft direction both of fabric samples (G1 and G2) after coating process.

As seen in Figure 4.22, the coating process cause to slight decrease on the fabric samples the breaking elongation values. The results would be concluded to the coating polymers are construed on the denim fabric structure and also limited yarn movement of the weave structure.

The breaking strength and elongation values of coated fabric samples are shown according to solvent type in (Figure 4.23, Figure 4.24, Figure 25, Figure 26, Figure 27 and Figure 4.28), before micro-cracking and after micro-cracking process. According to these figures, it can be clearly seen that the breaking strength values and the breaking elongation values no cause to affect negatively after micro-cracking process all the fabric samples.

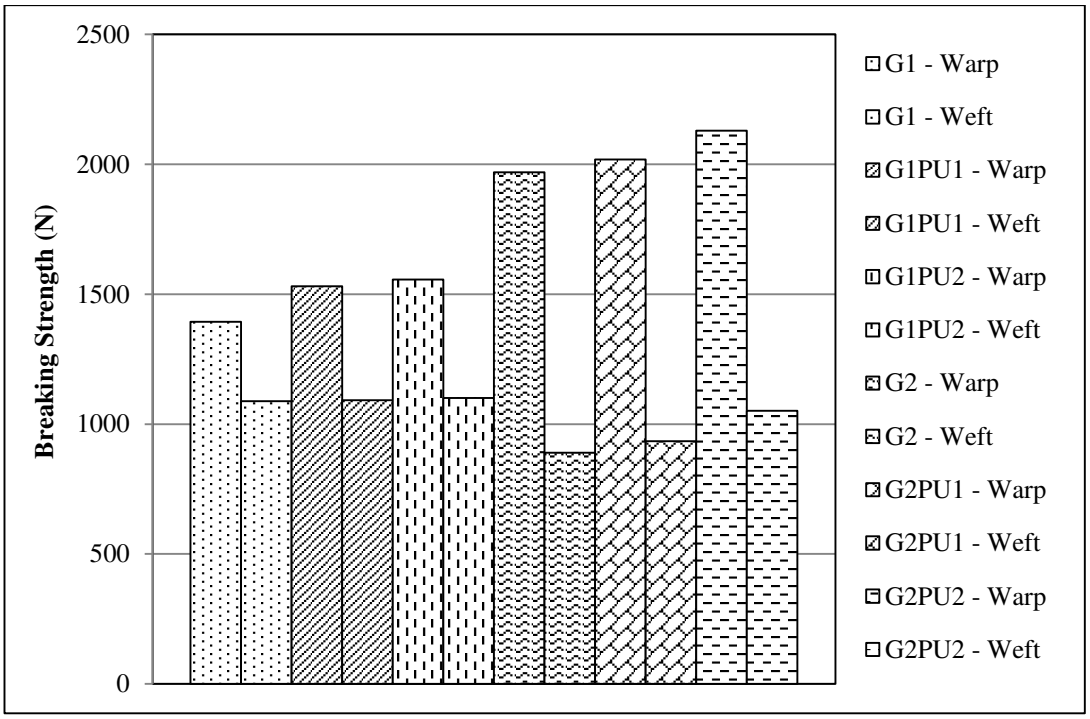


Figure 4.21 Breaking strength test result before PU coating process and after PU coating process, Warp-Weft

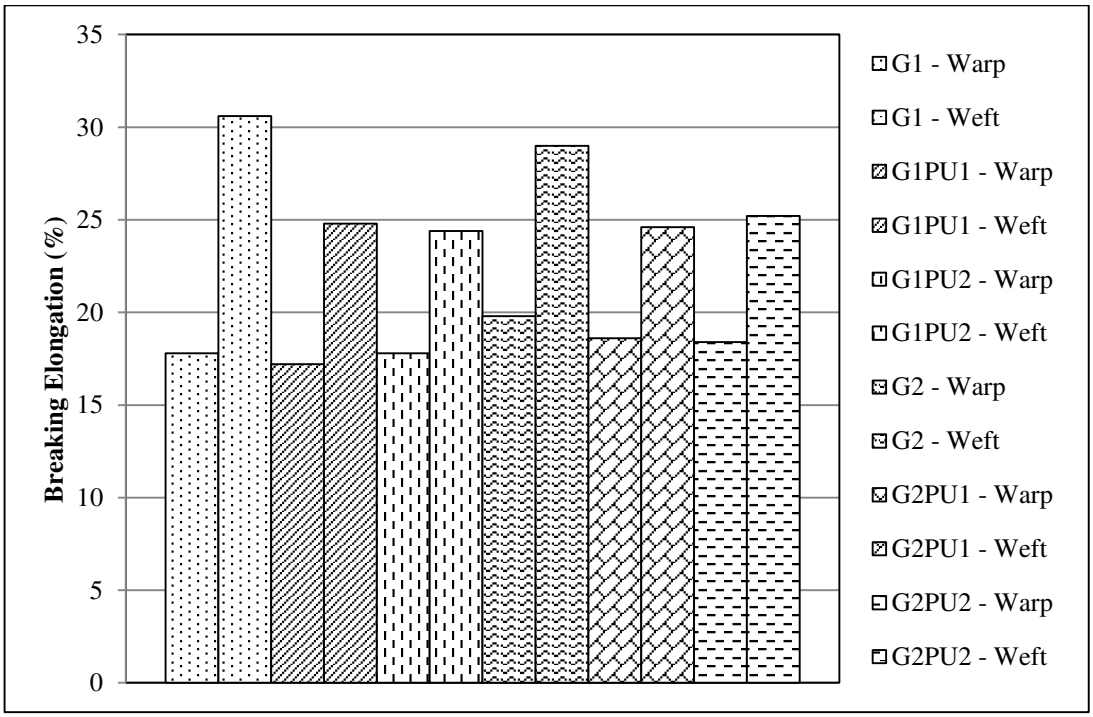


Figure 4.22 Breaking elongation test result before PU coating process and after PU coating process, Warp-Weft

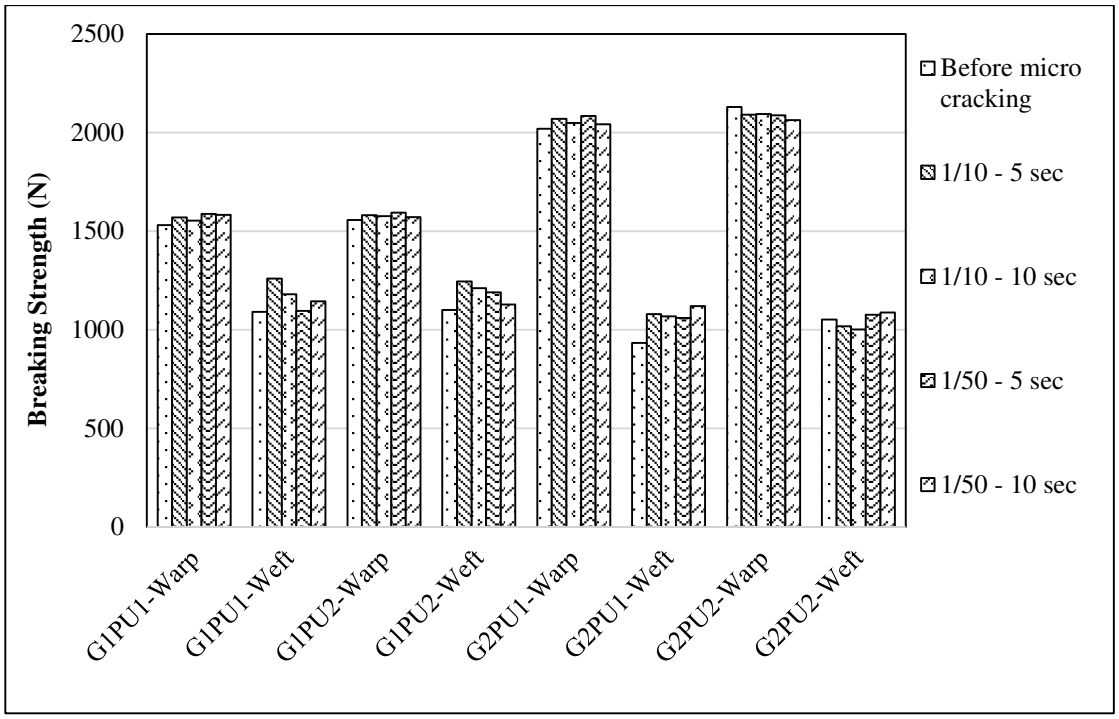


Figure 4.23 Breaking strength test result after micro-cracking with Acetone, Warp-Weft

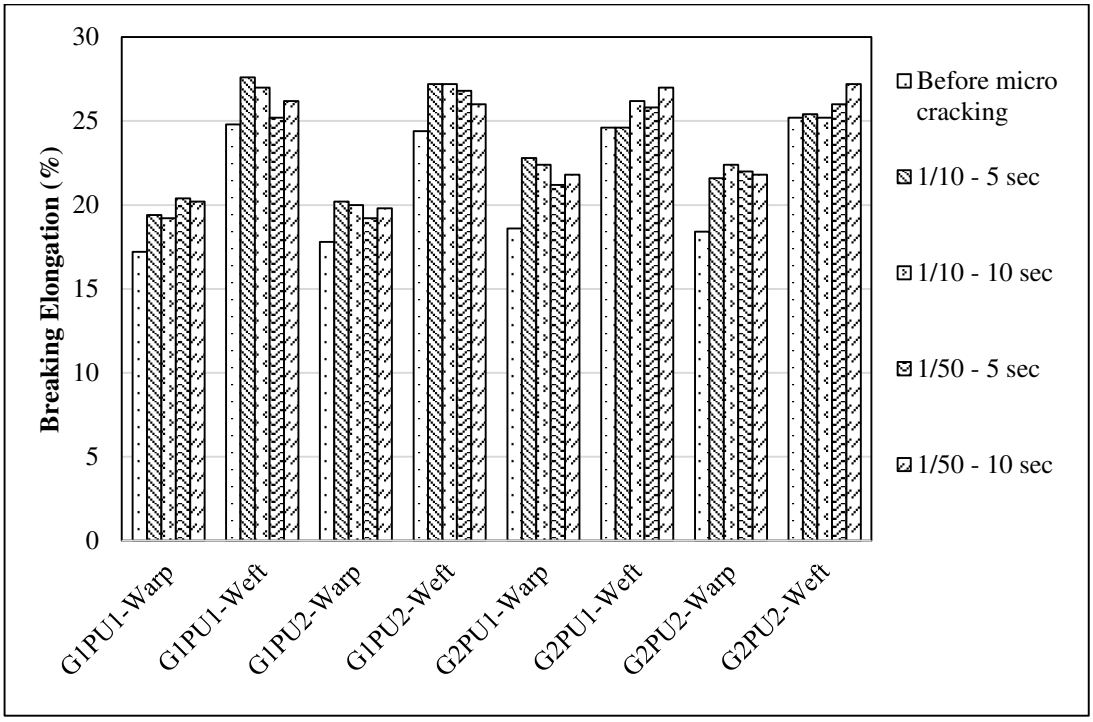


Figure 4.24 Breaking elongation test result after micro-cracking with Acetone, Warp-Weft

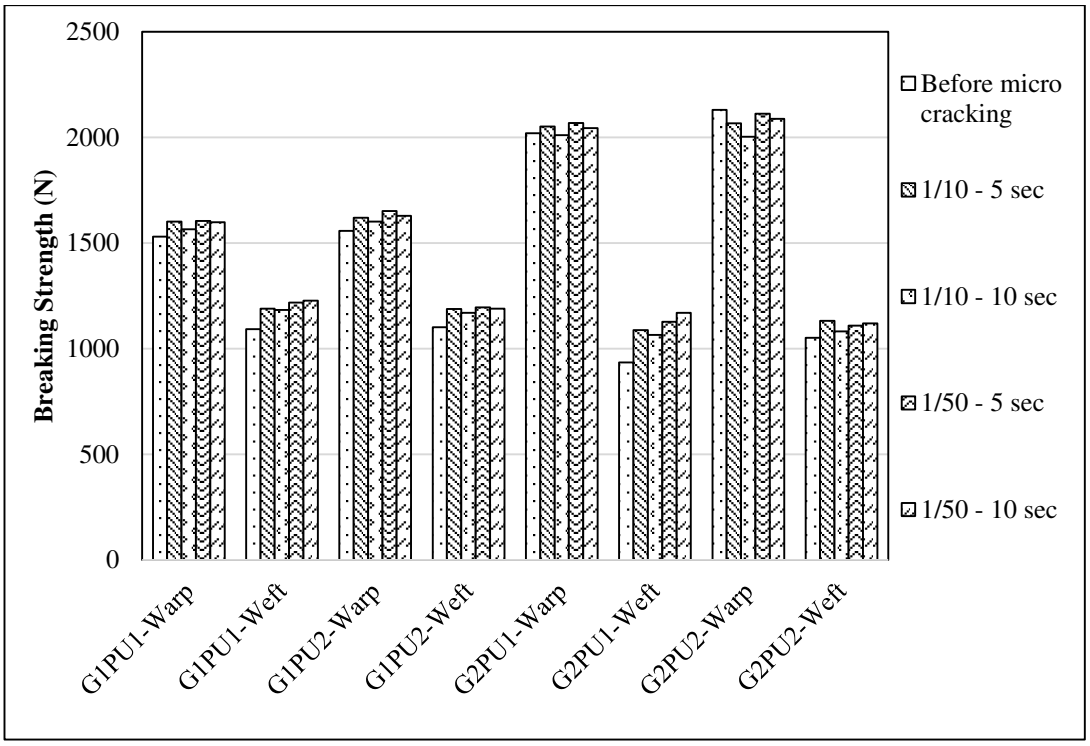


Figure 4.25 Breaking strength test result after micro-cracking with DMF, Warp-Weft

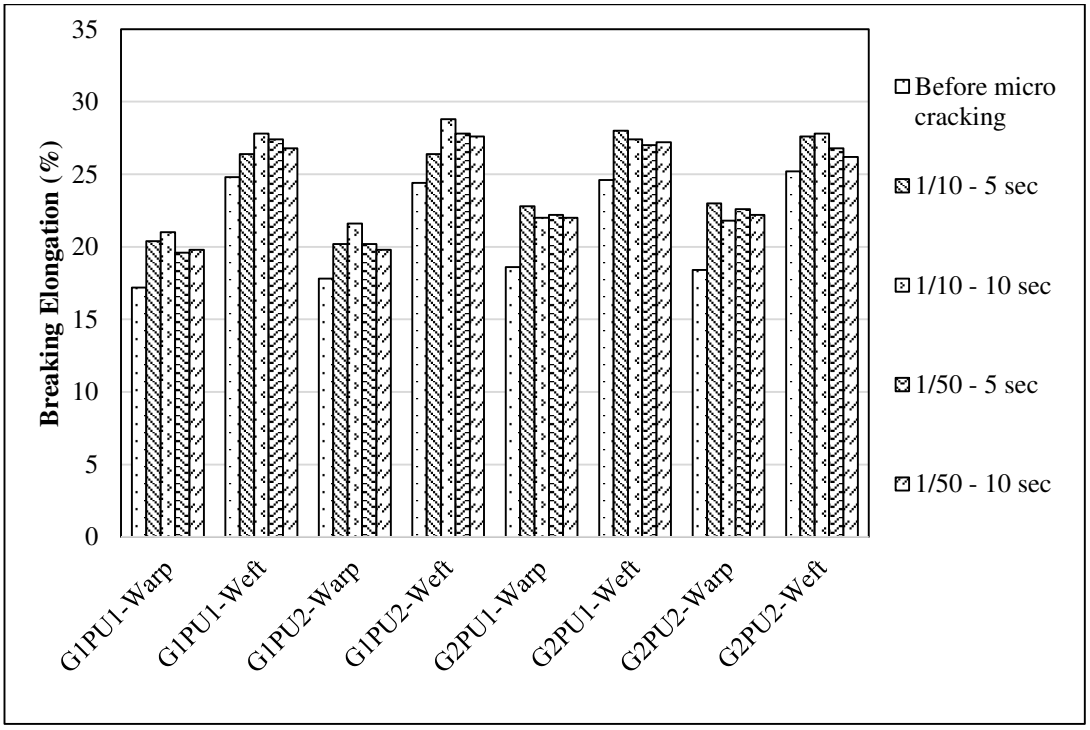


Figure 4.26 Breaking elongation test result after micro-cracking with DMF, Warp-Weft

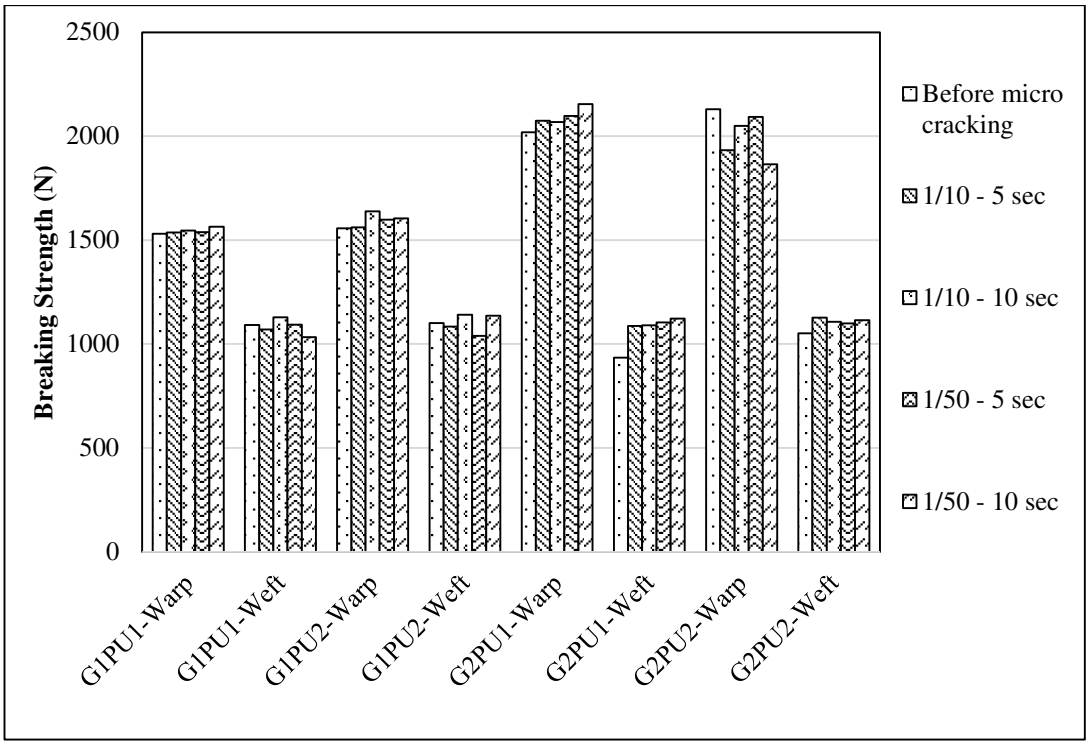


Figure 4.27 Breaking strength test result after micro-cracking with Ethanol, Warp-Weft

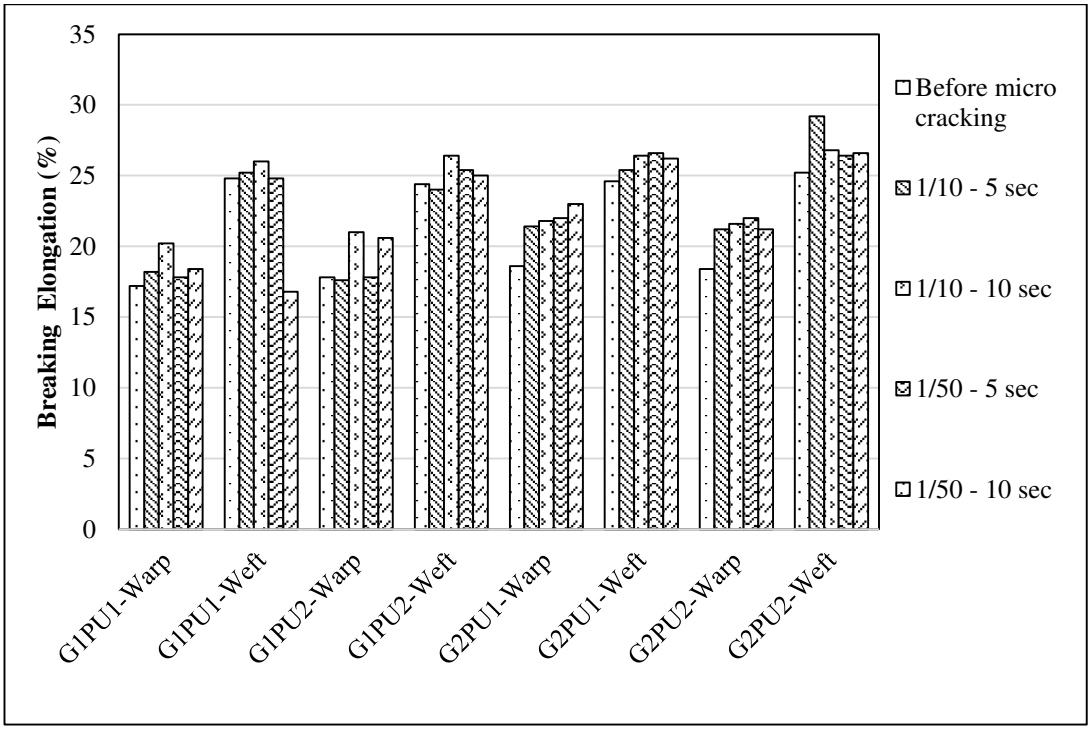


Figure 4.28 Breaking elongation test result after micro-cracking with Ethanol, Warp-Weft

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.49, Table 4.50 and Table 4.51 for G1PU1 fabric samples.

Table 4.49 ANOVA values of breaking strength test results (G1PU1/Warp-Weft)

	Breaking Strength-Warp			**Breaking Strength-Weft**		
Source	**F**	**Sig.**	**Partial Eta Squared**	**F**	**Sig.**	**Partial Eta Squared**
Chemical Type	2,867	,075	,181	19,278	,000	,597
Concentration Rate	,413	,526	,016	6,809	,015	,208
DurationTime	,607	,443	,023	,002	,964	,000
Chemical * concentration	,220	,804	,017	3,270	,054	,201
Chemical * time	,156	,856	,012	,191	,827	,014
Concentration * time	1,071	,310	,040	3,072	,091	,106
Chemical * concentration * time	,061	,941	,005	4,882	,016	,273

As a conclusion of the ANOVA statistical test (Table 4.49), the factors (chemical type, concentration rate, duration time) have no statistically different influence the fabric breaking strength values on the warp direction. However, the chemical type has an impact the fabric breaking strength values on the weft direction. From the Tukey test results (Table 4.50) are supported clearly, the factors have no statistically different impact on the warp direction. However, the chemical types are shown different effect among each other (acetone, DMF, ethanol) and have statistically significant effect before micro-cracking but there is no statistical different effect between them after micro-cracking process. The concentration rate (1/10, 1/50) the duration time (5 s, 10 s) has no statistically different influence between each other on the weft direction (Table 4.51).

Table 4.50 Tukey values of breaking strength test results (G1PU1-Warp)

Chemical Type	**Subset 1**	**Concentration Rate**	**Subset 1**	**Duration Time**	**Subset 1**
Ethanol	1538,1667	None	1539,6667	None	1539,6667
None	1539,6667	1:10	1556,5000	5 s	1569,7778
Acetone	1557,1667	1:50	1568,5000	10 s	1555,2222
DMF	1592,1667				
Sig.	,303	Sig.	,617	Sig.	,591

Table 4.51 Tukey values of breaking strength test results (G1PU1- Weft)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
None	1071,6667		
Ethanol	1090,0000	1090,0000	
Acetone		1159,4167	1159,4167
DMF			1218,0823
Sig.	,907	,077	,165

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	1071,6667		None	1071,6667	
1:50	1133,8333	1133,8333	5 s		1156,2222
1:10		1177,8333	10 s		1155,4444
Sig.	,080	,264	Sig.	1,000	1,000

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.52, Table 4.53 and Table 4.54 for G1PU1 fabric samples.

Table 4.52 ANOVA values of breaking elongation test results (G1PU1/Warp-Weft)

	Breaking Elongation-Warp			Breaking Elongation-Weft		
Source	F	Sig.	Partial Eta Squared	F	Sig.	Partial Eta Squared
Chemical Type	12,199	,000	,484	39,024	,000	,750
Concentration Rate	1,696	,204	,061	40,469	,000	,609
DurationTime	4,710	,039	,153	8,691	,007	,251
Chemical * concentration	11,163	,000	,462	11,580	,000	,471
Chemical * time	3,156	,059	,195	13,313	,000	,506
Concentration * time	,188	,668	,007	20,246	,000	,438
Chemical * concentration * time	,612	,550	,045	19,091	,000	,595

Results of ANOVA test (Table 4.52), the micro-cracking process especially has an influence on the breaking elongation both on the warp direction and the weft direction. The strongest effect is originated from the chemical types on the warp direction (,484) and the weft direction (,750).

It is clear that from the Tukey (Table 4.53 and Table 4.54) the chemical types are shown different effect among each other (acetone, DMF, ethanol) and have statistically significant effect before micro-cracking but there is no statistical

different effect between them after micro-cracking process. Besides, the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have no statistically different effect between the each other on the warp direction.

On the other hand (Table 4.54) according to Tukey test, ethanol is more effective than other chemicals on the weft direction. And also, the concentration time (1/50) has statistically different effect but the duration time (5 s, 10 s) has no statistically different impact on the weft direction. Generally, it can be observed that the micro-cracking process has statistically different properties comparing to the untreated or no micro-cracking process fabric samples (none).

Table 4.53 Tukey values of breaking elongation test results (G1PU1-Warp)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	**Subset**		
	3	**2**	**1**
None	17,3333		
Ethanol		18,7500	
Acetone		19,8333	19,8333
DMF			20,2500
Sig.	1,000	,066	,748

a

Concentration Rate	**Subset**	
	2	**1**
None	17,3333	
1.50		19,4444
1:10		19,7778
Sig.	1,000	,708

Duration Time	**Subset**	
	2	**1**
None	17,3333	
5 s		19,3333
10 s		19,8889
Sig.	1,000	,392

b

Table 4.54 Tukey values of breaking elongation test results (G1PU1-Weft)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	**Subset**		
	3	**2**	**1**
Ethanol	23,5000		
None	25,0000	25,0000	
Acetone		26,4167	26,4167
DMF			27,1667
Sig.	,070	,094	,576

a

Concentration Rate	**Subset**	
	2	**1**
None	25,0000	
1:50	24,5556	
1:10		26,8333
Sig.	,730	1,000

Duration Time	**Subset**
	2
None	25,0000
5 s	26,2222
10 s	25,1667
Sig.	,111

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.55, Table 4.56 and Table 4.57 for G1PU2 fabric samples.

Table 4.55 ANOVA values of breaking strength test results (G1PU2/Warp-Weft)

	Breaking Strength-Warp			**Breaking Strength-Weft**		
Source	**F**	**Sig.**	**Partial Eta Squared**	**F**	**Sig.**	**Partial Eta Squared**
Chemical Type	4,498	,021	,257	3,508	,045	,212
Concentration Rate	,880	,357	,033	2,798	,106	,097
DurationTime	,004	,951	,000	,099	,756	,004
Chemical * concentration	,781	,468	,057	2,369	,114	,154
Chemical * time	3,022	,066	,189	3,187	,058	,197
Concentration * time	4,973	,035	,161	,817	,374	,030
Chemical * concentration * time	,222	,802	,017	1,188	,321	,084

ANOVA statistical analysis results (Table 4.55) are illustrated that, the micro-cracking process has no effect on the breaking strength properties of G1PU2 fabric samples both of warp and weft direction. However, the chemical type is influenced a few breaking strength properties on the warp direction (,257) and the weft direction (,212).

It is concluded that, when the coating rate increases, the micro-cracking process has reduced effect on the breaking strength properties. The fact remains that, the Table 4.56 and Table 4.57 (Tukey) explain the chemical types (acetone, DMF, ethanol), the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have no statistically different influence among each other both of warp and weft direction.

Table 4.56 Tukey values of breaking strength test results (G1PU2-Warp)

Chemical Type	**Subset 1**	**Concentration Rate**	**Subset 1**	**Duration Time**	**Subset 1**
None	1572,3333	None	1572,3333	None	1572,3333
Acetone	1580,2500	1:10	1596,8333	5 s	1603,1111
Ethanol	1601,5833	1:50	1608,6111	10 s	1602,3333
DMF	1626,3333				
Sig.	,061	Sig.	,200	Sig.	,307

Table 4.57 Tukey values of breaking strength test results (G1PU2-Weft)

Chemical Type	Subset 1	Concentration Rate	Subset 2	1	Duration Time	Subset 1
None	1101,3333	None	1101,3333		None	1101,3333
Ethanol	1128,6667	1:50	1149,1667	1149,1667	5 s	1162,6111
Acetone	1183,2500	1:10		1128,2778	10 s	1168,8333
DMF	1185,2500					
Sig.	,066	Sig.	,317	,569	Sig.	,112

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.58, Table 4.59 and Table 4.60 for G1PU2 fabric samples.

Table 4.58 ANOVA values of breaking elongation test results (G1PU2/Warp-Weft)

	Breaking Elongation-Warp			Breaking Elongation-Weft		
Source	**F**	**Sig.**	**Partial Eta Squared**	**F**	**Sig.**	**Partial Eta Squared**
Chemical Type	43,658	,000	,771	17,286	,000	,571
Concentration Rate	27,733	,000	,516	,424	,521	,016
DurationTime	27,733	,000	,516	3,815	,062	,128
Chemical * concentration	1,408	,263	,098	2,967	,069	,186
Chemical * time	14,408	,000	,526	3,815	,035	,227
Concentration * time	21,233	,000	,450	13,612	,001	,344
Chemical * concentration * time	8,558	,001	,397	,612	,550	,045

The ANOVA test (Table 4.58) are shown that, the breaking elongation of G1PU2 fabric samples on the warp direction affected by the chemical type (,771), the concentration rate (,516) and the duration time (,516). From the Tukey test (Table 4.59) explains, acetone and DMF are more influence than ethanol. Besides, the concentration rate (1/10) and the duration time (10 sec) have an impact on the breaking elongation of G1PU2 fabric samples warp direction. On the other hand, The strongest influence is originated from the chemical types on the weft direction (,571).

Tukey test results (Table 4.60) are indicated that, acetone and DMF are more influence than ethanol on the breaking elongation of G1PU2 fabric samples weft direction. Besides, the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have statistically significant effect before micro-cracking but there is no statistical different effect between them after micro-cracking process.

Table 4.59 Tukey values of breaking elongation test results (G1PU2-Warp)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
None	17,6667		
Ethanol		18,5833	
Acetone			19,7500
DMF			20,5000
Sig.	1,000	1,000	,050

a

Concentration Rate	Subset			Duration Time	Subset		
	3	2	1		3	2	1
None	17,6667			None	17,6667		
1:50		19,1667		5 s		19,1667	
1:10			20,0556	10 s			20,0556
Sig.	1,000	1,000	1,000	Sig.			

b

Table 4.60 Tukey values of breaking elongation test results (G1PU2-Weft)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset		
	3	2	1
None	24,6667		
Ethanol	25,6667	25,6667	
Acetone		26,7500	26,7500
DMF			27,5000
Sig.	1,000	,066	,292

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	24,6667		None	24,6667	
1.50		26,5556	5 s		26,3889
1:10		26,7222	10 s		26,8889
Sig.	1,000	,916	Sig.	1,000	,466

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.61, Table 4.62 and Table 4.63 for G2PU1 fabric samples.

According to the ANOVA test results (Table 4.61), G2PU1 fabric samples have no statistically different effect on the breaking strength properties both of the warp and weft direction.

Table 4.61 ANOVA values of breaking strength test results (G2PU1/Warp-Weft)

	Breaking Strength- Warp			**Breaking Strength- Weft**		
Source	**F**	**Sig.**	**Partial Eta Squared**	**F**	**Sig.**	**Partial Eta Squared**
Chemical Type	,654	,528	,048	,717	,498	,052
Concentration Rate	,199	,659	,008	3,781	,063	,127
DurationTime	1,759	,196	,063	1,836	,187	,066
Chemical * concentration	1,212	,314	,085	,258	,775	,019
Chemical * time	,211	,811	,016	,012	,988	,001
Concentration * time	1,110	,302	,041	,143	,708	,005
Chemical * concentration * time	,608	,552	,045	,030	,970	,002

From the Tukey test (Table 4.62) accurately explains, there is no statistically different effect on the breaking strength on warp direction. However, the chemical type (acetone, DMF, ethanol) the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have no statistically different effect between the each other. However it can be observed that generally, the micro-cracking process has statistically different properties comparing to the untreated or no micro-cracking process fabric samples (none).

From the Tukey test (Table 4.63) the chemical types (acetone, DMF, ethanol) have statistically significant effect before micro-cracking but there is no statistical different effect between them after micro-cracking process. Besides, the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have no statistically different effect between the each other on the weft direction after micro-cracking process.

Table 4.62 Tukey values of breaking strength test results (G2PU1-Warp)

Chemical Type	**Subset 1**	**Concentration Rate**	**Subset 1**	**Duration Time**	**Subset 1**
None	2009,6667	None	2009,6667	None	2009,6667
Acetone	2046,0000	1:10	2055,6111	5 s	2089,1667
DMF	2051,6667	1:50	2072,5000	10 s	2038,9444
Ethanol	2094,5000				
Sig.	,521	Sig.	,573	Sig.	,416

Table 4.63 Tukey values of breaking strength test results (G2PU1-Weft)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	1
None	920,6667	
Acetone		1089,5000
Ethanol		1102,7500
DMF		1118,5000
Sig.		,803

a

Concentration Rate	Subset		Duration Time	Subset	
	2	1		2	1
None	920,6667		None	920,6667	
1:10		1084,3333	5 s		1090,1667
1:50		1122,8333	10 s		1117,0000
Sig.	1,000	,469	Sig.	1,000	,688

b

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.64, Table 4.65 and Table 4.66 for G2PU1 fabric samples.

Table 4.64 ANOVA values of breaking elongation test results (G2PU1/Warp-Weft)

	Breaking Elongation-Warp			Breaking Elongation-Weft		
Source	F	Sig.	Partial Eta Squared	F	Sig.	Partial Eta Squared
Chemical Type	,261	,772	,020	5,845	,008	,310
Concentration Rate	,934	,343	,035	,813	,376	,030
DurationTime	,934	,343	,035	3,250	,083	,111
Chemical * concentration	6,537	,005	,335	,880	,427	,063
Chemical * time	2,279	,122	,149	1,286	,293	,090
Concentration * time	3,026	,094	,104	3,250	,083	,111
Chemical * concentration * time	,336	,718	,025	,203	,817	,015

According to the ANOVA test results (Table 4.64), G2PU1 fabric samples have no statistically different effect on the breaking elongation properties the warp direction but, the chemical types (,310) influence the breaking elongation properties the weft direction. From the Tukey test (Table 4.65 and Table 4.66) accurately explains, the chemical type (acetone, DMF, ethanol) the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have no statistically different effect both of the warp and weft direction. However it can be observed that generally, the micro-cracking

process has statistically different properties comparing to the untreated or no micro-cracking process fabric samples (none).

Table 4.65 Tukey values of breaking elongation test results (G2PU1-Warp)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	Subset	
	2	**1**
None	18,3333	
Acetone		22,0000
DMF		22,1667
ethanol		22,2500
Sig.	1,000	,949

a

Concentration Rate	Subset		Duration Time	Subset	
	2	**1**		**2**	**1**
None	18,3333		None	18,3333	
1:50		22,0000	5 s		22,2778
1:10		22,2778	10 s		22,0000
Sig.	1,000	,826	Sig.	1,000	,826

b

Table 4.66 Tukey values of breaking elongation test results (G2PU1-Weft)

Chemical Type	Subset		Concentration Rate	Subset	Duration Time	Subset	
	2	**1**		**1**		**2**	**1**
None	25,3333		None	25,3333	None	25,3333	
Ethanol	26,0833	26,0833	1:10	26,4444	5 s	26,2778	26,2778
Acetone	26,2500	26,2500	1:50	26,7778	10 s		26,9444
DMF		27,5000					
Sig.	,435	,109	Sig.	,061	Sig.	,279	,520

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.67, Table 4.68 and Table 4.69 for G2PU2 fabric samples.

Table 4.67 ANOVA values of breaking strength test results (G2PU2/Warp-Weft)

	Breaking Strength-Warp			**Breaking Strength-Weft**		
Source	**F**	**Sig.**	**Partial Eta Squared**	**F**	**Sig.**	**Partial Eta Squared**
Chemical Type	3,197	,057	,197	1,877	,173	,126
Concentration Rate	,181	,674	,007	,500	,486	,019
DurationTime	,609	,442	,023	1,872	,183	,067
Chemical * concentration	1,310	,287	,092	,809	,456	,059
Chemical * time	,114	,893	,009	,204	,817	,015
Concentration * time	3,102	,090	,107	,249	,622	,009
Chemical * concentration * time	1,163	,328	,082	,094	,911	,007

According to the ANOVA test results (Table 4.67), G2PU2 fabric samples have no statistically different effect on the breaking strength properties both of the warp and weft direction. From the Tukey test (Table 4.68 and Table 4.69) accurately explains, the chemical type (acetone, DMF, ethanol) the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have no statistically different effect on the warp and weft direction.

Table 4.68 Tukey values of breaking strength test results (G2PU2-Warp)

Chemical Type	**Subset 1**	**Concentration Rate**	**Subset 1**	**Duration Time**	**Subset 1**
Ethanol	2006,4167	None	2133,6667	None	2133,6667
DMF	2035,9167	1:10	2054,8333	5 s	2060,4444
Acetone	2102,0000	1:50	2041,3889	10 s	2035,7778
None	2133,6667				
Sig.	,086	Sig.	,193	Sig.	,160

Table 4.69 Tukey values of breaking strength test results (G2PU2-Weft)

Chemical Type	**Subset 1**	**Concentration Rate**	**Subset 1**	**Duration Time**	**Subset 2**
None	1049,3333	None	1049,3333	None	1049,3333
Acetone	1076,0833	1:10	1094,2778	5 s	1113,1111
DMF	1109,9167	1:50	1107,1111	10 s	1088,2778
Ethanol	1116,0833				
Sig.	,131	Sig.	,145	Sig.	,099

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.70, Table 4.71 and Table 4.72 for G2PU2 fabric samples.

Table 4.70 ANOVA values of breaking elongation test results (G2PU2/Warp-Weft)

	Breaking Elongation-Warp			**Breaking Elongation-Weft**		
Source	**F**	**Sig.**	**Partial Eta Squared**	**F**	**Sig.**	**Partial Eta Squared**
Chemical Type	4,750	,017	,268	4,929	,015	,275
Concentration Rate	,750	,394	,028	4,387	,046	,144
DurationTime	,750	,394	,028	,487	,491	,018
Chemical * concentration	,750	,482	,055	20,637	,000	,614
Chemical * time	1,750	,194	,119	6,337	,006	,328
Concentration * time	4,083	,054	,136	1,354	,255	,050
Chemical * concentration * time	,083	,920	,006	6,879	,004	,346

According to the ANOVA test results (Table 4.71), the chemical types have statistically different effect on the breaking elongation properties both of the warp direction (,268) and weft direction (,275).

From the Tukey test (Table 4.71 and Table 4.72) explains, the chemical type (acetone, DMF, ethanol) the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have statistically significant effect before micro-cracking but there is no statistically different effect between them after micro-cracking process. Other words it can be observed, the micro-cracking process has statistically different properties comparing to the untreated or no micro-cracking process fabric samples (none).

Table 4.71 Tukey values of breaking elongation test results (G2PU2-Warp)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	**Subset**	
	2	**1**
None	18,6667	
Ethanol		21,5000
Acetone		22,0833
DMF		22,1667
Sig.	1,000	,168

a

Concentration Rate	**Subset**		**Duration Time**	**Subset**	
	2	**1**		**2**	**1**
None	18,6667		None	18,6667	
1:50		21,8333	5 s		22,0000
1:10		22,0000	10 s		21,8333
Sig.	1,000	,857	Sig.	1,000	,857

b

Table 4.72 Tukey values of breaking elongation test results (G2PU2-Weft)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	**Subset**	
	2	**1**
None	25,0000	
Acetone		26,3333
DMF		27,0833
Ethanol		27,1667
Sig.	1,000	,163

a

Concentration Rate	**Subset**		**Duration Time**	**Subset**	
	2	**1**		**2**	**1**
None	25,0000		None	25,0000	
1:50		26,6111	5 s		26,9444
1:10		27,1111	10 s		26,7778
Sig.	1,000	,417	Sig.	1,000	,905

b

4.2.3 Abrasion Resistance

All the samples abrasion resistance test results are demonstrate in Appendix Table A.6. Fabric samples have been measured the abrasion resistance values before PU coating process and after PU coating process. The results are expressed with graphical represantation in Figure 4.29.

As it is expected, (Figure 4.29) the abrasion resistance of the fabrics increase after the coating process with comparing before the coating process.In this scope of the study, the change of the fabric abrasion were performed with Martindale Abrasion tester and the fabric properties were evaluated according to mass loss (%) after 10.000 cycles.

Figure 4.29 illustrates that, mass loss decreases after coating process on G1 fabric samples respectively 2.5 - 3 times and on G2 fabric samples respectively 2.2 - 2.8 times. When the coating rate increase, the fabric abrasion resistance also increase.

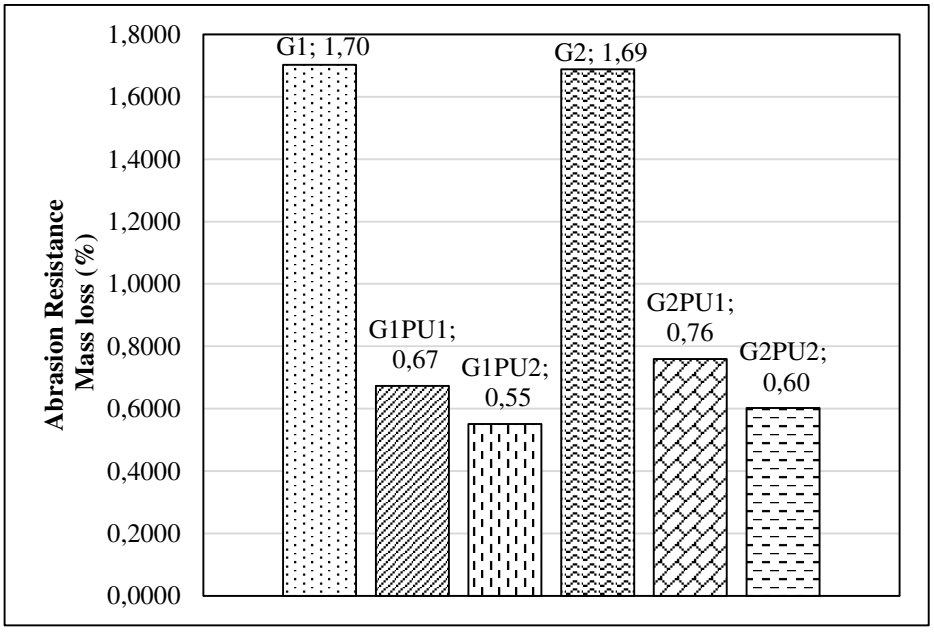
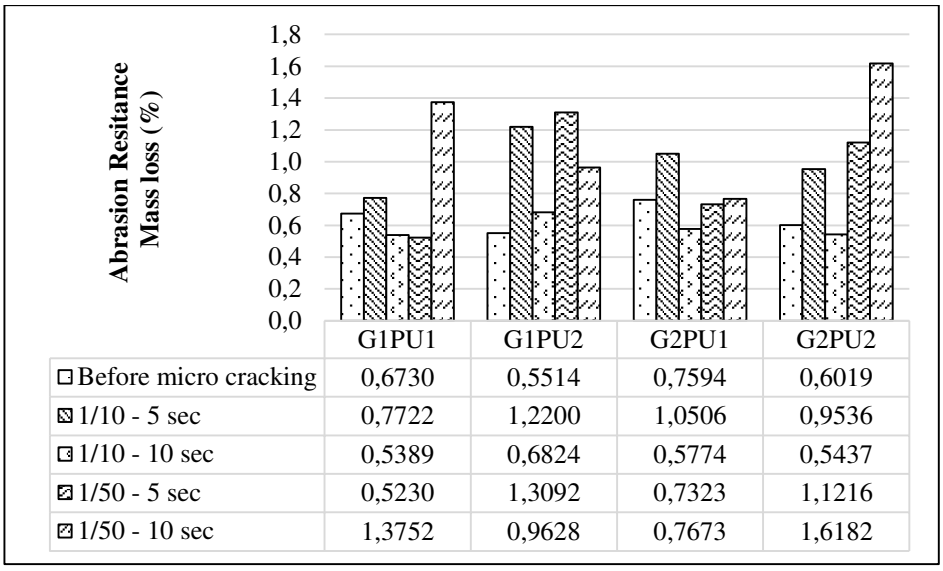


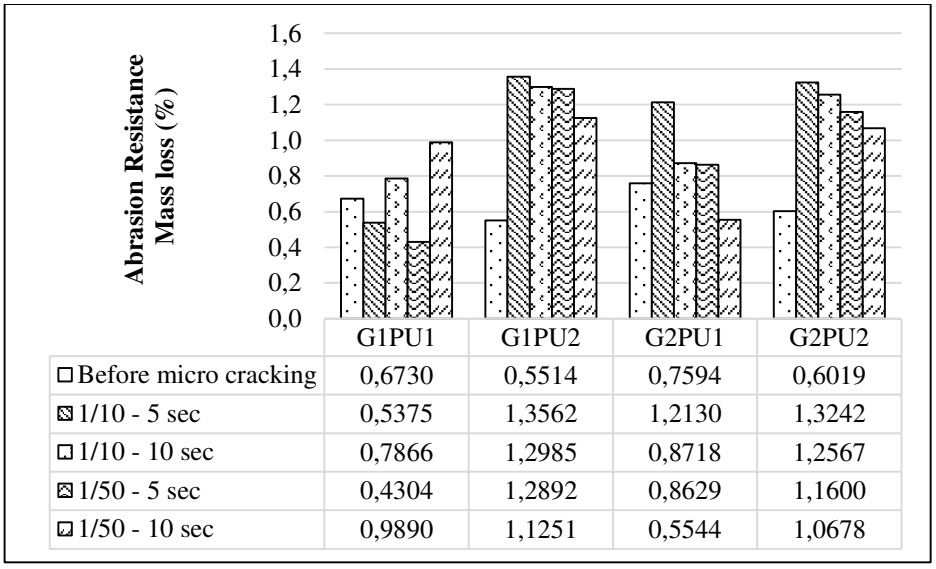
Figure 4.29 Abrasion resistance test result before PU coating process and after PU coating process

The abrasion resistance values of coated fabric samples are shown according to chemical type in (Figure 4.30, Figure 4.31 and Figure 4.32), before micro-cracking and after micro-cracking process.



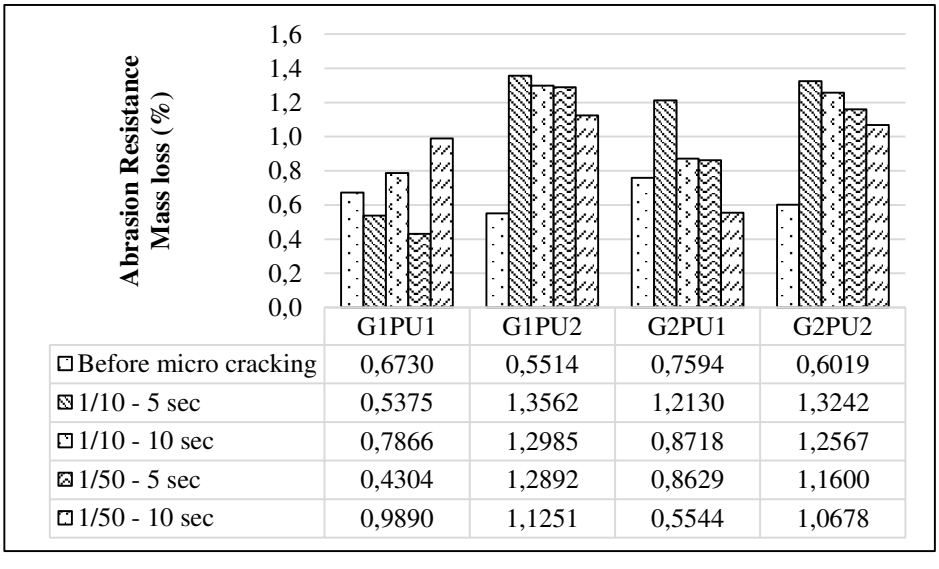
	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	0,6730	0,5514	0,7594	0,6019
1/10 - 5 sec	0,7722	1,2200	1,0506	0,9536
1/10 - 10 sec	0,5389	0,6824	0,5774	0,5437
1/50 - 5 sec	0,5230	1,3092	0,7323	1,1216
1/50 - 10 sec	1,3752	0,9628	0,7673	1,6182

Figure 4.30 Abrasion resistance test result after micro-cracking with Acetone



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	0,6730	0,5514	0,7594	0,6019
1/10 - 5 sec	0,5375	1,3562	1,2130	1,3242
1/10 - 10 sec	0,7866	1,2985	0,8718	1,2567
1/50 - 5 sec	0,4304	1,2892	0,8629	1,1600
1/50 - 10 sec	0,9890	1,1251	0,5544	1,0678

Figure 4.31 Abrasion resistance test result after micro-cracking with DMF



	G1PU1	G1PU2	G2PU1	G2PU2
Before micro cracking	0,6730	0,5514	0,7594	0,6019
1/10 - 5 sec	0,5375	1,3562	1,2130	1,3242
1/10 - 10 sec	0,7866	1,2985	0,8718	1,2567
1/50 - 5 sec	0,4304	1,2892	0,8629	1,1600
1/50 - 10 sec	0,9890	1,1251	0,5544	1,0678

Figure 4.32 Abrasion resistance test result after micro-cracking with Ethanol

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.73 and Table 4.74 for G1PU1 fabric samples.

Table 4.73 ANOVA values of abrasion resistance test results (G1PU1)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	13,195	,000	,504
Concentration Rate	2,582	,120	,092
DurationTime	6,644	,016	,204
Chemical * concentration	14,916	,000	,534
Chemical * time	4,068	,029	,238
Concentration * time	7,931	,009	,234
Chemical * concentration * time	4,837	,016	,271

According to the ANOVA test results (Table 4.73) the most effective factor is obtained that the chemical type (,504) on the G1PU1 fabric samples. From the Tukey test (Table 4.74) is explained DMF is less influence than acetone and ethanol on the abrasion resistance properties of the G1PU1 fabric samples. In addition to the concentration rate and duration time have no statistically different effect on the abrasion resistance of G1PU1 fabric samples.

Table 4.74 Tukey values of abrasion resistance test results (G1PU1)

Chemical Type	Subset 2	Subset 1	Concentration Rate	Subset 1	Duration Time	Subset 1
Ethanol	,7150		None	,7867	None	,7867
None	,7867		1:10	,9528	5 s	,8067
Acetone	,8342	,8342	1:50	,8406	10 s	,9867
DMF		1,1408				
Sig.	,720	,054	Sig.	,328	Sig.	,205

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.75 and Table 4.76 for G1PU2 fabric samples.

Table 4.75 ANOVA values of abrasion resistance test results (G1PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	5,528	,010	,298
Concentration Rate	1,368	,253	,050
DurationTime	36,140	,000	,582
Chemical * concentration	2,710	,085	,173
Chemical * time	9,662	,001	,425
Concentration * time	1,587	,219	,058
Chemical * concentration * time	,974	,391	,070

According to Table 4.75 (ANOVA), the duration time is the most effect on the G1PU2 fabric samples. The abrasion resistance of G1PU2 fabric sample properties a little change after micro-cracking process. From the Tukey test results (Table 4.76) are shown that the chemical type (acetone, DMF, ethanol) and concentration rate (1/10, 1/50) have no statistically different effect between each other on the abrasion resistance of G1PU2 fabric samples. However, the duration time (5 s, 10 s) has statistically different effect on the G1PU2 fabric samples.

Table 4.76 Tukey values of abrasion resistance test results (G1PU2)
(a;chemical type, b;concentration rate and duration time)

Chemical Type	**Subset**	
	2	**1**
None	,6000	
Acetone		1,0675
DMF		1,2608
Ethanol		1,3033
Sig.	1,000	,111

a

Concentration Rate	**Subset**		**Duration Time**	**Subset**		
	2	**1**		**3**	**2**	**1**
None	,6000		None	,6000		
1:10		1,1744	5 s		1,3961	
1:50		1,2467	10 s			1,0250
Sig.	1,000	,756	Sig.	1,000	1,000	1,000

b

Generally, it can be concluded that, the coating rate (PU1 and PU2) are exhibited that different properties after the micro-cracking process.

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.77 and Table 4.78 for G2PU1 fabric samples.

Table 4.77 ANOVA values of abrasion resistance test results (G2PU1)

Source	**F**	**Significance (P)**	**Partial Eta Squared**
Chemical Type	1,839	,179	,124
Concentration Rate	3,117	,089	,107
DurationTime	2,184	,151	,077
Chemical * concentration	21,228	,000	,620
Chemical * time	3,052	,064	,190
Concentration * time	6,907	,014	,210
Chemical * concentration * time	,779	,469	,057

According to the ANOVA test results (Table 4.77), G2PU1 fabric samples have no statistically different effect on the abrasion rasistance. From the Tukey test (Table 4.78) accurately explains, there is no statistically different effect between each other.

Table 4.78 Tukey values of abrasion resistance test results (G2PU1)

Chemical Type	Subset 1	Concentration Rate	Subset 1	Time	Subset 1
Acetone	,8158	1:10	,8361	10 s	,8461
None	,8933	None	,8933	None	,8933
Ethanol	,8975	1:50	,9589	5 s	,9489
DMF	,9792				
Sig.	,481	Sig.	,534	Sig.	,642

Statistical analysis (ANOVA and Tukey) test values are given in Table 4.79 and Table 4.80 for G2PU2 fabric samples.

Table 4.79 ANOVA values of abrasion resistance test results (G2PU2)

Source	F	Significance (P)	Partial Eta Squared
Chemical Type	2,132	,139	,141
Concentration Rate	7,465	,011	,223
DurationTime	1,778	,194	,064
Chemical * concentration	10,926	,000	,457
Chemical * time	3,275	,054	,201
Concentration * time	5,258	,030	,168
Chemical * concentration * time	3,567	,043	,215

Table 4.79 shown that (ANOVA), the concentration rate is more effective than the other factors. The fabric samples having high coating rate are exhibited higher abrasion resistance than the fabric samples having low coating rate.

According to the Tukey test (Table 4.80) the chemical type (acetone, DMF, ethanol) the concentration rate (1/10, 1/50) and the duration time (5 s, 10 s) have statistically significant effect before micro-cracking but there is no statistically different effect between them after micro-cracking process.

Table 4.80 Tukey values of abrasion resistance test results (G2PU2)

(a;chemical type, b;concentration rate and duration time)

Chemical Type	**Subset**	
	2	**1**
None	,6433	
DMF		1,0875
Acetone		1,0917
Ethanol		1,2392
Sig.	1,000	,529

a

Concentration Rate	**Subset**		**Duration Time**	**Subset**	
	2	**1**		**2**	**1**
None	,6433		None	,6433	
1:10		1,0461	5 s		1,0939
1:50		1,2328	10 s		1,1850
Sig.	1,000	,234	Sig.	1,000	,696

b

As a conclusion, the experimental and statistical results imply that, the coated denim fabric abrasion resistance properties are influence the micro-cracking process but not dramatically change these properties.

CHAPTER 5

CONCLUSION

Denim fabrics are a quite popular fabric type, which have a large marketing and to appeal consumers from child and young to old ages. Furthermore, it has various usage fields not only clothing industry but also accessories, bags, shoes and so on. As from of structure, denim fabrics are good breaking and tear strength, resistance to abrasion and also it is capable of different types of visual effects. Due to these reasons, denim fabrics are always appear in fashion or trend product groups.

Visual appeal is a significant factor in the placing on the market of product. In this respect coating process enhance the attraction of denim fabrics. On the other hand, this situation is important in terms of comfort on the denim fabrics preferably every climate. Because it is substantial not only visuality of the apparel fabrics but also harmony with human body and to feel comfortable. Constrictive the movement of body, sticky, sweaty, itchy etc. clothes cause the feeling of discomfort. Due to these reasons, a garment product bring a new feature; heat and mass transfer properties, mechanical and handle properties should be evaluate and should be review the availability of this new product.

Within the scope of the thesis with this point of view, the micro-cracking process is carried out on the polyurethane (PU) coated denim fabrics in order to diminish disadvantages such as poor air and water vapor permeability properties. For this purpose, the comfort properties (air permeability, water vapor permeability, wicking) and the mechanical properties (water resistance, breaking strength-elongation, abrasion resistance) of the fabric samples were determined and the test results were evaluated by using statistical analysis. Herein, there are used two different weights of fabrics and two different coating thickness or (coating weights) in order to consider effect of the micro-cracking process. In this process are performed in the coagulation

bath with as chemicals Acetone, DMF, Ethanol with 1/10 and 1/50 (chemical/distilled water) concentration rate and also 5 sec and 10 sec duration time.

The air permeability properties of the fabrics are influenced by various factors such as; the fabric construction, warp and weft sett, yarn type, finishing process and etc. The air permeability values of PU coated denim fabrics are indicated that the significant decreases approximately 90-95 %. Nevertheless, the air permeability values of the samples increase after micro-cracking process. Besides, this increment originated by the chemical type, especially the highest effect and the statistical significance of the air permeability values are acquired with Acetone, 1:10 and 5 s. When the fabric weight and the coating thickness or coating weights are changed, the effect of the micro-cracking process such as the duration time and the concentration rate is also changed. In view of this situation, when the coating rate increase, the air permeability values decrease even though micro-cracking process. It is possible to conclude that, the fabric weight and the coating rate or the coating weights have a noteworthy effect on the air permeability properties.

The water vapour permeability of the fabrics is a substantial property in the clothing and human body harmony. The human body cooling mechanisms is consists of two parts, these are sweating and evaporating. The clothing system must be allows to remove this moisture in order to preserve the comfort. At the same time, the water vapour permeability (WVP) and air permeability importantly influence the human body heat transfer or another words, these are significant criterion in terms of thermal comfort. The important difference between the WVP and air permeability is vapor absorbability properties according to type of fibers. When the coating process is applied on the fabric surface not only air permeability but also water vapour permeability properties is reduced due to the fabric porosity completely closed. In parallel with this situation, denim fabric WVP values diminish approximately 50-70 % after the coating process. On the other hand, after the micro-cracking process the WVP values of the coated denim fabric are increased all of the chemical types comparing with before micro-cracking process or (after coating process). When the coating rate or coating thickness is changed, the concentration rate and duration time is also changed in the micro-cracking process. Particularly, the highest WVP (%) values are obtained with Acetone. The WVP value of G1 fabric sample is measured

35 %. For G1PU1 fabric samples WVP values decrease from 35 % to 12.7 % after coating process or before micro-cracking process. Likewise, this values increase after micro-cracking process with Acetone chemical (1/10 concentration rate and 10 s duration time) approximately 25.8 %. For G1PU2 fabric samples WVP values decrease from 35 % to 9.7 % after coating process or before micro-cracking process. Nevertheless, this values increase after micro-cracking process with Acetone chemical (1/10 concentration rate and 10 s duration time) approximately 15 %. As it can be seen that the obtained results, the coating rate is affected the WVP properties of the fabrics.

The WVP value of G2 fabric sample is measured 24.9 %. For G2PU1 fabric samples WVP values decrease from 24.9 % to 14,25 % after coating process or before micro-cracking process. Furthermore, this values increase after micro-cracking process with Acetone chemical (1/10 concentration rate and 10 s duration time) approximately 20.53 %. For G2PU2 fabric samples WVP values decrease from 24.9 % to 9.15 % after coating process or before micro-cracking process. Nonetheless, this values increase after micro-cracking process with Acetone chemical (1/10 concentration rate and 10 s duration time) approximately 13.73 %. As it expected, when the coating rate increase the WVP values are reduced even though after micro-cracking process.

Coated fabrics have resistance to water vapour due to the film layer on the fabric surfaces. In this study as it expected that, water vapour resistance (RET) values of the denim fabrics increase after the coating process. On the other hand, water vapour resistance values are decreased after the micro-cracking process however, this decrement is not substantial in the meaning of statistically. The measurement results are obtained that, G2 fabric samples have more influential properties than G1 fabric samples after the micro-cracking process on the water vapour resistance values. In addition to this, the most efficient chemical is acetone in the micro-cracking process.

The sweat on the skin must be able to transferring from the fabric in order to maintain the human body dry. Through wetting and wicking. The wicking is precursor of wetting. In order to feel comfortable in the clothing, taking the sweat from the skin by the fabric and transferring the outer layer and than the sweat is drying by contact with air. In an attempt to stay with comfortable, it is not enough the fabric absorb the sweat. If the sweat is not transferring and diffusion from the

fabric structure, undesirable situation occurs such as; chills, pain, feeling cold, etc. So discomfort feeling come into existence in the human body. Due to these reasons, the wicking property is also considerable for the thermal comfort. When the fabric is coated, it gains to resistance to the water penetration so as it expected results, the wicking values reduce on the fabric structure. In this study, the obtained results are shown that the warp and weft direction of the vertical wicking properties diminish approximately 50 % after the PU coating process. All of the using chemicals (Acetone, DMF, Ethanol) in the micro-cracking process increase the wicking values. When considered of the obtained experimental and statistical results, the micro-cracking with acetone is given the highest values for G1 fabric samples types. After micro-cracking process, the wicking values reached to approximately 80 % of untreated (no applied PU coating and micro-cracking process) denim fabric of wicking values. And besides, the micro-cracking with DMF is given the highest values for G2 fabric sample types.

When the fabric surfaces are coated, they acquire water repellent properties. However, if it is not using for waterproof fabrics such as tents, tarpaulins, the reduction of this property is important in terms of clothing comfort. Because of when considered the comfort, in order that wetting-wicking-drying cycle of the clothing is related to the water. The water repellent values are increased 20 times after the coating process depending on the coating weight. However, the water repellent value of the coated fabric is reduced after micro-cracking process comparing with before micro-cracking. However, the values are found higher before coating process. As a consequence of these, when it is considered with the wicking values it can be conclude that, the interaction of water with the fabrics provide that changing of the PU coated fabrics after the micro-cracking process. Other test measurements in parallel with acetone are obtained lower water repellent values.

The fabric breaking strength reduce a seriously after finishing processes, it means that this process is deformed the fabric structure. The obtained results shown that, the breaking strength values are increased after the coating process for G1 and G2 fabric type not only warp direction but also weft direction. On the other hand, the breaking elongation values are decreased after coating process but no significantly (app. the warp direction 1 %, weft direction 5 %). According to obtained results, the coated

polymers are diffused on the fabric surfaces and caused to yarn motion. On the other hand, the micro-cracking process is changed the fabric breaking strength and elongation properties.

The coating process enhances the fabric abrasion resistance. As it expected that, the using of the denim fabrics (G1 and G2) the abrasion resistance increase after PU coating process. Abrasion resistances values of the coated fabric diminish after the micro-cracking process (app. max. 1.7 % mass loss). However, there is no significant mass loss observed at the abrasion resistance after micro-cracking process. Due to these results, the effect of the micro-cracking process is evaluated as weak on the abrasion resistance. According to the obtained results, the abrasion resistance of the fabrics, there are no determined the effect of the fabric weight or coating thickness. In other words, the coating weight or coating thickness increase on the fabric surface it has no statistically different impact on the abrasion resistance values.

Within the scope of this thesis, the micro-cracking process carried out on the coated denim fabric which is no caused to reduce the fabric mechanical properties such as water resistance, breaking strength and elongation, abrasion resistance. Furthermore, the obtained results indicate that, the comfort properties of the coated denim fabrics, to increase the air permeability values, water vapour permeability values and also wicking values after micro-cracking process. On the other hand, the disadvantages of the conventional PU coating are diminished by using of the micro-cracking process.

Consequently this thesis findings indicate that, the micro-cracking process carried out on the PU coated denim fabrics by using this recipe “1/10, Acetone, 10 s”. Results of this process, the breaking strength-elongation, abrasion resistance and water repellent values have no statistically changing on the fabric samples. On the other hand, the air permeability, water vapour permeability and wicking values are increase also statistical significant on the fabrics.

To determine the efficiency of the micro-cracking process on the fabric breathability properties, there is compared with membrane laminated fabric. The membrane lamination process was performed on the G1 denim fabric type in the plant. The PU membrane lamination carried out ratio of 40 g/m^2 on the fabric surface.

From the Table 5.1 is given information about G1PU1 and G1PU2 denim fabric samples measured the air permeability and water vapour permeability values after micro-cracking process with recipe of this, "1/10 Acetone 10 s" and also given information about the G1+Membrane laminated fabric. The obtained results indicate that, the air permeability values of the PU coated denim fabrics after the micro-cracking process are higher than the air permeability values of the G1+Membrane laminated fabric. However, the water vapour permeability values of the G1+Membrane laminated are higher than the water vapour permeability values of the PU coated denim fabrics after micro-cracking process.

Table 5.1 Comparison with the G1 fabric samples after micro-cracking (1/10, Acetone, 10 s) and membrane lamination of G1 fabric samples

Fabric Samples	**Weight (g/m^2)**	**Thickness (mm)**	**Air Permeability (dm^3/s)**	**Water Vapour Permeability (%)**
G1PU1	343	0,55	0,0052	25,80
G1PU2	350	0,56	0,0030	15,15
G1+Membrane	365	0,56	0,0021	35,28

Polyurethane (PU) coating process is using for to change fabric appearance and to enhance fabric performance properties. In recent years, PU coated denim fabric is remarkably increase all around the world, especially different color such as gray, metallic appearance are increase to choose. However, the fabric breathable properties decrease (air permeability, water vapour permeability and wicking) after PU coating process. It is an important disadvantage for PU coated fabrics.

In this study, conventional PU coated fabrics are subjected to micro-cracking to increase breathability (air permeability and water vapour permeability) and without decreasing the water resistance performance of the PU coated fabrics. Thus, the comfort properties of coated fabric are enhanced with micro-cracking process. Besides, it can be said that, enhanced breathability would be achieved with low cost PU coating compared to membrane laminated fabrics and best knowledge this type of study has not been down before.

When considered from this point of view, this study has the characteristics of the first work in the field. Next studies will carry out using different fabric structure for coating polymers with coating process and also different chemical (solvent) type, concentration rate and duration time or other parameters for micro-cracking process.

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APPENDIX A

EXPERMENTAL RESULTS OF THESIS

(**Note;** *__G1:__ 311 g/m^2 Denim fabric, **__G2:__400 g/m^2 Denim fabric, ***__PU1__:0.2 mm with knife distance made of polyurethane coated, ****__PU2__:0.4 mm with knife distance made of polyurethane coated.)

Table A.1 Fabric air permeability test results

Fabric Code	**Air Permeability (dm^3/s)**
Denim Fabric G1	0,04
Denim Fabric G2	0,0464
G1PU1	0,0029
G1PU2	0,0017
G2PU1	0,0032
G2PU2	0,0024
G1PU1, 1/10 Acetone, 5 sec	0,0045
G1PU2, 1/10 Acetone, 5 sec	0,0035
G2PU1, 1/10 Acetone, 5 sec	0,0046
G2PU2, 1/10 Acetone, 5 sec	0,0036
G1PU1, 1/10 Acetone, 10 sec	0,0051
G1PU2, 1/10 Acetone, 10 sec	0,003
G2PU1, 1/10 Acetone, 10 sec	0,0055
G2PU2, 1/10 Acetone, 10 sec	0,0039
G1PU1, 1/50 Acetone, 5 sec	0,0042
G1PU2, 1/50 Acetone, 5 sec	0,0025
G2PU1, 1/50 Acetone, 5 sec	0,0063
G2PU2, 1/50 Acetone, 5 sec	0,0031
G1PU1, 1/50 Acetone, 10 sec	0,0042
G1PU2, 1/50 Acetone, 10 sec	0,003
G2PU1, 1/50 Acetone, 10 sec	0,006
G2PU2, 1/50 Acetone, 10 sec	0,0046
G1PU1, 1/10 DMF, 5 sec	0,0043
G1PU2, 1/10 DMF, 5 sec	0,0028
G2PU1, 1/10 DMF, 5 sec	0,0056
G2PU2, 1/10 DMF, 5 sec	0,0036
G1PU1, 1/10 DMF, 10 sec	0,0038
G1PU2, 1/10 DMF, 10 sec	0,0025
G2PU1, 1/10 DMF, 10 sec	0,0039
G2PU2, 1/10 DMF, 10 sec	0,0033

Table A.1 (Cont.)

Fabric Code	Air Permeability (dm^3/s)
G1PU1, 1/50 DMF, 5 sec	0,0037
G1PU2, 1/50 DMF, 5 sec	0,0027
G2PU1, 1/50 DMF, 5 sec	0,0073
G2PU2, 1/50 DMF, 5 sec	0,0035
G1PU1, 1/50 DMF, 10 sec	0,0035
G1PU2, 1/50 DMF, 10 sec	0,0028
G2PU1, 1/50 DMF, 10 sec	0,0064
G2PU2, 1/50 DMF, 10 sec	0,0034
G1PU1, 1/10 Ethanol, 5 sec	0,0046
G1PU2, 1/10 Ethanol, 5 sec	0,0028
G2PU1, 1/10 Ethanol, 5 sec	0,0064
G2PU2, 1/10 Ethanol, 5 sec	0,0033
G1PU1, 1/10 Ethanol, 10 sec	0,0046
G1PU2, 1/10 Ethanol, 10 sec	0,0029
G2PU1, 1/10 Ethanol, 10 sec	0,0056
G2PU2, 1/10 Ethanol, 10 sec	0,0035
G1PU1, 1/50 Ethanol, 5 sec	0,0047
G1PU2, 1/50 Ethanol, 5 sec	0,0028
G2PU1, 1/50 Ethanol, 5 sec	0,0055
G2PU2, 1/50 Ethanol, 5 sec	0,0028
G1PU1, 1/50 Ethanol,10 sec	0,0049
G1PU2, 1/50 Ethanol, 10 sec	0,0021
G2PU1, 1/50 Ethanol, 10 sec	0,0065
G2PU2, 1/50 Ethanol, 10 sec	0,0041

Table A.2 % Relative values of air permeability of samples (dm^3/s)

	G1 denim fabric (0,04)	**% Relative**		**G2 denim fabric** (0,0464)	**% Relative**
G1PU1	0,0029	-92,75	**G2PU1**	0,0032	-93,10
G1PU2	0,0017	-96,34	**G2PU2**	0,0024	-94,83

Table A.2 (Cont.)

	Before micro-cracking	**1/10 Acetone 5 sec**	**% Relative**	**1/10 Acetone 10 sec**	**% Relative**
G1PU1	0,0029	0,0045	+55,17	0,0051	+75,86
G1PU2	0,0017	0,0035	+105,88	0,003	+76,47
G2PU1	0,0032	0,0046	+43,75	0,0055	+71,88
G2PU2	0,0024	0,0036	+50,00	0,0039	+62,50

Table A.2 (Cont.)

	Before micro-cracking	1/50 Acetone 5 sec	% Relative	1/50 Acetone 10 sec	% Relative
G1PU1	0,0029	0,0042	+44,83	0,0042	+44,83
G1PU2	0,0017	0,0025	+47,06	0,003	+76,47
G2PU1	0,0032	0,0063	+96,88	0,006	+87,50
G2PU2	0,0024	0,0031	+29,17	0,0046	+91,67

Table A.2 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	0,0029	0,0043	+48,28	0,0038	+31,03
G1PU2	0,0017	0,0028	+64,71	0,0025	+47,06
G2PU1	0,0032	0,0056	+75,00	0,0039	+21,88
G2PU2	0,0024	0,0036	+50,00	0,0033	+37,50

Table A.2 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	0,0029	0,0037	+27,59	0,0035	+20,69
G1PU2	0,0017	0,0027	+58,82	0,0028	+64,71
G2PU1	0,0032	0,0073	+128,13	0,0064	+100,00
G2PU2	0,0024	0,0035	+45,83	0,0034	+41,67

Table A.2 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	0,0029	0,0046	+58,62	0,0046	+58,62
G1PU2	0,0017	0,0028	+64,71	0,0029	+70,59
G2PU1	0,0032	0,0064	+100,00	0,0056	+75,00
G2PU2	0,0024	0,0033	+37,50	0,0035	+45,83

Table A.2 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	0,0029	0,0047	+62,07	0,0049	+68,97
G1PU2	0,0017	0,0028	+64,71	0,0021	+23,53
G2PU1	0,0032	0,0055	+71,88	0,0065	+103,13
G2PU2	0,0024	0,0028	+16,67	0,0041	+70,83

Table A.3 Fabric water vapour permeability test results

Fabric Code	Water Vapour Permeability	
	Permeability, (%)	Resistance, ($Pa.m^2.w^1$)
Denim Fabric G1	35,02	5,91
Denim Fabric G2	24,9	8,2
G1PU1	12,71	20,95
G1PU2	9,73	27,93
G2PU1	14,25	28,74
G2PU2	9,15	53,49
G1PU1, 1/10 Acetone, 5 sec	24,4	19,74
G1PU2, 1/10 Acetone, 5 sec	14,76	34,51
G2PU1, 1/10 Acetone, 5 sec	16,34	23,28
G2PU2, 1/10 Acetone, 5 sec	11,87	36,3
G1PU1, 1/10 Acetone, 10 sec	25,8	17,64
G1PU2, 1/10 Acetone, 10 sec	15,35	36,25
G2PU1, 1/10 Acetone, 10 sec	20,53	19,56
G2PU2, 1/10 Acetone, 10 sec	13,73	30,36
G1PU1, 1/50 Acetone, 5 sec	18,59	27,34
G1PU2, 1/50 Acetone, 5 sec	11,52	46,32
G2PU1, 1/50 Acetone, 5 sec	14,12	28,66
G2PU2, 1/50 Acetone, 5 sec	13,29	35,11
G1PU1, 1/50 Acetone, 10 sec	20	25,45
G1PU2, 1/50 Acetone, 10 sec	11,09	51,31
G2PU1, 1/50 Acetone, 10 sec	14,08	29,89
G2PU2, 1/50 Acetone, 10 sec	13,51	32,36
G1PU1, 1/10 DMF, 5 sec	17,64	22,49
G1PU2, 1/10 DMF, 5 sec	11,25	40,05
G2PU1, 1/10 DMF, 5 sec	16,48	24,38
G2PU2, 1/10 DMF, 5 sec	11,36	37,63
G1PU1, 1/10 DMF, 10 sec	18,5	21,83
G1PU2, 1/10 DMF, 10 sec	12,67	40,07
G2PU1, 1/10 DMF, 10 sec	19,2	20,24
G2PU2, 1/10 DMF, 10 sec	12,03	34,57
G1PU1, 1/50 DMF, 5 sec	14,46	30,22
G1PU2, 1/50 DMF, 5 sec	11,87	36,6
G2PU1, 1/50 DMF, 5 sec	16,02	23,65
G2PU2, 1/50 DMF, 5 sec	11,27	35,21
G1PU1, 1/50 DMF, 10 sec	18,78	26,38
G1PU2, 1/50 DMF, 10 sec	12,31	45,42
G2PU1, 1/50 DMF, 10 sec	17,34	22,89
G2PU2, 1/50 DMF, 10 sec	10,51	43,3

Table A.3 (Cont.)

Fabric Code	Water Vapour Permeability	
	Permeability, (%)	Resistance, (Pa.m².w¹)
G1PU1, 1/10 Ethanol, 5 sec	14,75	18,41
G1PU2, 1/10 Ethanol, 5 sec	11,38	27,52
G2PU1, 1/10 Ethanol, 5 sec	16,33	28,3
G2PU2, 1/10 Ethanol, 5 sec	11,49	41,47
G1PU1, 1/10 Ethanol, 10 sec	16,5	21,86
G1PU2, 1/10 Ethanol, 10 sec	13,07	28,6
G2PU1, 1/10 Ethanol, 10 sec	17,23	26,04
G2PU2, 1/10 Ethanol, 10 sec	13,64	37,06
G1PU1, 1/50 Ethanol, 5 sec	15,8	22,33
G1PU2, 1/50 Ethanol, 5 sec	13,73	27,23
G2PU1, 1/50 Ethanol, 5 sec	16,72	28,03
G2PU2, 1/50 Ethanol, 5 sec	10,12	58,83
G1PU1, 1/50 Ethanol,10 sec	17	21,17
G1PU2, 1/50 Ethanol, 10 sec	12,03	32,17
G2PU1, 1/50 Ethanol, 10 sec	17,57	28,36
G2PU2, 1/50 Ethanol, 10 sec	10,52	51,28

Table A.4 % Relative values of water vapour permeability of samples (%)

	G1 denim fabric (35,02)	**% Relative**		**G2 denim fabric** (24,9)	**% Relative**
G1PU1	12,71	-63,71	**G2PU1**	14,25	-42,77
G1PU2	9,73	-72,22	**G2PU2**	9,15	-63,25

Table A.4 (Cont.)

	Before micro-cracking	**1/10 Acetone 5 sec**	**% Relative**	**1/10 Acetone 10 sec**	**% Relative**
G1PU1	12,71	24,4	+91,97	25,8	+102,99
G1PU2	9,73	14,76	+51,70	15,35	+57,76
G2PU1	14,25	16,34	+14,67	20,53	+44,07
G2PU2	9,15	11,87	+29,73	13,73	+50,05

Table A.4 (Cont.)

	Before micro-cracking	**1/50 Acetone 5 sec**	**% Relative**	**1/50 Acetone 10 sec**	**% Relative**
G1PU1	12,71	18,59	+46,26	20	+57,36
G1PU2	9,73	11,52	+18,40	11,09	+13,98
G2PU1	14,25	14,12	-0,91	14,08	-1,19
G2PU2	9,15	13,29	+45,25	13,51	+47,65

Table A.4 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	12,71	17,64	+38,79	18,5	+45,55
G1PU2	9,73	11,25	+15,62	12,67	+30,22
G2PU1	14,25	16,48	+15,65	19,2	+34,74
G2PU2	9,15	11,36	+24,15	12,03	+31,48

Table A.4 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	12,71	14,46	+13,77	18,78	+47,76
G1PU2	9,73	11,87	+21,99	12,31	+26,52
G2PU1	14,25	16,02	+12,42	17,34	+21,68
G2PU2	9,15	11,27	+23,17	10,51	+14,86

Table A.4 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	12,71	14,75	+16,05	16,5	+29,82
G1PU2	9,73	11,38	+16,96	13,07	+34,33
G2PU1	14,25	16,33	+14,60	17,23	+20,91
G2PU2	9,15	11,49	+25,57	13,64	+49,07

Table A.4 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	12,71	15,8	+24,31	17	+33,75
G1PU2	9,73	13,73	+41,11	12,03	+23,64
G2PU1	14,25	16,72	+17,33	17,57	+23,30
G2PU2	9,15	10,12	+10,60	10,52	+14,97

Table A.5 % Relative values of water vapour resistance of samples ($Pa.m^2.w^1$)

	G1 denim fabric (5,91)	% Relative		G2 denim fabric (8,2)	% Relative
G1PU1	20,95	+254,48	**G2PU1**	28,74	+250,49
G1PU2	27,93	+372,59	**G2PU2**	53,49	+552,32

Table A.5 (Cont.)

	Before micro-cracking	1/10 Acetone 5 sec	% Relative	1/10 Acetone 10 sec	% Relative
G1PU1	20,95	19,74	-5,78	17,64	-15,80
G1PU2	27,93	34,51	+23,56	36,25	+29,79
G2PU1	28,74	23,28	-19,00	19,56	-31,94
G2PU2	53,49	36,3	-32,14	30,36	-43,24

Table A.5 (Cont.)

	Before micro-cracking	1/50 Acetone 5 sec	% Relative	1/50 Acetone 10 sec	% Relative
G1PU1	20,95	27,34	+30,50	25,45	+21,48
G1PU2	27,93	46,32	+65,84	51,31	+83,71
G2PU1	28,74	28,66	-0,28	29,89	+4,00
G2PU2	53,49	35,11	-34,36	32,36	-39,50

Table A.5 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	20,95	22,49	+7,35	21,83	+4,20
G1PU2	27,93	40,05	+43,39	40,07	+43,47
G2PU1	28,74	24,38	-15,17	20,24	-29,58
G2PU2	53,49	37,63	-29,65	34,57	-35,37

Table A.5 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	20,95	30,22	+44,25	26,38	+25,92
G1PU2	27,93	36,6	+31,04	45,42	+62,62
G2PU1	28,74	23,65	-17,71	22,89	-20,35
G2PU2	53,49	35,21	-34,17	43,3	-19,05

Table A.5 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	20,95	18,41	-12,12	21,86	+4,34
G1PU2	27,93	27,52	-1,47	28,6	+2,40
G2PU1	28,74	28,3	-1,53	26,04	-9,39
G2PU2	53,49	41,47	-22,47	37,06	-30,72

Table A.5 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	20,95	22,33	+6,59	21,17	+1,05
G1PU2	27,93	27,23	-2,51	32,17	+15,18
G2PU1	28,74	28,03	-2,47	28,36	-1,32
G2PU2	53,49	58,83	+9,98	51,28	-4,13

Table A.6 Fabric wicking test results

Fabric Code	Wicking (mm)	
	Warp	Weft
Denim Fabric G1	105	77
Denim Fabric G2	108	74
G1PU1	49	42
G1PU2	44	36
G2PU1	53	45
G2PU2	50	42
G1PU1, 1/10 Acetone, 5 sec	82	72
G1PU2, 1/10 Acetone, 5 sec	70	64
G2PU1, 1/10 Acetone, 5 sec	73	72
G2PU2, 1/10 Acetone, 5 sec	71	71
G1PU1, 1/10 Acetone, 10 sec	78	70
G1PU2, 1/10 Acetone, 10 sec	74	70
G2PU1, 1/10 Acetone, 10 sec	74	70
G2PU2, 1/10 Acetone, 10 sec	70	66
G1PU1, 1/50 Acetone, 5 sec	64	56
G1PU2, 1/50 Acetone, 5 sec	58	58
G2PU1, 1/50 Acetone, 5 sec	67	65
G2PU2, 1/50 Acetone, 5 sec	68	68
G1PU1, 1/50 Acetone, 10 sec	64	61
G1PU2, 1/50 Acetone, 10 sec	58	58
G2PU1, 1/50 Acetone, 10 sec	68	72
G2PU2, 1/50 Acetone, 10 sec	70	72
G1PU1, 1/10 DMF, 5 sec	67	64
G1PU2, 1/10 DMF, 5 sec	62	59
G2PU1, 1/10 DMF, 5 sec	71	72
G2PU2, 1/10 DMF, 5 sec	66	73
G1PU1, 1/10 DMF, 10 sec	74	68
G1PU2, 1/10 DMF, 10 sec	61	64
G2PU1, 1/10 DMF, 10 sec	76	75
G2PU2, 1/10 DMF, 10 sec	73	73

Table A.6 (Cont.)

Fabric Code	Wicking (mm)	
	Warp	Weft
G1PU1, 1/50 DMF, 5 sec	55	49
G1PU2, 1/50 DMF, 5 sec	48	45
G2PU1, 1/50 DMF, 5 sec	67	69
G2PU2, 1/50 DMF, 5 sec	67	73
G1PU1, 1/50 DMF, 10 sec	58	55
G1PU2, 1/50 DMF, 10 sec	54	53
G2PU1, 1/50 DMF, 10 sec	75	71
G2PU2, 1/50 DMF, 10 sec	70	69
G1PU1, 1/10 Ethanol, 5 sec	51	45
G1PU2, 1/10 Ethanol, 5 sec	43	40
G2PU1, 1/10 Ethanol, 5 sec	72	73
G2PU2, 1/10 Ethanol, 5 sec	70	72
G1PU1, 1/10 Ethanol, 10 sec	70	65
G1PU2, 1/10 Ethanol, 10 sec	65	63
G2PU1, 1/10 Ethanol, 10 sec	73	74
G2PU2, 1/10 Ethanol, 10 sec	72	72
G1PU1, 1/50 Ethanol, 5 sec	44	39
G1PU2, 1/50 Ethanol, 5 sec	46	41
G2PU1, 1/50 Ethanol, 5 sec	70	71
G2PU2, 1/50 Ethanol, 5 sec	68	66
G1PU1, 1/50 Ethanol, 10 sec	44	41
G1PU2, 1/50 Ethanol, 10 sec	45	42
G2PU1, 1/50 Ethanol, 10 sec	74	71
G2PU2, 1/50 Ethanol, 10 sec	71	71

Table A.7 % Relative values of wicking (warp) of samples (mm)

	G1 denim fabric (105)	**% Relative**		**G2 denim fabric** (108)	**% Relative**
G1PU1	49	-53,33	**G2PU1**	53	-50,93
G1PU2	44	-59,26	**G2PU2**	50	-53,70

Table A.7 (Cont.)

	Before micro-cracking	**1/10 Acetone 5 sec**	**% Relative**	**1/10 Acetone 10 sec**	**% Relative**
G1PU1	49	82	+67,35	78	+59,18
G1PU2	44	70	+59,09	74	+68,18
G2PU1	53	73	+37,74	74	+39,62
G2PU2	50	71	+42,00	70	+40,00

Table A.7 (Cont.)

	Before micro-cracking	1/50 Acetone 5 sec	% Relative	1/50 Acetone 10 sec	% Relative
G1PU1	49	64	+30,61	64	+30,61
G1PU2	44	58	+31,82	58	+31,82
G2PU1	53	67	+26,42	68	+28,30
G2PU2	50	68	+36,00	70	+40,00

Table A.7 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	49	67	+36,73	74	+51,02
G1PU2	44	62	+40,91	61	+38,64
G2PU1	53	71	+33,96	76	+43,40
G2PU2	50	66	+32,00	73	+46,00

Table A.7 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	49	55	+12,24	58	+18,37
G1PU2	44	48	+9,09	54	+22,73
G2PU1	53	67	+26,42	75	+41,51
G2PU2	50	67	+34,00	70	+40,00

Table A.7 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	49	51	+4,08	70	+42,86
G1PU2	44	43	-2,27	65	+47,73
G2PU1	53	72	+35,85	73	+37,74
G2PU2	50	70	+40,00	72	+44,00

Table A.7 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	49	44	-10,20	44	-10,20
G1PU2	44	46	+4,55	45	+2,27
G2PU1	53	70	+32,08	74	+39,62
G2PU2	50	68	+36,00	71	+42,00

Table A.8 % Relative values of wicking (weft) of samples (mm)

	G1 denim fabric (77)	% Relative		G2 denim fabric (74)	% Relative
G1PU1	42	-53,33	**G2PU1**	45	-50,93
G1PU2	36	-58,10	**G2PU2**	42	-53,70

Table A.8 (Cont.)

	Before micro-cracking	1/10 Acetone 5 sec	% Relative	1/10 Acetone 10 sec	% Relative
G1PU1	42	72	+71,43	70	+66,67
G1PU2	36	64	+77,78	70	+94,44
G2PU1	45	72	+60,00	70	+55,56
G2PU2	42	71	+69,05	66	+57,14

Table A.8 (Cont.)

	Before micro-cracking	1/50 Acetone 5 sec	% Relative	1/50 Acetone 10 sec	% Relative
G1PU1	42	56	+33,33	61	+45,24
G1PU2	36	58	+61,11	58	+61,11
G2PU1	45	65	+44,44	72	+60,00
G2PU2	42	68	+61,90	72	+71,43

Table A.8 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	42	64	+52,38	68	+61,90
G1PU2	36	59	+63,89	64	+77,78
G2PU1	45	72	+60,00	75	+66,67
G2PU2	42	73	+73,81	73	+73,81

Table A.8 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	42	49	+16,67	55	+30,95
G1PU2	36	45	+25,00	53	+47,22
G2PU1	45	69	+53,33	71	+57,78
G2PU2	42	73	+73,81	69	+64,29

Table A.8 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	42	45	+7,14	65	+54,76
G1PU2	36	40	+11,11	63	+75,00
G2PU1	45	73	+62,22	74	+64,44
G2PU2	42	72	+71,43	72	+71,43

Table A.8 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	42	39	-7,14	41	-2,38
G1PU2	36	41	+13,89	42	+16,67
G2PU1	45	71	+57,78	71	+57,78
G2PU2	42	66	+57,14	71	+69,05

Table A.9 Fabric water resistance test results

Fabric Code	Water Resistence (mbar)
Denim Fabric G1	1,8
Denim Fabric G2	0,28
G1PU1	6,5
G1PU2	7,56
G2PU1	3,45
G2PU2	5,6
G1PU1, 1/10 Acetone, 5 sec	3,53
G1PU2, 1/10 Acetone, 5 sec	4,88
G2PU1, 1/10 Acetone, 5 sec	4,58
G2PU2, 1/10 Acetone, 5 sec	5,08

Table A.9 (Cont.)

Fabric Code	Water Resistence (mbar)
G1PU1, 1/10 Acetone, 10 sec	3,23
G1PU2, 1/10 Acetone, 10 sec	4
G2PU1, 1/10 Acetone, 10 sec	4,9
G2PU2, 1/10 Acetone, 10 sec	5,13
G1PU1, 1/50 Acetone, 5 sec	3,8
G1PU2, 1/50 Acetone, 5 sec	5,08
G2PU1, 1/50 Acetone, 5 sec	3,93
G2PU2, 1/50 Acetone, 5 sec	6,05
G1PU1, 1/50 Acetone, 10 sec	3,95
G1PU2, 1/50 Acetone, 10 sec	5,53
G2PU1, 1/50 Acetone, 10 sec	4,73
G2PU2, 1/50 Acetone, 10 sec	5,9
G1PU1, 1/10 DMF, 5 sec	4,85
G1PU2, 1/10 DMF, 5 sec	6,23
G2PU1, 1/10 DMF, 5 sec	4,8
G2PU2, 1/10 DMF, 5 sec	6,13
G1PU1, 1/10 DMF, 10 sec	3,98
G1PU2, 1/10 DMF, 10 sec	4,9
G2PU1, 1/10 DMF, 10 sec	4,35
G2PU2, 1/10 DMF, 10 sec	5,08
G1PU1, 1/50 DMF, 5 sec	4,38
G1PU2, 1/50 DMF, 5 sec	5,63
G2PU1, 1/50 DMF, 5 sec	4,17
G2PU2, 1/50 DMF, 5 sec	5,3
G1PU1, 1/50 DMF, 10 sec	4,25
G1PU2, 1/50 DMF, 10 sec	5,08
G2PU1, 1/50 DMF, 10 sec	4,23
G2PU2, 1/50 DMF, 10 sec	5,33
G1PU1, 1/10 Ethanol, 5 sec	5,1
G1PU2, 1/10 Ethanol, 5 sec	6,08
G2PU1, 1/10 Ethanol, 5 sec	4,1
G2PU2, 1/10 Ethanol, 5 sec	4,58
G1PU1, 1/10 Ethanol, 10 sec	3,05
G1PU2, 1/10 Ethanol, 10 sec	4,1
G2PU1, 1/10 Ethanol, 10 sec	2,98
G2PU2, 1/10 Ethanol, 10 sec	4,05
G1PU1, 1/50 Ethanol, 5 sec	5,15
G1PU2, 1/50 Ethanol, 5 sec	6,2
G2PU1, 1/50 Ethanol, 5 sec	5,35
G2PU2, 1/50 Ethanol, 5 sec	5,13
G1PU1, 1/50 Ethanol,10 sec	4,68
G1PU2, 1/50 Ethanol, 10 sec	5,33
G2PU1, 1/50 Ethanol, 10 sec	4,78
G2PU2, 1/50 Ethanol, 10 sec	5,1

Table A.10 % Relative values of water resistance of samples (mbar)

	G1 denim fabric (1,8)	**% Relative**		**G2 denim fabric** (0,28)	**% Relative**
G1PU1	6,5	+261,11	**G2PU1**	3,45	+1132,14
G1PU2	7,56	+320,00	**G2PU2**	5,6	+1900,00

Table A.10 (Cont.)

	Before micro-cracking	**1/10 Acetone 5 sec**	**% Relative**	**1/10 Acetone 10 sec**	**% Relative**
G1PU1	6,5	3,53	-45,69	3,23	-50,31
G1PU2	7,56	4,88	-35,45	4	-47,09
G2PU1	3,45	4,58	+32,75	4,9	+42,03
G2PU2	5,6	5,08	-9,29	5,13	-8,39

Table A.10 (Cont.)

	Before micro-cracking	**1/50 Acetone 5 sec**	**% Relative**	**1/50 Acetone 10 sec**	**% Relative**
G1PU1	6,5	3,8	-41,54	3,95	-39,23
G1PU2	7,56	5,08	-32,80	5,53	-26,85
G2PU1	3,45	3,93	+13,91	4,73	+37,10
G2PU2	5,6	6,05	+8,04	5,9	+5,36

Table A.10 (Cont.)

	Before micro-cracking	**1/10 DMF 5 sec**	**% Relative**	**1/10 DMF 10 sec**	**% Relative**
G1PU1	6,5	4,85	-25,38	3,98	-38,77
G1PU2	7,56	6,23	-17,59	4,9	-35,19
G2PU1	3,45	4,8	+39,13	4,35	+26,09
G2PU2	5,6	6,13	+9,46	5,08	-9,29

Table A.10 (Cont.)

	Before micro-cracking	**1/50 DMF 5 sec**	**% Relative**	**1/50 DMF 10 sec**	**% Relative**
G1PU1	6,5	4,38	-32,62	4,25	-34,62
G1PU2	7,56	5,63	-25,53	5,08	-32,80
G2PU1	3,45	4,17	+20,87	4,23	+22,61
G2PU2	5,6	5,3	-5,36	5,33	-4,82

Table A.10 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	6,5	5,1	-21,54	3,05	-53,08
G1PU2	7,56	6,08	-19,58	4,1	-45,77
G2PU1	3,45	4,1	+18,84	2,98	-13,62
G2PU2	5,6	4,58	-18,21	4,05	-27,68

Table A.10 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	6,5	5,15	-20,77	4,68	-28,00
G1PU2	7,56	6,2	-17,99	5,33	-29,50
G2PU1	3,45	5,35	+55,07	4,78	+38,55
G2PU2	5,6	5,13	-8,39	5,1	-8,93

Table A.11 Fabric breaking strength and breaking elongation test results

Fabric Code	Breaking Strength (N)		Breaking Elongation (%)	
	Warp	Weft	Warp	Weft
Denim Fabric G1	1394	1088	18	31
Denim Fabric G2	1970	890	20	29
G1PU1	1530	1092	17	25
G1PU2	1557	1101	18	24
G2PU1	2019	934	19	25
G2PU2	2130	1052	18	25
G1PU1, 1/10 Acetone, 5 sec	1570	1259	17	28
G1PU2, 1/10 Acetone, 5 sec	1581	1246	20	27
G2PU1, 1/10 Acetone, 5 sec	2069	1080	23	25
G2PU2, 1/10 Acetone, 5 sec	2091	1018	22	25
G1PU1, 1/10 Acetone, 10 sec	1554	1180	19	27
G1PU2, 1/10 Acetone, 10 sec	1576	1210	20	27
G2PU1, 1/10 Acetone, 10 sec	2049	1068	22	26
G2PU2, 1/10 Acetone, 10 sec	2094	1002	22	25
G1PU1, 1/50 Acetone, 5 sec	1587	1096	20	25
G1PU2, 1/50 Acetone, 5 sec	1595	1189	19	27
G2PU1, 1/50 Acetone, 5 sec	2083	1060	21	26
G2PU2, 1/50 Acetone, 5 sec	2087	1077	22	26

Table A.11 (Cont.)

Fabric Code	Breaking Strength (N)		Breaking Elongation (%)	
	Warp	Weft	Warp	Weft
G1PU1, 1/50 Acetone, 10 sec	1583	1145	20	26
G1PU2, 1/50 Acetone, 10 sec	1572	1128	20	26
G2PU1, 1/50 Acetone, 10 sec	2043	1120	22	27
G2PU2, 1/50 Acetone, 10 sec	2063	1087	22	27
G1PU1, 1/10 DMF, 5 sec	1602	1190	20	26
G1PU2, 1/10 DMF, 5 sec	1619	1188	20	26
G2PU1, 1/10 DMF, 5 sec	2051	1088	23	28
G2PU2, 1/10 DMF, 5 sec	2066	1132	23	28
G1PU1, 1/10 DMF, 10 sec	1565	1183	21	28
G1PU2, 1/10 DMF, 10 sec	1601	1170	22	29
G2PU1, 1/10 DMF, 10 sec	2010	1065	22	27
G2PU2, 1/10 DMF, 10 sec	2002	1082	22	28
G1PU1, 1/50 DMF, 5 sec	1605	1217	20	27
G1PU2, 1/50 DMF, 5 sec	1652	1196	20	28
G2PU1, 1/50 DMF, 5 sec	2068	1127	22	27
G2PU2, 1/50 DMF, 5 sec	2111	1108	23	27
G1PU1, 1/50 DMF, 10 sec	1599	1227	20	27
G1PU2, 1/50 DMF, 10 sec	1628	1189	20	28
G2PU1, 1/50 DMF, 10 sec	2044	1170	22	27
G2PU2, 1/50 DMF, 10 sec	2087	1120	22	26
G1PU1, 1/10 Ethanol, 5 sec	1536	1070	18	25
G1PU2, 1/10 Ethanol, 5 sec	1561	1084	18	24
G2PU1, 1/10 Ethanol, 5 sec	2074	1086	21	25
G2PU2, 1/10 Ethanol, 5 sec	1932	1127	21	29
G1PU1, 1/10 Ethanol, 10 sec	1546	1129	20	26
G1PU2, 1/10 Ethanol, 10 sec	1638	1140	21	26
G2PU1, 1/10 Ethanol, 10 sec	2068	1090	22	26
G2PU2, 1/10 Ethanol, 10 sec	2049	1107	22	27
G1PU1, 1/50 Ethanol, 5 sec	1539	1093	18	25
G1PU2, 1/50 Ethanol, 5 sec	1598	1040	18	25
G2PU1, 1/50 Ethanol, 5 sec	2097	1103	22	27
G2PU2, 1/50 Ethanol, 5 sec	2092	1100	22	26
G1PU1, 1/50 Ethanol,10 sec	1565	1033	18	17
G1PU2, 1/50 Ethanol, 10 sec	1604	1135	21	25
G2PU1, 1/50 Ethanol, 10 sec	2154	1123	23	26
G2PU2, 1/50 Ethanol, 10 sec	1865	1115	21	27

Table A.12 % Relative values of breaking strength (warp) of samples (N)

	G1 denim fabric (1394)	**% Relative**		**G2 denim fabric** (1970)	**% Relative**
G1PU1	1530	+9,76	**G2PU1**	2019	+2,49
G1PU2	1557	+11,69	**G2PU2**	2130	+8,12

Table A.12 (Cont.)

	Before micro-cracking	**1/10 Acetone 5 sec**	**% Relative**	**1/10 Acetone 10 sec**	**% Relative**
G1PU1	1530	1570	+2,61	1554	+1,57
G1PU2	1557	1581	+1,54	1576	+1,22
G2PU1	2019	2069	+2,48	2049	+1,49
G2PU2	2130	2091	-1,83	2094	-1,69

Table A.12 (Cont.)

	Before micro-cracking	**1/50 Acetone 5 sec**	**% Relative**	**1/50 Acetone 10 sec**	**% Relative**
G1PU1	1530	1587	+3,73	1583	+3,46
G1PU2	1557	1595	+2,44	1572	+0,96
G2PU1	2019	2083	+3,17	2043	+1,19
G2PU2	2130	2087	-2,02	2063	-3,15

Table A.12 (Cont.)

	Before micro-cracking	**1/10 DMF 5 sec**	**% Relative**	**1/10 DMF 10 sec**	**% Relative**
G1PU1	1530	1602	+4,71	1565	+2,29
G1PU2	1557	1619	+3,98	1601	+2,83
G2PU1	2019	2051	+1,58	2010	-0,45
G2PU2	2130	2066	-3,00	2002	-6,01

Table A.12 (Cont.)

	Before micro-cracking	**1/50 DMF 5 sec**	**% Relative**	**1/50 DMF 10 sec**	**% Relative**
G1PU1	1530	1605	+4,90	1599	+4,51
G1PU2	1557	1652	+6,10	1628	+4,56
G2PU1	2019	2068	+2,43	2044	+1,24
G2PU2	2130	2111	-0,89	2087	-2,02

Table A.12 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	1530	1536	+0,39	1546	+1,05
G1PU2	1557	1561	+0,26	1638	+5,20
G2PU1	2019	2074	+2,72	2068	+2,43
G2PU2	2130	1932	-9,30	2049	-3,80

Table A.12 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	1530	1539	+0,59	1565	+2,29
G1PU2	1557	1598	+2,63	1604	+3,02
G2PU1	2019	2097	+3,86	2154	+6,69
G2PU2	2130	2092	-1,78	1865	-12,44

Table A.13 % Relative values of breaking strength (weft) of samples (N)

	G1 denim fabric (1088)	% Relative		G2 denim fabric (890)	% Relative
G1PU1	1092	+0,37	**G2PU1**	934	+4,94
G1PU2	1101	+1,19	**G2PU2**	1052	+18,20

Table A.13 (Cont.)

	Before micro-cracking	1/10 Acetone 5 sec	% Relative	1/10 Acetone 10 sec	% Relative
G1PU1	1092	1259	+15,29	1180	+8,06
G1PU2	1101	1246	+13,17	1210	+9,90
G2PU1	934	1080	+15,63	1068	+14,35
G2PU2	1052	1018	-3,23	1002	-4,75

Table A.13 (Cont.)

	Before micro-cracking	1/50 Acetone 5 sec	% Relative	1/50 Acetone 10 sec	% Relative
G1PU1	1092	1096	+0,37	1145	+4,85
G1PU2	1101	1189	+7,99	1128	+2,45
G2PU1	934	1060	+13,49	1120	+19,91
G2PU2	1052	1077	+2,38	1087	+3,33

Table A.13 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	1092	1190	+8,97	1183	+8,33
G1PU2	1101	1188	+7,90	1170	+6,27
G2PU1	934	1088	+16,49	1065	+14,03
G2PU2	1052	1132	+7,60	1082	+2,85

Table A.13 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	1092	1217	+11,45	1227	+12,36
G1PU2	1101	1196	+8,63	1189	+7,99
G2PU1	934	1127	+20,66	1170	+25,27
G2PU2	1052	1108	+5,32	1120	+6,46

Table A.13 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	1092	1070	-2,01	1129	+3,39
G1PU2	1101	1084	-1,54	1140	+3,54
G2PU1	934	1086	+16,27	1090	+16,70
G2PU2	1052	1127	+7,13	1107	+5,23

Table A.13 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	1092	1093	+0,09	1033	-5,40
G1PU2	1101	1040	-5,54	1135	+3,09
G2PU1	934	1103	+18,09	1123	+20,24
G2PU2	1052	1100	+4,56	1115	+5,99

Table A.14 % Relative values of breaking elongation (warp) of samples (%)

	G1 denim fabric (18)	% Relative		G2 denim fabric (20)	% Relative
G1PU1	17	-5,56	**G2PU1**	19	-5,00
G1PU2	18	0,00	**G2PU2**	18	+5,88

Table A.14 (Cont.)

	Before micro-cracking	1/10 Acetone 5 sec	% Relative	1/10 Acetone 10 sec	% Relative
G1PU1	17	17	0,00	19	+11,76
G1PU2	18	20	+11,11	20	+11,11
G2PU1	19	23	+21,05	22	+15,79
G2PU2	18	22	+22,22	22	+22,22

Table A.14 (Cont.)

	Before micro-cracking	1/50 Acetone 5 sec	% Relative	1/50 Acetone 10 sec	% Relative
G1PU1	17	20	+17,65	20	+17,65
G1PU2	18	19	+5,56	20	+11,11
G2PU1	19	21	+10,53	22	+15,79
G2PU2	18	22	+22,22	22	+22,22

Table A.14 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	17	20	+17,65	21	+23,53
G1PU2	18	20	+11,11	22	+22,22
G2PU1	19	23	+21,05	22	+15,79
G2PU2	18	23	+27,78	22	+22,22

Table A.14 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	17	20	+17,65	20	+17,65
G1PU2	18	20	+11,11	20	+11,11
G2PU1	19	22	+15,79	22	+15,79
G2PU2	18	23	+27,78	22	+22,22

Table A.14 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	17	18	+5,88	20	+17,65
G1PU2	18	18	0,00	21	+16,67
G2PU1	19	21	+10,53	22	+15,79
G2PU2	18	21	+16,67	22	+22,22

Table A.14 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	17	18	+5,88	18	+5,88
G1PU2	18	18	0,00	21	+16,67
G2PU1	19	22	+15,79	23	+21,05
G2PU2	18	22	+22,22	21	+16,67

Table A.15 % Relative values of breaking elongation (weft) of samples (%)

	G1 denim fabric (31)	% Relative		G2 denim fabric (29)	% Relative
G1PU1	25	-19,35	**G2PU1**	25	-13,79
G1PU2	24	-22,58	**G2PU2**	25	-13,79

Table A.15 (Cont.)

	Before micro-cracking	1/10 Acetone 5 sec	% Relative	1/10 Acetone 10 sec	% Relative
G1PU1	25	28	+12,00	27	+8,00
G1PU2	24	27	+12,50	27	+12,50
G2PU1	25	25	0,00	26	+4,00
G2PU2	25	25	0,00	25	0,00

Table A.15 (Cont.)

	Before micro-cracking	1/50 Acetone 5 sec	% Relative	1/50 Acetone 10 sec	% Relative
G1PU1	25	25	0,00	26	+4,00
G1PU2	24	27	+12,50	26	+8,33
G2PU1	25	26	+4,00	27	+8,00
G2PU2	25	26	+4,00	27	+8,00

Table A.15 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	25	26	+4,00	28	+12,00
G1PU2	24	26	+8,33	29	+20,83
G2PU1	25	28	+12,00	27	+8,00
G2PU2	25	28	+12,00	28	+12,00

Table A.15 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	25	27	+8,00	27	+8,00
G1PU2	24	28	+16,67	28	+16,67
G2PU1	25	27	+8,00	27	+8,00
G2PU2	25	27	+8,00	26	+4,00

Table A.15 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	25	25	0,00	26	+4,00
G1PU2	24	24	0,00	26	+8,33
G2PU1	25	25	0,00	26	+4,00
G2PU2	25	29	+16,00	27	+8,00

Table A.15 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	25	25	0,00	17	-32,00
G1PU2	24	25	+4,17	25	+4,17
G2PU1	25	27	+8,00	26	+4,00
G2PU2	25	26	+4,00	27	+8,00

Table A.16 Fabric abrasion resistance test results

Fabric Code	**Abrasion Resistance (% Mass loss)**
Denim Fabric G1	1,70
Denim Fabric G2	1,69
G1PU1	0,67
G1PU2	0,55
G2PU1	0,76
G2PU2	0,6
G1PU1, 1/10 Acetone, 5 sec	0,77
G1PU2, 1/10 Acetone, 5 sec	1,22
G2PU1, 1/10 Acetone, 5 sec	1,05
G2PU2, 1/10 Acetone, 5 sec	0,95
G1PU1, 1/10 Acetone, 10 sec	0,53
G1PU2, 1/10 Acetone, 10 sec	0,68
G2PU1, 1/10 Acetone, 10 sec	0,58
G2PU2, 1/10 Acetone, 10 sec	0,54
G1PU1, 1/50 Acetone, 5 sec	0,52
G1PU2, 1/50 Acetone, 5 sec	1,00
G2PU1, 1/50 Acetone, 5 sec	0,73
G2PU2, 1/50 Acetone, 5 sec	1,12
G1PU1, 1/50 Acetone, 10 sec	1,38
G1PU2, 1/50 Acetone, 10 sec	0,96
G2PU1, 1/50 Acetone, 10 sec	0,77
G2PU2, 1/50 Acetone, 10 sec	1,62
G1PU1, 1/10 DMF, 5 sec	1,46
G1PU2, 1/10 DMF, 5 sec	1,63
G2PU1, 1/10 DMF, 5 sec	0,57
G2PU2, 1/10 DMF, 5 sec	0,84
G1PU1, 1/10 DMF, 10 sec	1,43
G1PU2, 1/10 DMF, 10 sec	0,73
G2PU1, 1/10 DMF, 10 sec	0,57
G2PU2, 1/10 DMF, 10 sec	1,14
G1PU1, 1/50 DMF, 5 sec	0,81
G1PU2, 1/50 DMF, 5 sec	1,71
G2PU1, 1/50 DMF, 5 sec	1,18
G2PU2, 1/50 DMF, 5 sec	0,93
G1PU1, 1/50 DMF, 10 sec	0,71
G1PU2, 1/50 DMF, 10 sec	1,06
G2PU1, 1/50 DMF, 10 sec	1,42
G2PU2, 1/50 DMF, 10 sec	1,32
G1PU1, 1/10 Ethanol, 5 sec	0,54
G1PU2, 1/10 Ethanol, 5 sec	1,36

Table A.16 (Cont.)

Fabric Code	Abrasion Resistance (% Mass loss)
G2PU1, 1/10 Ethanol, 5 sec	1,21
G2PU2, 1/10 Ethanol, 5 sec	1,32
G1PU1, 1/10 Ethanol, 10 sec	0,78
G1PU2, 1/10 Ethanol, 10 sec	1,3
G2PU1, 1/10 Ethanol, 10 sec	0,87
G2PU2, 1/10 Ethanol, 10 sec	1,26
G1PU1, 1/50 Ethanol, 5 sec	0,43
G1PU2, 1/50 Ethanol, 5 sec	1,3
G2PU1, 1/50 Ethanol, 5 sec	0,86
G2PU2, 1/50 Ethanol, 5 sec	1,16
G1PU1, 1/50 Ethanol, 10 sec	0,99
G1PU2, 1/50 Ethanol, 10 sec	1,25
G2PU1, 1/50 Ethanol, 10 sec	0,55
G2PU2, 1/50 Ethanol, 10 sec	1,07

Table A.17 % Relative values of abrasion resistance of samples (%)

	G1 denim fabric (1,70)	**% Relative**		**G2 denim fabric** (1,69)	**% Relative**
G1PU1	0,67	-60,59	**G2PU1**	0,76	-55,03
G1PU2	0,55	-67,65	**G2PU2**	0,6	-64,50

Table A.17 (Cont.)

	Before micro-cracking	**1/10 Acetone 5 sec**	**% Relative**	**1/10 Acetone 10 sec**	**% Relative**
G1PU1	0,67	0,77	+14,93	0,53	-20,90
G1PU2	0,55	1,22	+121,82	0,68	+23,64
G2PU1	0,76	1,05	+38,16	0,58	-23,68
G2PU2	0,6	0,95	+58,33	0,54	-10,00

Table A.17 (Cont.)

	Before micro-cracking	**1/50 Acetone 5 sec**	**% Relative**	**1/50 Acetone 10 sec**	**% Relative**
G1PU1	0,67	0,52	-22,39	1,38	+105,97
G1PU2	0,55	1	+81,82	0,96	+74,55
G2PU1	0,76	0,73	-3,95	0,77	+1,32
G2PU2	0,6	1,12	+86,67	1,62	+170,00

Table A.17 (Cont.)

	Before micro-cracking	1/10 DMF 5 sec	% Relative	1/10 DMF 10 sec	% Relative
G1PU1	0,67	1,46	+117,91	1,43	+113,43
G1PU2	0,55	1,63	+196,36	0,73	+32,73
G2PU1	0,76	0,57	-25,00	0,57	-25,00
G2PU2	0,6	0,84	+40,00	1,14	+90,00

Table A.17 (Cont.)

	Before micro-cracking	1/50 DMF 5 sec	% Relative	1/50 DMF 10 sec	% Relative
G1PU1	0,67	0,81	+20,90	0,71	+5,97
G1PU2	0,55	1,71	+210,91	1,06	+92,73
G2PU1	0,76	1,18	+55,26	1,42	+86,84
G2PU2	0,6	0,93	+55,00	1,32	+120,00

Table A.17 (Cont.)

	Before micro-cracking	1/10 Ethanol 5 sec	% Relative	1/10 Ethanol 10 sec	% Relative
G1PU1	0,67	0,54	-19,40	0,78	+16,42
G1PU2	0,55	1,36	+147,27	1,3	+136,36
G2PU1	0,76	1,21	+59,21	0,87	+14,47
G2PU2	0,6	1,32	+120,00	1,26	+110,00

Table A.17 (Cont.)

	Before micro-cracking	1/50 Ethanol 5 sec	% Relative	1/50 Ethanol 10 sec	% Relative
G1PU1	0,67	0,43	-35,82	0,99	+47,76
G1PU2	0,55	1,3	+136,36	1,25	+127,27
G2PU1	0,76	0,86	+13,16	0,55	-27,63
G2PU2	0,6	1,16	+93,33	1,07	+78,33

APPENDIX B

STATISTICAL ANALYSIS OF THESIS EXPERMENTAL RESULTS

Table B.1 Tukey multiple comparisons of air permeability test results (G1PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,001592(*)	,0002534	,000	-,002287	-,000897
	DMF	-,000942(*)	,0002534	,005	-,001637	-,000247
	Ethanol	-,001792(*)	,0002534	,000	-,002487	-,001097
Acetone	None	,001592(*)	,0002534	,000	,000897	,002287
	DMF	,000650(*)	,0001603	,002	,000210	,001090
	Ethanol	-,000200	,0001603	,603	-,000640	,000240
DMF	None	,000942(*)	,0002534	,005	,000247	,001637
	Acetone	-,000650(*)	,0001603	,002	-,001090	-,000210
	Ethanol	-,000850(*)	,0001603	,000	-,001290	-,000410
Ethanol	None	,001792(*)	,0002534	,000	,001097	,002487
	Acetone	,000200	,0001603	,603	-,000240	,000640
	DMF	,000850(*)	,0001603	,000	,000410	,001290

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,001567(*)	,0002448	,000	-,002175	-,000958
	1:50	-,001317(*)	,0002448	,000	-,001925	-,000708
1:10	None	,001567(*)	,0002448	,000	,000958	,002175
	1:50	,000250	,0001309	,156	-,000075	,000575
1:50	None	,001317(*)	,0002448	,000	,000708	,001925
	1:10	-,000250	,0001309	,156	-,000575	,000075

b

(I)Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,001428(*)	,0002448	,000	-,002036	-,000819
	10 s	-,001456(*)	,0002448	,000	-,002064	-,000847
5 s	None	,001428(*)	,0002448	,000	,000819	,002036
	10 s	-,000028	,0001309	,975	-,000353	,000297
10 s	None	,001456(*)	,0002448	,000	,000847	,002064
	5 s	,000028	,0001309	,975	-,000297	,000353

c

Based on observed means.

* The mean difference is significant at the ,05 level

Table B.2 Tukey multiple comparisons of air permeability test results (G1PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,001233(*)	,0001947	,000	-,001768	-,000699
	DMF	-,000933(*)	,0001947	,000	-,001468	-,000399
	Ethanol	-,000875(*)	,0001947	,001	-,001409	-,000341
Acetone	None	,001233(*)	,0001947	,000	,000699	,001768
	DMF	,000300	,0001232	,095	-,000038	,000638
	Ethanol	,000358(*)	,0001232	,035	,000020	,000696
DMF	None	,000933(*)	,0001947	,000	,000399	,001468
	Acetone	-,000300	,0001232	,095	-,000638	,000038
	Ethanol	,000058	,0001232	,964	-,000280	,000396
Ethanol	None	,000875(*)	,0001947	,001	,000341	,001409
	Acetone	-,000358(*)	,0001232	,035	-,000696	-,000020
	DMF	-,000058	,0001232	,964	-,000396	,000280

a

(I)Concentration Rate	(J)Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,001144(*)	,0001881	,000	-,001612	-,000677
	1:50	-,000883(*)	,0001881	,000	-,001351	-,000416
1:10	None	,001144(*)	,0001881	,000	,000677	,001612
	1:50	,000261(*)	,0001006	,039	,000011	,000511
1:50	None	,000883(*)	,0001881	,000	,000416	,001351
	1:10	-,000261(*)	,0001006	,039	-,000511	-,000011

b

(I)Duration Time	(J)Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,001078(*)	,0001881	,000	-,001545	-,000610
	10 s	-,000950(*)	,0001881	,000	-,001418	-,000482
5 s	None	,001078(*)	,0001881	,000	,000610	,001545
	10 s	,000128	,0001006	,424	-,000122	,000378
10 s	None	,000950(*)	,0001881	,000	,000482	,001418
	5 s	-,000128	,0001006	,424	-,000378	,000122

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.3 Tukey multiple comparisons of air permeability test results (G2PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,002383(*)	,0003201	,000	-,003261	-,001505
	DMF	-,002592(*)	,0003201	,000	-,003470	-,001714
	Ethanol	-,002783(*)	,0003201	,000	-,003661	-,001905
Acetone	None	,002383(*)	,0003201	,000	,001505	,003261
	DMF	-,000208	,0002024	,734	-,000764	,000347
	Ethanol	-,000400	,0002024	,223	-,000955	,000155
DMF	None	,002592(*)	,0003201	,000	,001714	,003470
	Acetone	,000208	,0002024	,734	-,000347	,000764
	Ethanol	-,000192	,0002024	,780	-,000747	,000364
Ethanol	None	,002783(*)	,0003201	,000	,001905	,003661
	Acetone	,000400	,0002024	,223	-,000155	,000955
	DMF	,000192	,0002024	,780	-,000364	,000747

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,002072(*)	,0003092	,000	-,002841	-,001304
	1:50	-,003100(*)	,0003092	,000	-,003868	-,002332
1:10	None	,002072(*)	,0003092	,000	,001304	,002841
	1:50	-,001028(*)	,0001653	,000	-,001439	-,000617
1:50	None	,003100(*)	,0003092	,000	,002332	,003868
	1:10	,001028(*)	,0001653	,000	,000617	,001439

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,002722(*)	,0003092	,000	-,003491	-,001954
	10 s	-,002450(*)	,0003092	,000	-,003218	-,001682
5 s	None	,002722(*)	,0003092	,000	,001954	,003491
	10 s	,000272	,0001653	,245	-,000139	,000683
10 s	None	,002450(*)	,0003092	,000	,001682	,003218
	5 s	-,000272	,0001653	,245	-,000683	,000139

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.4 Tukey multiple comparisons of air permeability test results (G2PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,001367(*)	,0003379	,002	-,002294	-,000440
	DMF	-,001000(*)	,0003379	,031	-,001927	-,000073
	Ethanol	-,001008(*)	,0003379	,029	-,001935	-,000081
Acetone	None	,001367(*)	,0003379	,002	,000440	,002294
	DMF	,000367	,0002137	,336	-,000220	,000953
	Ethanol	,000358	,0002137	,356	-,000228	,000945
DMF	None	,001000(*)	,0003379	,031	,000073	,001927
	Acetone	-,000367	,0002137	,336	-,000953	,000220
	Ethanol	-,000008	,0002137	1,000	-,000595	,000578
Ethanol	None	,001008(*)	,0003379	,029	,000081	,001935
	Acetone	-,000358	,0002137	,356	-,000945	,000228
	DMF	,000008	,0002137	1,000	-,000578	,000595

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,001100(*)	,0003265	,006	-,001911	-,000289
	1:50	-,001150(*)	,0003265	,004	-,001961	-,000339
1:10	None	,001100(*)	,0003265	,006	,000289	,001911
	1:50	-,000050	,0001745	,956	-,000484	,000384
1:50	None	,001150(*)	,0003265	,004	,000339	,001961
	1:10	,000050	,0001745	,956	-,000384	,000484

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,000883(*)	,0003265	,031	-,001695	-,000072
	10 s	-,001367(*)	,0003265	,001	-,002178	-,000555
5 s	None	,000883(*)	,0003265	,031	,000072	,001695
	10 s	-,000483(*)	,0001745	,027	-,000917	-,000050
10 s	None	,001367(*)	,0003265	,001	,000555	,002178
	5 s	,000483(*)	,0001745	,027	,000050	,000917

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.5 Tukey multiple comparisons of water vapour permeability test results (G1PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-9,4842(*)	1,01648	,000	-12,2727	-6,6956
	DMF	-4,6317(*)	1,01648	,001	-7,4202	-1,8431
	Ethanol	-3,3000(*)	1,01648	,016	-6,0885	-,5115
Acetone	None	9,4842(*)	1,01648	,000	6,6956	12,2727
	DMF	4,8525(*)	,64288	,000	3,0889	6,6161
	Ethanol	6,1842(*)	,64288	,000	4,4205	7,9478
DMF	None	4,6317(*)	1,01648	,001	1,8431	7,4202
	Acetone	-4,8525(*)	,64288	,000	-6,6161	-3,0889
	Ethanol	1,3317	,64288	,189	-,4320	3,0953
Ethanol	None	3,3000(*)	1,01648	,016	,5115	6,0885
	Acetone	-6,1842(*)	,64288	,000	-7,9478	-4,4205
	DMF	-1,3317	,64288	,189	-3,0953	,4320

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-6,8856(*)	,98201	,000	-9,3258	-4,4454
	1:50	-4,7250(*)	,98201	,000	-7,1652	-2,2848
1:10	None	6,8856(*)	,98201	,000	4,4454	9,3258
	1:50	2,1606(*)	,52491	,001	,8562	3,4649
1:50	None	4,7250(*)	,98201	,000	2,2848	7,1652
	1:10	-2,1606(*)	,52491	,001	-3,4649	-,8562

b

(I)Duration Time	(J)Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-4,8933(*)	,98201	,000	-7,3335	-2,4531
	10 s	-6,7172(*)	,98201	,000	-9,1574	-4,2770
5 s	None	4,8933(*)	,98201	,000	2,4531	7,3335
	10 s	-1,8239(*)	,52491	,005	-3,1282	-,5195
10 s	None	6,7172(*)	,98201	,000	4,2770	9,1574
	5 s	1,8239(*)	,52491	,005	,5195	3,1282

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.6 Tukey multiple comparisons of water vapour permeability test results (G1PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-3,3967	1,26376	,056	-6,8636	,0702
	DMF	-2,2917	1,26376	,290	-5,7586	1,1752
	Ethanol	-2,8192	1,26376	,141	-6,2861	,6477
Acetone	None	3,3967	1,26376	,056	-,0702	6,8636
	DMF	1,1050	,79927	,521	-1,0877	3,2977
	Ethanol	,5775	,79927	,887	-1,6152	2,7702
DMF	None	2,2917	1,26376	,290	-1,1752	5,7586
	Acetone	-1,1050	,79927	,521	-3,2977	1,0877
	Ethanol	-,5275	,79927	,911	-2,7202	1,6652
Ethanol	None	2,8192	1,26376	,141	-,6477	6,2861
	Acetone	-,5775	,79927	,887	-2,7702	1,6152
	DMF	,5275	,79927	,911	-1,6652	2,7202

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-3,3122(*)	1,22091	,030	-6,3460	-,2784
	1:50	-2,3594	1,22091	,150	-5,3933	,6744
1:10	None	3,3122(*)	1,22091	,030	,2784	6,3460
	1:50	,9528	,65260	,326	-,6689	2,5744
1:50	None	2,3594	1,22091	,150	-,6744	5,3933
	1:10	-,9528	,65260	,326	-2,5744	,6689

b

(I)Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-2,6867	1,22091	,090	-5,7205	,3472
	10 s	-2,9850	1,22091	,054	-6,0188	,0488
5 s	None	2,6867	1,22091	,090	-,3472	5,7205
	10 s	-,2983	,65260	,892	-1,9200	1,3233
10 s	None	2,9850	1,22091	,054	-,0488	6,0188
	5 s	,2983	,65260	,892	-1,3233	1,9200

c

Based on observed means.

* The mean difference is significant at the ,05 level

Table B.7 Tukey multiple comparisons of water vapour permeability test results (G2PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-2,0183	,74335	,053	-4,0576	,0209
	DMF	-3,0108(*)	,74335	,002	-5,0501	-,9716
	Ethanol	-2,7108(*)	,74335	,006	-4,7501	-,6716
Acetone	None	2,0183	,74335	,053	-,0209	4,0576
	DMF	-,9925	,47014	,176	-2,2822	,2972
	Ethanol	-,6925	,47014	,468	-1,9822	,5972
DMF	None	3,0108(*)	,74335	,002	,9716	5,0501
	Acetone	,9925	,47014	,176	-,2972	2,2822
	Ethanol	,3000	,47014	,919	-,9897	1,5897
Ethanol	None	2,7108(*)	,74335	,006	,6716	4,7501
	Acetone	,6925	,47014	,468	-,5972	1,9822
	DMF	-,3000	,47014	,919	-1,5897	,9897

a

(I)Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-3,4344(*)	,71815	,000	-5,2190	-1,6499
	1:50	-1,7256	,71815	,059	-3,5101	,0590
1:10	None	3,4344(*)	,71815	,000	1,6499	5,2190
	1:50	1,7089(*)	,38387	,000	,7550	2,6628
1:50	None	1,7256	,71815	,059	-,0590	3,5101
	1:10	-1,7089(*)	,38387	,000	-2,6628	-,7550

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-1,7517	,71815	,055	-3,5362	,0329
	10 s	-3,4083(*)	,71815	,000	-5,1929	-1,6238
5 s	None	1,7517	,71815	,055	-,0329	3,5362
	10 s	-1,6567(*)	,38387	,001	-2,6105	-,7028
10 s	None	3,4083(*)	,71815	,000	1,6238	5,1929
	5 s	1,6567(*)	,38387	,001	,7028	2,6105

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.8 Tukey multiple comparisons of water vapour permeability test results (G2PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-3,9508	1,46678	,056	-7,9747	,0730
	DMF	-2,1433	1,46678	,474	-6,1672	1,8805
	Ethanol	-2,2917	1,46678	,417	-6,3155	1,7322
Acetone	None	3,9508	1,46678	,056	-,0730	7,9747
	DMF	1,8075	,92767	,233	-,7374	4,3524
	Ethanol	1,6592	,92767	,301	-,8857	4,2041
DMF	None	2,1433	1,46678	,474	-1,8805	6,1672
	Acetone	-1,8075	,92767	,233	-4,3524	,7374
	Ethanol	-,1483	,92767	,999	-2,6932	2,3966
Ethanol	None	2,2917	1,46678	,417	-1,7322	6,3155
	Acetone	-1,6592	,92767	,301	-4,2041	,8857
	DMF	,1483	,92767	,999	-2,3966	2,6932

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-3,2028	1,41705	,080	-6,7240	,3184
	1:50	-2,3878	1,41705	,230	-5,9090	1,1334
1:10	None	3,2028	1,41705	,080	-,3184	6,7240
	1:50	,8150	,75744	,537	-1,0672	2,6972
1:50	None	2,3878	1,41705	,230	-1,1334	5,9090
	1:10	-,8150	,75744	,537	-2,6972	1,0672

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-2,4172	1,41705	,222	-5,9384	1,1040
	10 s	-3,1733	1,41705	,083	-6,6945	,3479
5 s	None	2,4172	1,41705	,222	-1,1040	5,9384
	10 s	-,7561	,75744	,585	-2,6383	1,1261
10 s	None	3,1733	1,41705	,083	-,3479	6,6945
	5 s	,7561	,75744	,585	-1,1261	2,6383

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.9 Tukey multiple comparisons of water vapour resistance (RET) test results (G1PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-1,5950	1,25248	,587	-5,0310	1,8410
	DMF	-4,2825(*)	1,25248	,011	-7,7185	-,8465
	Ethanol	,0042	1,25248	1,000	-3,4318	3,4401
Acetone	None	1,5950	1,25248	,587	-1,8410	5,0310
	DMF	-2,6875(*)	,79214	,011	-4,8606	-,5144
	Ethanol	1,5992	,79214	,207	-,5739	3,7723
DMF	None	4,2825(*)	1,25248	,011	,8465	7,7185
	Acetone	2,6875(*)	,79214	,011	,5144	4,8606
	Ethanol	4,2867(*)	,79214	,000	2,1136	6,4598
Ethanol	None	-,0042	1,25248	1,000	-3,4401	3,4318
	Acetone	-1,5992	,79214	,207	-3,7723	,5739
	DMF	-4,2867(*)	,79214	,000	-6,4598	-2,1136

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	,6172	1,21001	,867	-2,3895	3,6240
	1:50	-4,5328(*)	1,21001	,003	-7,5395	-1,5260
1:10	None	-,6172	1,21001	,867	-3,6240	2,3895
	1:50	-5,1500(*)	,64678	,000	-6,7572	-3,5428
1:50	None	4,5328(*)	1,21001	,003	1,5260	7,5395
	1:10	5,1500(*)	,64678	,000	3,5428	6,7572

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-2,4750	1,21001	,121	-5,4818	,5318
	10 s	-1,4406	1,21001	,469	-4,4473	1,5662
5 s	None	2,4750	1,21001	,121	-,5318	5,4818
	10 s	1,0344	,64678	,264	-,5727	2,6416
10 s	None	1,4406	1,21001	,469	-1,5662	4,4473
	5 s	-1,0344	,64678	,264	-2,6416	,5727

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.10 Tukey multiple comparisons of water vapour resistance (RET) test results (G1PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-14,4175(*)	4,16833	,010	-25,8526	-2,9824
	DMF	-12,6017(*)	4,16833	,027	-24,0367	-1,1666
	Ethanol	-,9458	4,16833	,996	-12,3809	10,4892
Acetone	None	14,4175(*)	4,16833	,010	2,9824	25,8526
	DMF	1,8158	2,63628	,900	-5,4163	9,0480
	Ethanol	13,4717(*)	2,63628	,000	6,2395	20,7038
DMF	None	12,6017(*)	4,16833	,027	1,1666	24,0367
	Acetone	-1,8158	2,63628	,900	-9,0480	5,4163
	Ethanol	11,6558(*)	2,63628	,001	4,4237	18,8880
Ethanol	None	,9458	4,16833	,996	-10,4892	12,3809
	Acetone	-13,4717(*)	2,63628	,000	-20,7038	-6,2395
	DMF	-11,6558(*)	2,63628	,001	-18,8880	-4,4237

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-6,5678	4,02699	,251	-16,5744	3,4389
	1:50	-12,0756(*)	4,02699	,016	-22,0822	-2,0689
1:10	None	6,5678	4,02699	,251	-3,4389	16,5744
	1:50	-5,5078(*)	2,15252	,043	-10,8565	-,1590
1:50	None	12,0756(*)	4,02699	,016	2,0689	22,0822
	1:10	5,5078(*)	2,15252	,043	,1590	10,8565

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-7,5222	4,02699	,168	-17,5289	2,4844
	10 s	-11,1211(*)	4,02699	,027	-21,1277	-1,1145
5 s	None	7,5222	4,02699	,168	-2,4844	17,5289
	10 s	-3,5989	2,15252	,235	-8,9477	1,7499
10 s	None	11,1211(*)	4,02699	,027	1,1145	21,1277
	5 s	3,5989	2,15252	,235	-1,7499	8,9477

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.11 Tukey multiple comparisons of water vapour resistance (RET) test results (G2PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	3,3967	1,51415	,138	-,7571	7,5505
	DMF	5,9517(*)	1,51415	,003	1,7979	10,1055
	Ethanol	1,0608	1,51415	,896	-3,0930	5,2146
Acetone	None	-3,3967	1,51415	,138	-7,5505	,7571
	DMF	2,5550	,95763	,059	-,0721	5,1821
	Ethanol	-2,3358	,95763	,094	-4,9629	,2913
DMF	None	-5,9517(*)	1,51415	,003	-10,1055	-1,7979
	Acetone	-2,5550	,95763	,059	-5,1821	,0721
	Ethanol	-4,8908(*)	,95763	,000	-7,5179	-2,2637
Ethanol	None	-1,0608	1,51415	,896	-5,2146	3,0930
	Acetone	2,3358	,95763	,094	-,2913	4,9629
	DMF	4,8908(*)	,95763	,000	2,2637	7,5179

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	5,1100(*)	1,46281	,005	1,4751	8,7449
	1:50	1,8294	1,46281	,435	-1,8055	5,4644
1:10	None	-5,1100(*)	1,46281	,005	-8,7449	-1,4751
	1:50	-3,2806(*)	,78190	,001	-5,2235	-1,3376
1:50	None	-1,8294	1,46281	,435	-5,4644	1,8055
	1:10	3,2806(*)	,78190	,001	1,3376	5,2235

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	2,6928	1,46281	,176	-,9421	6,3277
	10 s	4,2467(*)	1,46281	,020	,6118	7,8816
5 s	None	-2,6928	1,46281	,176	-6,3277	,9421
	10 s	1,5539	,78190	,135	-,3891	3,4968
10 s	None	-4,2467(*)	1,46281	,020	-7,8816	-,6118
	5 s	-1,5539	,78190	,135	-3,4968	,3891

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.12 Tukey multiple comparisons of water vapour resistance (RET) test results (G2PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	19,9617(*)	6,46677	,023	2,2212	37,7021
	DMF	15,8167	6,46677	,093	-1,9238	33,5571
	Ethanol	6,3325	6,46677	,762	-11,4079	24,0729
Acetone	None	-19,9617(*)	6,46677	,023	-37,7021	-2,2212
	DMF	-4,1450	4,08995	,743	-15,3650	7,0750
	Ethanol	-13,6292(*)	4,08995	,013	-24,8492	-2,4091
DMF	None	-15,8167	6,46677	,093	-33,5571	1,9238
	Acetone	4,1450	4,08995	,743	-7,0750	15,3650
	Ethanol	-9,4842	4,08995	,120	-20,7042	1,7359
Ethanol	None	-6,3325	6,46677	,762	-24,0729	11,4079
	Acetone	13,6292(*)	4,08995	,013	2,4091	24,8492
	DMF	9,4842	4,08995	,120	-1,7359	20,7042

a

(I)Concentration Rate	(J)Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	17,2617(*)	6,24750	,027	1,7373	32,7860
	1:50	10,8122	6,24750	,213	-4,7121	26,3366
1:10	None	-17,2617(*)	6,24750	,027	-32,7860	-1,7373
	1:50	-6,4494	3,33943	,150	-14,7476	1,8487
1:50	None	-10,8122	6,24750	,213	-26,3366	4,7121
	1:10	6,4494	3,33943	,150	-1,8487	14,7476

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	12,7361	6,24750	,123	-2,7883	28,2605
	10 s	15,3378	6,24750	,053	-,1866	30,8621
5 s	None	-12,7361	6,24750	,123	-28,2605	2,7883
	10 s	2,6017	3,33943	,719	-5,6965	10,8998
10 s	None	-15,3378	6,24750	,053	-30,8621	,1866
	5 s	-2,6017	3,33943	,719	-10,8998	5,6965

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.13 Tukey multiple comparisons of wicking test results (G1PU1-Warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-22,5000(*)	1,49429	,000	-26,5993	-18,4007
	DMF	-14,0833(*)	1,49429	,000	-18,1827	-9,9840
	Ethanol	-3,0000	1,49429	,211	-7,0993	1,0993
Acetone	None	22,5000(*)	1,49429	,000	18,4007	26,5993
	DMF	8,4167(*)	,94507	,000	5,8240	11,0093
	Ethanol	19,5000(*)	,94507	,000	16,9074	22,0926
DMF	None	14,0833(*)	1,49429	,000	9,9840	18,1827
	Acetone	-8,4167(*)	,94507	,000	-11,0093	-5,8240
	Ethanol	11,0833(*)	,94507	,000	8,4907	13,6760
Ethanol	None	3,0000	1,49429	,211	-1,0993	7,0993
	Acetone	-19,5000(*)	,94507	,000	-22,0926	-16,9074
	DMF	-11,0833(*)	,94507	,000	-13,6760	-8,4907

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-20,8333(*)	1,44362	,000	-24,4206	-17,2461
	1:50	-5,5556(*)	1,44362	,002	-9,1428	-1,9683
1:10	None	20,8333(*)	1,44362	,000	17,2461	24,4206
	1:50	15,2778(*)	,77165	,000	13,3603	17,1952
1:50	None	5,5556(*)	1,44362	,002	1,9683	9,1428
	1:10	-15,2778(*)	,77165	,000	-17,1952	-13,3603

b

(I)Duration Time	(J)Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-11,0556(*)	1,44362	,000	-14,6428	-7,4683
	10 s	-15,3333(*)	1,44362	,000	-18,9206	-11,7461
5 s	None	11,0556(*)	1,44362	,000	7,4683	14,6428
	10 s	-4,2778(*)	,77165	,000	-6,1952	-2,3603
10 s	None	15,3333(*)	1,44362	,000	11,7461	18,9206
	5 s	4,2778(*)	,77165	,000	2,3603	6,1952

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.14 Tukey multiple comparisons of wicking test results (G1PU1-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-22,5000(*)	1,52962	,000	-26,6962	-18,3038
	DMF	-16,8333(*)	1,52962	,000	-21,0296	-12,6371
	Ethanol	-5 s00(*)	1,52962	,015	-9,1962	-,8038
Acetone	None	22,5000(*)	1,52962	,000	18,3038	26,6962
	DMF	5,6667(*)	,96742	,000	3,0127	8,3206
	Ethanol	17,5000(*)	,96742	,000	14,8461	20,1539
DMF	None	16,8333(*)	1,52962	,000	12,6371	21,0296
	Acetone	-5,6667(*)	,96742	,000	-8,3206	-3,0127
	Ethanol	11,8333(*)	,96742	,000	9,1794	14,4873
Ethanol	None	5 s00(*)	1,52962	,015	,8038	9,1962
	Acetone	-17,5000(*)	,96742	,000	-20,1539	-14,8461
	DMF	-11,8333(*)	,96742	,000	-14,4873	-9,1794

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-21,7778(*)	1,47776	,000	-25,4498	-18,1057
	1:50	-7,7778(*)	1,47776	,000	-11,4498	-4,1057
1:10	None	21,7778(*)	1,47776	,000	18,1057	25,4498
	1:50	14,0000(*)	,78989	,000	12,0372	15,9628
1:50	None	7,7778(*)	1,47776	,000	4,1057	11,4498
	1:10	-14,0000(*)	,78989	,000	-15,9628	-12,0372

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-11,8333(*)	1,47776	,000	-15,5054	-8,1613
	10 s	-17,7222(*)	1,47776	,000	-21,3943	-14,0502
5 s	None	11,8333(*)	1,47776	,000	8,1613	15,5054
	10 s	-5,8889(*)	,78989	,000	-7,8517	-3,9261
10 s	None	17,7222(*)	1,47776	,000	14,0502	21,3943
	5 s	5,8889(*)	,78989	,000	3,9261	7,8517

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.15 Tukey multiple comparisons of wicking test results (G1PU2-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-20,9167(*)	1,40588	,000	-24,7734	-17,0599
	DMF	-12,2500(*)	1,40588	,000	-16,1068	-8,3932
	Ethanol	-5,9167(*)	1,40588	,001	-9,7734	-2,0599
Acetone	None	20,9167(*)	1,40588	,000	17,0599	24,7734
	DMF	8,6667(*)	,88916	,000	6,2274	11,1059
	Ethanol	15 s00(*)	,88916	,000	12,5608	17,4392
DMF	None	12,2500(*)	1,40588	,000	8,3932	16,1068
	Acetone	-8,6667(*)	,88916	,000	-11,1059	-6,2274
	Ethanol	6,3333(*)	,88916	,000	3,8941	8,7726
Ethanol	None	5,9167(*)	1,40588	,001	2,0599	9,7734
	Acetone	-15 s00(*)	,88916	,000	-17,4392	-12,5608
	DMF	-6,3333(*)	,88916	,000	-8,7726	-3,8941

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-18,5556(*)	1,35821	,000	-21,9306	-15,1806
	1:50	-7,5000(*)	1,35821	,000	-10,8750	-4,1250
1:10	None	18,5556(*)	1,35821	,000	15,1806	21,9306
	1:50	11,0556(*)	,72599	,000	9,2515	12,8596
1:50	None	7,5000(*)	1,35821	,000	4,1250	10,8750
	1:10	-11,0556(*)	,72599	,000	-12,8596	-9,2515

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-10,5000(*)	1,35821	,000	-13,8750	-7,1250
	10 s	-15,5556(*)	1,35821	,000	-18,9306	-12,1806
5 s	None	10,5000(*)	1,35821	,000	7,1250	13,8750
	10 s	-5,0556(*)	,72599	,000	-6,8596	-3,2515
10 s	None	15,5556(*)	1,35821	,000	12,1806	18,9306
	5 s	5,0556(*)	,72599	,000	3,2515	6,8596

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.16 Tukey multiple comparisons of wicking test results (G1PU2-weft (a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-27,0833(*)	1,06919	,000	-30,0165	-24,1502
	DMF	-19,5000(*)	1,06919	,000	-22,4331	-16,5669
	Ethanol	-10,5833(*)	1,06919	,000	-13,5165	-7,6502
Acetone	None	27,0833(*)	1,06919	,000	24,1502	30,0165
	DMF	7,5833(*)	,67621	,000	5,7283	9,4384
	Ethanol	16,5000(*)	,67621	,000	14,6449	18,3551
DMF	None	19,5000(*)	1,06919	,000	16,5669	22,4331
	Acetone	-7,5833(*)	,67621	,000	-9,4384	-5,7283
	Ethanol	8,9167(*)	,67621	,000	7,0616	10,7717
Ethanol	None	10,5833(*)	1,06919	,000	7,6502	13,5165
	Acetone	-16,5000(*)	,67621	,000	-18,3551	-14,6449
	DMF	-8,9167(*)	,67621	,000	-10,7717	-7,0616

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-24,0556(*)	1,03293	,000	-26,6223	-21,4888
	1:50	-14,0556(*)	1,03293	,000	-16,6223	-11,4888
1:10	None	24,0556(*)	1,03293	,000	21,4888	26,6223
	1:50	10 s00(*)	,55213	,000	8,6280	11,3720
1:50	None	14,0556(*)	1,03293	,000	11,4888	16,6223
	1:10	-10 s00(*)	,55213	,000	-11,3720	-8,6280

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-15,5000(*)	1,03293	,000	-18,0667	-12,9333
	10 s	-22,6111(*)	1,03293	,000	-25,1778	-20,0444
5 s	None	15,5000(*)	1,03293	,000	12,9333	18,0667
	10 s	-7,1111(*)	,55213	,000	-8,4831	-5,7391
10 s	None	22,6111(*)	1,03293	,000	20,0444	25,1778
	5 s	7,1111(*)	,55213	,000	5,7391	8,4831

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.17 Tukey multiple comparisons of wicking test results (G2PU1-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-17,5833(*)	1,11325	,000	-20,6373	-14,5293
	DMF	-19,3333(*)	1,11325	,000	-22,3873	-16,2793
	Ethanol	-19,2500(*)	1,11325	,000	-22,3040	-16,1960
Acetone	None	17,5833(*)	1,11325	,000	14,5293	20,6373
	DMF	-1,7500	,70408	,086	-3,6815	,1815
	Ethanol	-1,6667	,70408	,109	-3,5982	,2648
DMF	None	19,3333(*)	1,11325	,000	16,2793	22,3873
	Acetone	1,7500	,70408	,086	-,1815	3,6815
	Ethanol	,0833	,70408	,999	-1,8482	2,0148
Ethanol	None	19,2500(*)	1,11325	,000	16,1960	22,3040
	Acetone	1,6667	,70408	,109	-,2648	3,5982
	DMF	-,0833	,70408	,999	-2,0148	1,8482

a

(I)Concentration Rate	(J)Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-20,1667(*)	1,07550	,000	-22,8392	-17,4942
	1:50	-17,2778(*)	1,07550	,000	-19,9503	-14,6053
1:10	None	20,1667(*)	1,07550	,000	17,4942	22,8392
	1:50	2,8889(*)	,57488	,000	1,4604	4,3174
1:50	None	17,2778(*)	1,07550	,000	14,6053	19,9503
	1:10	-2,8889(*)	,57488	,000	-4,3174	-1,4604

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-17,2222(*)	1,07550	,000	-19,8947	-14,5497
	10 s	-20,2222(*)	1,07550	,000	-22,8947	-17,5497
5 s	None	17,2222(*)	1,07550	,000	14,5497	19,8947
	10 s	-3,0000(*)	,57488	,000	-4,4285	-1,5715
10 s	None	20,2222(*)	1,07550	,000	17,5497	22,8947
	5 s	3,0000(*)	,57488	,000	1,5715	4,4285

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.18 Tukey multiple comparisons of wicking test results (G2PU1-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-24,4167(*)	,94733	,000	-27,0155	-21,8178
	DMF	-26,5000(*)	,94733	,000	-29,0988	-23,9012
	Ethanol	-27,0000(*)	,94733	,000	-29,5988	-24,4012
Acetone	None	24,4167(*)	,94733	,000	21,8178	27,0155
	DMF	-2,0833(*)	,59914	,009	-3,7270	-,4397
	Ethanol	-2,5833(*)	,59914	,001	-4,2270	-,9397
DMF	None	26,5000(*)	,94733	,000	23,9012	29,0988
	Acetone	2,0833(*)	,59914	,009	,4397	3,7270
	Ethanol	-,5000	,59914	,838	-2,1436	1,1436
Ethanol	None	27,0000(*)	,94733	,000	24,4012	29,5988
	Acetone	2,5833(*)	,59914	,001	,9397	4,2270
	DMF	,5000	,59914	,838	-1,1436	2,1436

a

(I)Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-27,5000(*)	,91521	,000	-29,7742	-25,2258
	1:50	-24,4444(*)	,91521	,000	-26,7186	-22,1702
1:10	None	27,5000(*)	,91521	,000	25,2258	29,7742
	1:50	3,0556(*)	,48920	,000	1,8399	4,2712
1:50	None	24,4444(*)	,91521	,000	22,1702	26,7186
	1:10	-3,0556(*)	,48920	,000	-4,2712	-1,8399

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-25,1111(*)	,91521	,000	-27,3853	-22,8369
	10 s	-26,8333(*)	,91521	,000	-29,1075	-24,5591
5 s	None	25,1111(*)	,91521	,000	22,8369	27,3853
	10 s	-1,7222(*)	,48920	,004	-2,9378	-,5066
10 s	None	26,8333(*)	,91521	,000	24,5591	29,1075
	5 s	1,7222(*)	,48920	,004	,5066	2,9378

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.19 Tukey multiple comparisons of wicking test results (G2PU2-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-19,6667(*)	1,16483	,000	-22,8622	-16,4712
	DMF	-18,9167(*)	1,16483	,000	-22,1122	-15,7212
	Ethanol	-20,3333(*)	1,16483	,000	-23,5288	-17,1378
Acetone	None	19,6667(*)	1,16483	,000	16,4712	22,8622
	DMF	,7500	,73671	,740	-1,2710	2,7710
	Ethanol	-,6667	,73671	,802	-2,6877	1,3544
DMF	None	18,9167(*)	1,16483	,000	15,7212	22,1122
	Acetone	-,7500	,73671	,740	-2,7710	1,2710
	Ethanol	-1,4167	,73671	,243	-3,4377	,6044
Ethanol	None	20,3333(*)	1,16483	,000	17,1378	23,5288
	Acetone	,6667	,73671	,802	-1,3544	2,6877
	DMF	1,4167	,73671	,243	-,6044	3,4377

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-20,4444(*)	1,12534	,000	-23,2408	-17,6481
	1:50	-18,8333(*)	1,12534	,000	-21,6297	-16,0370
1:10	None	20,4444(*)	1,12534	,000	17,6481	23,2408
	1:50	1,6111(*)	,60152	,033	,1164	3,1058
1:50	None	18,8333(*)	1,12534	,000	16,0370	21,6297
	1:10	-1,6111(*)	,60152	,033	-3,1058	-,1164

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-18,2778(*)	1,12534	,000	-21,0741	-15,4814
	10 s	-21,0000(*)	1,12534	,000	-23,7963	-18,2037
5 s	None	18,2778(*)	1,12534	,000	15,4814	21,0741
	10 s	-2,7222(*)	,60152	,000	-4,2169	-1,2275
10 s	None	21,0000(*)	1,12534	,000	18,2037	23,7963
	5 s	2,7222(*)	,60152	,000	1,2275	4,2169

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.20 Tukey multiple comparisons of wicking test results (G2PU2-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-27,0833(*)	,83972	,000	-29,3870	-24,7797
	DMF	-29,5833(*)	,83972	,000	-31,8870	-27,2797
	Ethanol	-28,0000(*)	,83972	,000	-30,3036	-25,6964
Acetone	None	27,0833(*)	,83972	,000	24,7797	29,3870
	DMF	-2,5000(*)	,53109	,000	-3,9569	-1,0431
	Ethanol	-,9167	,53109	,331	-2,3736	,5403
DMF	None	29,5833(*)	,83972	,000	27,2797	31,8870
	Acetone	2,5000(*)	,53109	,000	1,0431	3,9569
	Ethanol	1,5833(*)	,53109	,029	,1264	3,0403
Ethanol	None	28,0000(*)	,83972	,000	25,6964	30,3036
	Acetone	,9167	,53109	,331	-,5403	2,3736
	DMF	-1,5833(*)	,53109	,029	-3,0403	-,1264

a

(I)Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-28,8333(*)	,81125	,000	-30,8492	-26,8175
	1:50	-27,6111(*)	,81125	,000	-29,6270	-25,5953
1:10	None	28,8333(*)	,81125	,000	26,8175	30,8492
	1:50	1,2222(*)	,43363	,024	,1447	2,2997
1:50	None	27,6111(*)	,81125	,000	25,5953	29,6270
	1:10	-1,2222(*)	,43363	,024	-2,2997	-,1447

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-28,3333(*)	,81125	,000	-30,3492	-26,3175
	10 s	-28,1111(*)	,81125	,000	-30,1270	-26,0953
5 s	None	28,3333(*)	,81125	,000	26,3175	30,3492
	10 s	,2222	,43363	,866	-,8553	1,2997
10 s	None	28,1111(*)	,81125	,000	26,0953	30,1270
	5 s	-,2222	,43363	,866	-1,2997	,8553

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.21 Tukey multiple comparisons of water resistance test results (G1PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	2,9917(*)	,31009	,000	2,1410	3,8423
	DMF	2,3167(*)	,31009	,000	1,4660	3,1673
	Ethanol	2,0750(*)	,31009	,000	1,2243	2,9257
Acetone	None	-2,9917(*)	,31009	,000	-3,8423	-2,1410
	DMF	-,6750(*)	,19612	,010	-1,2130	-,1370
	Ethanol	-,9167(*)	,19612	,000	-1,4547	-,3787
DMF	None	-2,3167(*)	,31009	,000	-3,1673	-1,4660
	Acetone	,6750(*)	,19612	,010	,1370	1,2130
	Ethanol	-,2417	,19612	,613	-,7797	,2963
Ethanol	None	-2,0750(*)	,31009	,000	-2,9257	-1,2243
	Acetone	,9167(*)	,19612	,000	,3787	1,4547
	DMF	,2417	,19612	,613	-,2963	,7797

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	2,6500(*)	,29957	,000	1,9056	3,3944
	1:50	2,2722(*)	,29957	,000	1,5278	3,0166
1:10	None	-2,6500(*)	,29957	,000	-3,3944	-1,9056
	1:50	-,3778	,16013	,065	-,7757	,0201
1:50	None	-2,2722(*)	,29957	,000	-3,0166	-1,5278
	1:10	,3778	,16013	,065	-,0201	,7757

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	2,1778(*)	,29957	,000	1,4334	2,9222
	10 s	2,7444(*)	,29957	,000	2,0000	3,4888
5 s	None	-2,1778(*)	,29957	,000	-2,9222	-1,4334
	10 s	,5667(*)	,16013	,004	,1688	,9646
10 s	None	-2,7444(*)	,29957	,000	-3,4888	-2,0000
	5 s	-,5667(*)	,16013	,004	-,9646	-,1688

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.22 Tukey multiple comparisons of water resistance test results (G1PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	2,6083(*)	,28457	,000	1,8277	3,3890
	DMF	2,0750(*)	,28457	,000	1,2943	2,8557
	Ethanol	2,1750(*)	,28457	,000	1,3943	2,9557
Acetone	None	-2,6083(*)	,28457	,000	-3,3890	-1,8277
	DMF	-,5333(*)	,17998	,031	-1,0271	-,0396
	Ethanol	-,4333	,17998	,101	-,9271	,0604
DMF	None	-2,0750(*)	,28457	,000	-2,8557	-1,2943
	Acetone	,5333(*)	,17998	,031	,0396	1,0271
	Ethanol	,1000	,17998	,944	-,3937	,5937
Ethanol	None	-2,1750(*)	,28457	,000	-2,9557	-1,3943
	Acetone	,4333	,17998	,101	-,0604	,9271
	DMF	-,1000	,17998	,944	-,5937	,3937

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	2,5222(*)	,27493	,000	1,8391	3,2054
	1:50	2,0500(*)	,27493	,000	1,3668	2,7332
1:10	None	-2,5222(*)	,27493	,000	-3,2054	-1,8391
	1:50	-,4722(*)	,14695	,009	-,8374	-,1071
1:50	None	-2,0500(*)	,27493	,000	-2,7332	-1,3668
	1:10	,4722(*)	,14695	,009	,1071	,8374

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	1,8000(*)	,27493	,000	1,1168	2,4832
	10 s	2,7722(*)	,27493	,000	2,0891	3,4554
5 s	None	-1,8000(*)	,27493	,000	-2,4832	-1,1168
	10 s	,9722(*)	,14695	,000	,6071	1,3374
10 s	None	-2,7722(*)	,27493	,000	-3,4554	-2,0891
	5 s	-,9722(*)	,14695	,000	-1,3374	-,6071

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.23 Tukey multiple comparisons of water resistance test results (G2PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,7833	,34437	,130	-1,7280	,1614
	DMF	-,6417	,34437	,268	-1,5864	,3030
	Ethanol	-,5083	,34437	,466	-1,4530	,4364
Acetone	None	,7833	,34437	,130	-,1614	1,7280
	DMF	,1417	,21780	,914	-,4558	,7392
	Ethanol	,2750	,21780	,594	-,3225	,8725
DMF	None	,6417	,34437	,268	-,3030	1,5864
	Acetone	-,1417	,21780	,914	-,7392	,4558
	Ethanol	,1333	,21780	,927	-,4642	,7308
Ethanol	None	,5083	,34437	,466	-,4364	1,4530
	Acetone	-,2750	,21780	,594	-,8725	,3225
	DMF	-,1333	,21780	,927	-,7308	,4642

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,5833	,33269	,205	-1,4100	,2434
	1:50	-,7056	,33269	,105	-1,5323	,1211
1:10	None	,5833	,33269	,205	-,2434	1,4100
	1:50	-,1222	,17783	,773	-,5641	,3197
1:50	None	,7056	,33269	,105	-,1211	1,5323
	1:10	,1222	,17783	,773	-,3197	,5641

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,7778	,33269	,068	-1,6045	,0489
	10 s	-,5111	,33269	,291	-1,3378	,3156
5 s	None	,7778	,33269	,068	-,0489	1,6045
	10 s	,2667	,17783	,308	-,1752	,7086
10 s	None	,5111	,33269	,291	-,3156	1,3378
	5 s	-,2667	,17783	,308	-,7086	,1752

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.24 Tukey multiple comparisons of water resistance test results (G2PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	,0083	,24957	1,000	-,6763	,6930
	DMF	,0167	,24957	1,000	-,6680	,7013
	Ethanol	,7417(*)	,24957	,030	,0570	1,4263
Acetone	None	-,0083	,24957	1,000	-,6930	,6763
	DMF	,0083	,15784	1,000	-,4247	,4413
	Ethanol	,7333(*)	,15784	,000	,3003	1,1663
DMF	None	-,0167	,24957	1,000	-,7013	,6680
	Acetone	-,0083	,15784	1,000	-,4413	,4247
	Ethanol	,7250(*)	,15784	,001	,2920	1,1580
Ethanol	None	-,7417(*)	,24957	,030	-1,4263	-,0570
	Acetone	-,7333(*)	,15784	,000	-1,1663	-,3003
	DMF	-,7250(*)	,15784	,001	-1,1580	-,2920

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	,4778	,24111	,137	-,1214	1,0769
	1:50	,0333	,24111	,990	-,5658	,6325
1:10	None	-,4778	,24111	,137	-1,0769	,1214
	1:50	-,4444(*)	,12888	,005	-,7647	-,1242
1:50	None	-,0333	,24111	,990	-,6325	,5658
	1:10	,4444(*)	,12888	,005	,1242	,7647

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	,0667	,24111	,959	-,5325	,6658
	10 s	,4444	,24111	,176	-,1547	1,0436
5 s	None	-,0667	,24111	,959	-,6658	,5325
	10 s	,3778(*)	,12888	,018	,0575	,6980
10 s	None	-,4444	,24111	,176	-1,0436	,1547
	5 s	-,3778(*)	,12888	,018	-,6980	-,0575

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.25 Tukey multiple comparisons of breaking strength test results (G1PU1-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-17,5000	36,17591	,962	-116,7421	81,7421
	DMF	-52,5000	36,17591	,480	-151,7421	46,7421
	Ethanol	1,5000	36,17591	1,000	-97,7421	100,7421
Acetone	None	17,5000	36,17591	,962	-81,7421	116,7421
	DMF	-35 s00	22,87966	,435	-97,7662	27,7662
	Ethanol	11:1000	22,87966	,840	-43,7662	81,7662
DMF	None	52,5000	36,17591	,480	-46,7421	151,7421
	Acetone	35 s00	22,87966	,435	-27,7662	97,7662
	Ethanol	54,0000	22,87966	,110	-8,7662	116,7662
Ethanol	None	-1,5000	36,17591	1,000	-100,7421	97,7421
	Acetone	-11:1000	22,87966	,840	-81,7662	43,7662
	DMF	-54,0000	22,87966	,110	-116,7662	8,7662

a

(I) Concentration Rate	(J)Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-16,8333	34,94925	,881	-103,6785	70,0118
	1:50	-28,8333	34,94925	,691	-115,6785	58,0118
1:10	None	16,8333	34,94925	,881	-70,0118	103,6785
	1:50	-12,0000	18,68116	,798	-58,4207	34,4207
1:50	None	28,8333	34,94925	,691	-58,0118	115,6785
	1:10	12,0000	18,68116	,798	-34,4207	58,4207

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-30,1111	34,94925	,669	-116,9563	56,7341
	10 s	-15,5556	34,94925	,897	-102,4007	71,2896
5 s	None	30,1111	34,94925	,669	-56,7341	116,9563
	10 s	14,5556	18,68116	,719	-31,8651	60,9763
10 s	None	15,5556	34,94925	,897	-71,2896	102,4007
	5 s	-14,5556	18,68116	,719	-60,9763	31,8651

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.26 Tukey multiple comparisons of breaking strength test results (G1PU1-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-87,7500	32,65299	,056	-177,3276	1,8276
	DMF	-146,4167(*)	32,65299	,001	-235,9943	-56,8391
	Ethanol	-18,3333	32,65299	,943	-107,9109	71,2443
Acetone	None	87,7500	32,65299	,056	-1,8276	177,3276
	DMF	-58,6667(*)	20,65157	,040	-115,3205	-2,0128
	Ethanol	69,4167(*)	20,65157	,012	12,7628	126,0705
DMF	None	146,4167(*)	32,65299	,001	56,8391	235,9943
	Acetone	58,6667(*)	20,65157	,040	2,0128	115,3205
	Ethanol	128,0833(*)	20,65157	,000	71,4295	184,7372
Ethanol	None	18,3333	32,65299	,943	-71,2443	107,9109
	Acetone	-69,4167(*)	20,65157	,012	-126,0705	-12,7628
	DMF	-128,0833(*)	20,65157	,000	-184,7372	-71,4295

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-106,1667(*)	31,54579	,007	-184,5546	-27,7787
	1:50	-62,1667	31,54579	,140	-140,5546	16,2213
1:10	None	106,1667(*)	31,54579	,007	27,7787	184,5546
	1:50	44,0000(*)	16,86193	,038	2,0999	85,9001
1:50	None	62,1667	31,54579	,140	-16,2213	140,5546
	1:10	-44,0000(*)	16,86193	,038	-85,9001	-2,0999

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-84,5556(*)	31,54579	,033	-162,9435	-6,1676
	10 s	-83,7778(*)	31,54579	,034	-162,1657	-5,3898
5 s	None	84,5556(*)	31,54579	,033	6,1676	162,9435
	10 s	,7778	16,86193	,999	-41,1223	42,6779
10 s	None	83,7778(*)	31,54579	,034	5,3898	162,1657
	5 s	-,7778	16,86193	,999	-42,6779	41,1223

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.27 Tukey multiple comparisons of breaking strength test results (G1PU2-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-7,9167	24,31541	,988	-74,6216	58,7883
	DMF	-54,0000	24,31541	,144	-120,7050	12,7050
	Ethanol	-29,2500	24,31541	,631	-95,9550	37,4550
Acetone	None	7,9167	24,31541	,988	-58,7883	74,6216
	DMF	-46,0833(*)	15,37842	,028	-88,2713	-3,8954
	Ethanol	-21,3333	15,37842	,518	-63,5213	20,8546
DMF	None	54,0000	24,31541	,144	-12,7050	120,7050
	Acetone	46,0833(*)	15,37842	,028	3,8954	88,2713
	Ethanol	24,7500	15,37842	,391	-17,4379	66,9379
Ethanol	None	29,2500	24,31541	,631	-37,4550	95,9550
	Acetone	21,3333	15,37842	,518	-20,8546	63,5213
	DMF	-24,7500	15,37842	,391	-66,9379	17,4379

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-24,5000	23,49092	,557	-82,8724	33,8724
	1:50	-36,2778	23,49092	,287	-94,6502	22,0947
1:10	None	24,5000	23,49092	,557	-33,8724	82,8724
	1:50	-11,7778	12,55643	,622	-42,9792	19,4236
1:50	None	36,2778	23,49092	,287	-22,0947	94,6502
	1:10	11,7778	12,55643	,622	-19,4236	42,9792

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-30,7778	23,49092	,402	-89,1502	27,5947
	10 s	-30,0000	23,49092	,420	-88,3724	28,3724
5 s	None	30,7778	23,49092	,402	-27,5947	89,1502
	10 s	,7778	12,55643	,998	-30,4236	31,9792
10 s	None	30,0000	23,49092	,420	-28,3724	88,3724
	5 s	-,7778	12,55643	,998	-31,9792	30,4236

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.28 Tukey multiple comparisons of breaking strength test results (G1PU2-weft) (a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-81,9167	38,33305	,168	-187,0765	23,2432
	DMF	-83,9167	38,33305	,153	-189,0765	21,2432
	Ethanol	-27,3333	38,33305	,891	-132,4932	77,8265
Acetone	None	81,9167	38,33305	,168	-23,2432	187,0765
	DMF	-2,0000	24,24395	1,000	-68,5089	64,5089
	Ethanol	54,5833	24,24395	,136	-11,9256	121,0922
DMF	None	83,9167	38,33305	,153	-21,2432	189,0765
	Acetone	2,0000	24,24395	1,000	-64,5089	68,5089
	Ethanol	56,5833	24,24395	,116	-9,9256	123,0922
Ethanol	None	27,3333	38,33305	,891	-77,8265	132,4932
	Acetone	-54,5833	24,24395	,136	-121,0922	11,9256
	DMF	-56,5833	24,24395	,116	-123,0922	9,9256

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-80,9444	37,03325	,093	-172,9681	11,0792
	1:50	-47,8333	37,03325	,412	-139,8570	44,1904
1:10	None	80,9444	37,03325	,093	-11,0792	172,9681
	1:50	33,1111	19,79510	,235	-16,0776	82,2998
1:50	None	47,8333	37,03325	,412	-44,1904	139,8570
	1:10	-33,1111	19,79510	,235	-82,2998	16,0776

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-61,2778	37,03325	,242	-153,3015	30,7459
	10 s	-67,5000	37,03325	,182	-159,5237	24,5237
5 s	None	61,2778	37,03325	,242	-30,7459	153,3015
	10 s	-6,2222	19,79510	,947	-55,4110	42,9665
10 s	None	67,5000	37,03325	,182	-24,5237	159,5237
	5 s	6,2222	19,79510	,947	-42,9665	55,4110

c

Based on observed means.
* The mean difference is significant at the ,05 level.

Table B.29 Tukey multiple comparisons of breaking strength test results (G2PU1-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-36,3333	73,32080	,959	-237,4757	164,8091
	DMF	-42,0000	73,32080	,939	-243,1424	159,1424
	Ethanol	-84,8333	73,32080	,658	-285,9757	116,3091
Acetone	None	36,3333	73,32080	,959	-164,8091	237,4757
	DMF	-5,6667	46,37215	,999	-132,8803	121,5470
	Ethanol	-48,5000	46,37215	,724	-175,7136	78,7136
DMF	None	42,0000	73,32080	,939	-159,1424	243,1424
	Acetone	5,6667	46,37215	,999	-121,5470	132,8803
	Ethanol	-42,8333	46,37215	,792	-170,0470	84,3803
Ethanol	None	84,8333	73,32080	,658	-116,3091	285,9757
	Acetone	48,5000	46,37215	,724	-78,7136	175,7136
	DMF	42,8333	46,37215	,792	-84,3803	170,0470

a

(I)Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-45,9444	70,83463	,795	-221,9610	130,0721
	1:50	-62,8333	70,83463	,653	-238,8499	113,1832
1:10	None	45,9444	70,83463	,795	-130,0721	221,9610
	1:50	-16,8889	37,86270	,897	-110,9737	77,1959
1:50	None	62,8333	70,83463	,653	-113,1832	238,8499
	1:10	16,8889	37,86270	,897	-77,1959	110,9737

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-79,5000	70,83463	,509	-255,5165	96,5165
	10 s	-29,2778	70,83463	,910	-205,2943	146,7387
5 s	None	79,5000	70,83463	,509	-96,5165	255,5165
	10 s	50,2222	37,86270	,394	-43,8626	144,3070
10 s	None	29,2778	70,83463	,910	-146,7387	205,2943
	5 s	-50,2222	37,86270	,394	-144,3070	43,8626

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.30 Tukey multiple comparisons of breaking strength test results (G2PU1-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-168,8333(*)	38,34378	,001	-274,0226	-63,6441
	DMF	-197,8333(*)	38,34378	,000	-303,0226	-92,6441
	Ethanol	-182,0833(*)	38,34378	,000	-287,2726	-76,8941
Acetone	None	168,8333(*)	38,34378	,001	63,6441	274,0226
	DMF	-21:1000	24,25074	,635	-95,5275	37,5275
	Ethanol	-13,2500	24,25074	,947	-79,7775	53,2775
DMF	None	197,8333(*)	38,34378	,000	92,6441	303,0226
	Acetone	21:1000	24,25074	,635	-37,5275	95,5275
	Ethanol	15,7500	24,25074	,915	-50,7775	82,2775
Ethanol	None	182,0833(*)	38,34378	,000	76,8941	287,2726
	Acetone	13,2500	24,25074	,947	-53,2775	79,7775
	DMF	-15,7500	24,25074	,915	-82,2775	50,7775

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-163,6667(*)	37,04361	,000	-255,7161	-71,6172
	1:50	-202,1667(*)	37,04361	,000	-294,2161	-110,1172
1:10	None	163,6667(*)	37,04361	,000	71,6172	255,7161
	1:50	-38,5000	19,80064	,147	-87,7025	10,7025
1:50	None	202,1667(*)	37,04361	,000	110,1172	294,2161
	1:10	38,5000	19,80064	,147	-10,7025	87,7025

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-169,5000(*)	37,04361	,000	-261,5494	-77,4506
	10 s	-196,3333(*)	37,04361	,000	-288,3828	-104,2839
5 s	None	169,5000(*)	37,04361	,000	77,4506	261,5494
	10 s	-26,8333	19,80064	,379	-76,0358	22,3692
10 s	None	196,3333(*)	37,04361	,000	104,2839	288,3828
	5 s	26,8333	19,80064	,379	-22,3692	76,0358

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.31 Tukey multiple comparisons of breaking strength test results (G2PU2-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	31,6667	61,20566	,954	-136,2400	199,5734
	DMF	97,7500	61,20566	,398	-70,1567	265,6567
	Ethanol	127,2500	61,20566	,186	-40,6567	295,1567
Acetone	None	-31,6667	61,20566	,954	-199,5734	136,2400
	DMF	66,0833	38,70986	,340	-40,1102	172,2769
	Ethanol	95,5833	38,70986	,089	-10,6102	201,7769
DMF	None	-97,7500	61,20566	,398	-265,6567	70,1567
	Acetone	-66,0833	38,70986	,340	-172,2769	40,1102
	Ethanol	29,5000	38,70986	,871	-76,6935	135,6935
Ethanol	None	-127,2500	61,20566	,186	-295,1567	40,6567
	Acetone	-95,5833	38,70986	,089	-201,7769	10,6102
	DMF	-29,5000	38,70986	,871	-135,6935	76,6935

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	78,8333	59,13028	,390	-68,0991	225,7658
	1:50	92,2778	59,13028	,280	-54,6547	239,2103
1:10	None	-78,8333	59,13028	,390	-225,7658	68,0991
	1:50	13,4444	31,60647	,905	-65,0943	91,9832
1:50	None	-92,2778	59,13028	,280	-239,2103	54,6547
	1:10	-13,4444	31,60647	,905	-91,9832	65,0943

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	73,2222	59,13028	,442	-73,7103	220,1547
	10 s	97,8889	59,13028	,241	-49,0436	244,8214
5 s	None	-73,2222	59,13028	,442	-220,1547	73,7103
	10 s	24,6667	31,60647	,718	-53,8720	103,2054
10 s	None	-97,8889	59,13028	,241	-244,8214	49,0436
	5 s	-24,6667	31,60647	,718	-103,2054	53,8720

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.32 Tukey multiple comparisons of breaking strength test results (G2PU2-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-26,7500	35,15138	,871	-123,1815	69,6815
	DMF	-60,5833	35,15138	,332	-157,0148	35,8482
	Ethanol	-66,7500	35,15138	,253	-163,1815	29,6815
Acetone	None	26,7500	35,15138	,871	-69,6815	123,1815
	DMF	-33,8333	22,23169	,439	-94,8220	27,1553
	Ethanol	-40,0000	22,23169	,296	-100,9886	20,9886
DMF	None	60,5833	35,15138	,332	-35,8482	157,0148
	Acetone	33,8333	22,23169	,439	-27,1553	94,8220
	Ethanol	-6,1667	22,23169	,992	-67,1553	54,8220
Ethanol	None	66,7500	35,15138	,253	-29,6815	163,1815
	Acetone	40,0000	22,23169	,296	-20,9886	100,9886
	DMF	6,1667	22,23169	,992	-54,8220	67,1553

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-44,9444	33,95946	,395	-129,3301	39,4412
	1:50	-57,7778	33,95946	,224	-142,1634	26,6079
1:10	None	44,9444	33,95946	,395	-39,4412	129,3301
	1:50	-12,8333	18,15210	,762	-57,9394	32,2727
1:50	None	57,7778	33,95946	,224	-26,6079	142,1634
	1:10	12,8333	18,15210	,762	-32,2727	57,9394

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-63,7778	33,95946	,165	-148,1634	20,6079
	10 s	-38,9444	33,95946	,495	-123,3301	45,4412
5 s	None	63,7778	33,95946	,165	-20,6079	148,1634
	10 s	24,8333	18,15210	,372	-20,2727	69,9394
10 s	None	38,9444	33,95946	,495	-45,4412	123,3301
	5 s	-24,8333	18,15210	,372	-69,9394	20,2727

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.33 Tukey multiple comparisons of breaking elongation test results (G1PU1-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-2,5000(*)	,49571	,000	-3,8599	-1,1401
	DMF	-2,9167(*)	,49571	,000	-4,2766	-1,5568
	Ethanol	-1,4167(*)	,49571	,039	-2,7766	-,0568
Acetone	None	2,5000(*)	,49571	,000	1,1401	3,8599
	DMF	-,4167	,31351	,553	-1,2767	,4434
	Ethanol	1,0833(*)	,31351	,010	,2233	1,9434
DMF	None	2,9167(*)	,49571	,000	1,5568	4,2766
	Acetone	,4167	,31351	,553	-,4434	1,2767
	Ethanol	1,5000(*)	,31351	,000	,6399	2,3601
Ethanol	None	1,4167(*)	,49571	,039	,0568	2,7766
	Acetone	-1,0833(*)	,31351	,010	-1,9434	-,2233
	DMF	-1,5000(*)	,31351	,000	-2,3601	-,6399

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-2,4444(*)	,47890	,000	-3,6345	-1,2544
	1:50	-2,1111(*)	,47890	,000	-3,3011	-,9211
1:10	None	2,4444(*)	,47890	,000	1,2544	3,6345
	1:50	,3333	,25598	,407	-,3028	,9694
1:50	None	2,1111(*)	,47890	,000	,9211	3,3011
	1:10	-,3333	,25598	,407	-,9694	,3028

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-2,0000(*)	,47890	,001	-3,1900	-,8100
	10 s	-2,5556(*)	,47890	,000	-3,7456	-1,3655
5 s	None	2,0000(*)	,47890	,001	,8100	3,1900
	10 s	-,5556	,25598	,095	-1,1916	,0805
10 s	None	2,5556(*)	,47890	,000	1,3655	3,7456
	5 s	,5556	,25598	,095	-,0805	1,1916

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.34 Tukey multiple comparisons of breaking elongation test results (G1PU1-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-1,4167	,69338	,199	-3,3188	,4855
	DMF	-2,1667(*)	,69338	,021	-4,0688	-,2645
	Ethanol	1,5000	,69338	,160	-,4022	3,4022
Acetone	None	1,4167	,69338	,199	-,4855	3,3188
	DMF	-,7500	,43853	,339	-1,9530	,4530
	Ethanol	2,9167(*)	,43853	,000	1,7136	4,1197
DMF	None	2,1667(*)	,69338	,021	,2645	4,0688
	Acetone	,7500	,43853	,339	-,4530	1,9530
	Ethanol	3,6667(*)	,43853	,000	2,4636	4,8697
Ethanol	None	-1,5000	,69338	,160	-3,4022	,4022
	Acetone	-2,9167(*)	,43853	,000	-4,1197	-1,7136
	DMF	-3,6667(*)	,43853	,000	-4,8697	-2,4636

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-1,8333(*)	,66986	,029	-3,4979	-,1688
	1:50	,4444	,66986	,786	-1,2201	2,1090
1:10	None	1,8333(*)	,66986	,029	,1688	3,4979
	1:50	2,2778(*)	,35806	,000	1,3880	3,1675
1:50	None	-,4444	,66986	,786	-2,1090	1,2201
	1:10	-2,2778(*)	,35806	,000	-3,1675	-1,3880

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-1,2222	,66986	,181	-2,8868	,4423
	10 s	-,1667	,66986	,966	-1,8312	1,4979
5 s	None	1,2222	,66986	,181	-,4423	2,8868
	10 s	1,0556(*)	,35806	,018	,1658	1,9453
10 s	None	,1667	,66986	,966	-1,4979	1,8312
	5 s	-1,0556(*)	,35806	,018	-1,9453	-,1658

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.35 Tukey multiple comparisons of breaking elongation test results (G1PU2-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-2,0833(*)	,32686	,000	-2,9800	-1,1867
	DMF	-2,8333(*)	,32686	,000	-3,7300	-1,9367
	Ethanol	-,9167(*)	,32686	,044	-1,8133	-,0200
Acetone	None	2,0833(*)	,32686	,000	1,1867	2,9800
	DMF	-,7500(*)	,20672	,006	-1,3171	-,1829
	Ethanol	1,1667(*)	,20672	,000	,5996	1,7338
DMF	None	2,8333(*)	,32686	,000	1,9367	3,7300
	Acetone	,7500(*)	,20672	,006	,1829	1,3171
	Ethanol	1,9167(*)	,20672	,000	1,3496	2,4838
Ethanol	None	,9167(*)	,32686	,044	,0200	1,8133
	Acetone	-1,1667(*)	,20672	,000	-1,7338	-,5996
	DMF	-1,9167(*)	,20672	,000	-2,4838	-1,3496

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-2,3889(*)	,31578	,000	-3,1736	-1,6042
	1:50	-1,5000(*)	,31578	,000	-2,2847	-,7153
1:10	None	2,3889(*)	,31578	,000	1,6042	3,1736
	1:50	,8889(*)	,16879	,000	,4695	1,3083
1:50	None	1,5000(*)	,31578	,000	,7153	2,2847
	1:10	-,8889(*)	,16879	,000	-1,3083	-,4695

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-1,5000(*)	,31578	,000	-2,2847	-,7153
	10 s	-2,3889(*)	,31578	,000	-3,1736	-1,6042
5 s	None	1,5000(*)	,31578	,000	,7153	2,2847
	10 s	-,8889(*)	,16879	,000	-1,3083	-,4695
10 s	None	2,3889(*)	,31578	,000	1,6042	3,1736
	5 s	,8889(*)	,16879	,000	,4695	1,3083

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.36 Tukey multiple comparisons of breaking elongation test results (G1PU2-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-2,0833(*)	,49571	,001	-3,4432	-,7234
	DMF	-2,8333(*)	,49571	,000	-4,1932	-1,4734
	Ethanol	-1,0000	,49571	,208	-2,3599	,3599
Acetone	None	2,0833(*)	,49571	,001	,7234	3,4432
	DMF	-,7500	,31351	,104	-1,6101	,1101
	Ethanol	1,0833(*)	,31351	,010	,2233	1,9434
DMF	None	2,8333(*)	,49571	,000	1,4734	4,1932
	Acetone	,7500	,31351	,104	-,1101	1,6101
	Ethanol	1,8333(*)	,31351	,000	,9733	2,6934
Ethanol	None	1,0000	,49571	,208	-,3599	2,3599
	Acetone	-1,0833(*)	,31351	,010	-1,9434	-,2233
	DMF	-1,8333(*)	,31351	,000	-2,6934	-,9733

a

(I)Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-2,0556(*)	,47890	,001	-3,2456	-,8655
	1:50	-1,8889(*)	,47890	,002	-3,0789	-,6989
1:10	None	2,0556(*)	,47890	,001	,8655	3,2456
	1:50	,1667	,25598	,793	-,4694	,8028
1:50	None	1,8889(*)	,47890	,002	,6989	3,0789
	1:10	-,1667	,25598	,793	-,8028	,4694

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-1,7222(*)	,47890	,004	-2,9122	-,5322
	10 s	-2,2222(*)	,47890	,000	-3,4122	-1,0322
5 s	None	1,7222(*)	,47890	,004	,5322	2,9122
	10 s	-,5000	,25598	,144	-1,1361	,1361
10 s	None	2,2222(*)	,47890	,000	1,0322	3,4122
	5 s	,5000	,25598	,144	-,1361	1,1361

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.37 Tukey multiple comparisons of breaking elongation test results (G2PU1-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-3,6667(*)	,55662	,000	-5,1937	-2,1397
	DMF	-3,8333(*)	,55662	,000	-5,3603	-2,3063
	Ethanol	-3,9167(*)	,55662	,000	-5,4437	-2,3897
Acetone	None	3,6667(*)	,55662	,000	2,1397	5,1937
	DMF	-,1667	,35204	,964	-1,1324	,7991
	Ethanol	-,2500	,35204	,892	-1,2158	,7158
DMF	None	3,8333(*)	,55662	,000	2,3063	5,3603
	Acetone	,1667	,35204	,964	-,7991	1,1324
	Ethanol	-,0833	,35204	,995	-1,0491	,8824
Ethanol	None	3,9167(*)	,55662	,000	2,3897	5,4437
	Acetone	,2500	,35204	,892	-,7158	1,2158
	DMF	,0833	,35204	,995	-,8824	1,0491

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-3,9444(*)	,53775	,000	-5,2807	-2,6082
	1:50	-3,6667(*)	,53775	,000	-5 s29	-2,3304
1:10	None	3,9444(*)	,53775	,000	2,6082	5,2807
	1:50	,2778	,28744	,604	-,4365	,9920
1:50	None	3,6667(*)	,53775	,000	2,3304	5 s29
	1:10	-,2778	,28744	,604	-,9920	,4365

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-3,9444(*)	,53775	,000	-5,2807	-2,6082
	10 s	-3,6667(*)	,53775	,000	-5 s29	-2,3304
5 s	None	3,9444(*)	,53775	,000	2,6082	5,2807
	10 s	,2778	,28744	,604	-,4365	,9920
10 s	None	3,6667(*)	,53775	,000	2,3304	5 s29
	5 s	-,2778	,28744	,604	-,9920	,4365

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.38 Tukey multiple comparisons of breaking elongation test results (G2PU1-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,9167	,71611	,583	-2,8812	1,0479
	DMF	-2,1667(*)	,71611	,027	-4,1312	-,2021
	Ethanol	-,7500	,71611	,724	-2,7145	1,2145
Acetone	None	,9167	,71611	,583	-1,0479	2,8812
	DMF	-1,2500(*)	,45291	,048	-2,4925	-,0075
	Ethanol	,1667	,45291	,983	-1,0758	1,4091
DMF	None	2,1667(*)	,71611	,027	,2021	4,1312
	Acetone	1,2500(*)	,45291	,048	,0075	2,4925
	Ethanol	1,4167(*)	,45291	,021	,1742	2,6591
Ethanol	None	,7500	,71611	,724	-1,2145	2,7145
	Acetone	-,1667	,45291	,983	-1,4091	1,0758
	DMF	-1,4167(*)	,45291	,021	-2,6591	-,1742

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-1,1111	,69183	,261	-2,8302	,6080
	1:50	-1,4444	,69183	,112	-3,1636	,2747
1:10	None	1,1111	,69183	,261	-,6080	2,8302
	1:50	-,3333	,36980	,644	-1,2522	,5856
1:50	None	1,4444	,69183	,112	-,2747	3,1636
	1:10	,3333	,36980	,644	-,5856	1,2522

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,9444	,69183	,373	-2,6636	,7747
	10 s	-1,6111	,69183	,069	-3,3302	,1080
5 s	None	,9444	,69183	,373	-,7747	2,6636
	10 s	-,6667	,36980	,188	-1,5856	,2522
10 s	None	1,6111	,69183	,069	-,1080	3,3302
	5 s	,6667	,36980	,188	-,2522	1,5856

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.39 Tukey multiple comparisons of breaking elongation test results (G2PU2-warp)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-3,4167(*)	,37268	,000	-4,4390	-2,3943
	DMF	-3,5000(*)	,37268	,000	-4,5224	-2,4776
	Ethanol	-2,8333(*)	,37268	,000	-3,8557	-1,8110
Acetone	None	3,4167(*)	,37268	,000	2,3943	4,4390
	DMF	-,0833	,23570	,984	-,7299	,5633
	Ethanol	,5833	,23570	,088	-,0633	1,2299
DMF	None	3,5000(*)	,37268	,000	2,4776	4,5224
	Acetone	,0833	,23570	,984	-,5633	,7299
	Ethanol	,6667(*)	,23570	,042	,0201	1,3133
Ethanol	None	2,8333(*)	,37268	,000	1,8110	3,8557
	Acetone	-,5833	,23570	,088	-1,2299	,0633
	DMF	-,6667(*)	,23570	,042	-1,3133	-,0201

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-3,3333(*)	,36004	,000	-4,2280	-2,4387
	1:50	-3,1667(*)	,36004	,000	-4,0613	-2,2720
1:10	None	3,3333(*)	,36004	,000	2,4387	4,2280
	1:50	,1667	,19245	,666	-,3116	,6449
1:50	None	3,1667(*)	,36004	,000	2,2720	4,0613
	1:10	-,1667	,19245	,666	-,6449	,3116

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-3,3333(*)	,36004	,000	-4,2280	-2,4387
	10 s	-3,1667(*)	,36004	,000	-4,0613	-2,2720
5 s	None	3,3333(*)	,36004	,000	2,4387	4,2280
	10 s	,1667	,19245	,666	-,3116	,6449
10 s	None	3,1667(*)	,36004	,000	2,2720	4,0613
	5 s	-,1667	,19245	,666	-,6449	,3116

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.40 Tukey multiple comparisons of breaking elongation test results (G2PU2-weft)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-1,3333(*)	,46225	,037	-2,6014	-,0652
	DMF	-2,0833(*)	,46225	,001	-3,3514	-,8152
	Ethanol	-2,1667(*)	,46225	,000	-3,4348	-,8986
Acetone	None	1,3333(*)	,46225	,037	,0652	2,6014
	DMF	-,7500	,29235	,073	-1,5520	,0520
	Ethanol	-,8333(*)	,29235	,040	-1,6354	-,0313
DMF	None	2,0833(*)	,46225	,001	,8152	3,3514
	Acetone	,7500	,29235	,073	-,0520	1,5520
	Ethanol	-,0833	,29235	,992	-,8854	,7187
Ethanol	None	2,1667(*)	,46225	,000	,8986	3,4348
	Acetone	,8333(*)	,29235	,040	,0313	1,6354
	DMF	,0833	,29235	,992	-,7187	,8854

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-2,1111(*)	,44658	,000	-3,2208	-1,0014
	1:50	-1,6111(*)	,44658	,004	-2,7208	-,5014
1:10	None	2,1111(*)	,44658	,000	1,0014	3,2208
	1:50	,5000	,23870	,111	-,0932	1,0932
1:50	None	1,6111(*)	,44658	,004	,5014	2,7208
	1:10	-,5000	,23870	,111	-1,0932	,0932

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-1,9444(*)	,44658	,001	-3,0541	-,8348
	10 s	-1,7778(*)	,44658	,001	-2,8875	-,6681
5 s	None	1,9444(*)	,44658	,001	,8348	3,0541
	10 s	,1667	,23870	,767	-,4265	,7598
10 s	None	1,7778(*)	,44658	,001	,6681	2,8875
	5 s	-,1667	,23870	,767	-,7598	,4265

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.41 Tukey multiple comparisons of abrasion resistance test results (G1PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,0475	,13523	,985	-,4185	,3235
	DMF	-,3542	,13523	,065	-,7252	,0168
	Ethanol	,0717	,13523	,951	-,2993	,4427
Acetone	None	,0475	,13523	,985	-,3235	,4185
	DMF	-,3067(*)	,08553	,007	-,5413	-,0720
	Ethanol	,1192	,08553	,515	-,1155	,3538
DMF	None	,3542	,13523	,065	-,0168	,7252
	Acetone	,3067(*)	,08553	,007	,0720	,5413
	Ethanol	,4258(*)	,08553	,000	,1912	,6605
Ethanol	None	-,0717	,13523	,951	-,4427	,2993
	Acetone	-,1192	,08553	,515	-,3538	,1155
	DMF	-,4258(*)	,08553	,000	-,6605	-,1912

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,1661	,13065	,423	-,4908	,1585
	1:50	-,0539	,13065	,911	-,3785	,2708
1:10	None	,1661	,13065	,423	-,1585	,4908
	1:50	,1122	,06983	,261	-,0613	,2858
1:50	None	,0539	,13065	,911	-,2708	,3785
	1:10	-,1122	,06983	,261	-,2858	,0613

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,0200	,13065	,987	-,3446	,3046
	10 s	-,2000	,13065	,293	-,5246	,1246
5 s	None	,0200	,13065	,987	-,3046	,3446
	10 s	-,1800(*)	,06983	,041	-,3535	-,0065
10 s	None	,2000	,13065	,293	-,1246	,5246
	5 s	,1800(*)	,06983	,041	,0065	,3535

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.42 Tukey multiple comparisons of abrasion resistance test results (G1PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,4675(*)	,11954	,003	-,7954	-,1396
	DMF	-,6608(*)	,11954	,000	-,9888	-,3329
	Ethanol	-,7033(*)	,11954	,000	-1,0313	-,3754
Acetone	None	,4675(*)	,11954	,003	,1396	,7954
	DMF	-,1933	,07561	,074	-,4007	,0141
	Ethanol	-,2358(*)	,07561	,021	-,4432	-,0284
DMF	None	,6608(*)	,11954	,000	,3329	,9888
	Acetone	,1933	,07561	,074	-,0141	,4007
	Ethanol	-,0425	,07561	,942	-,2499	,1649
Ethanol	None	,7033(*)	,11954	,000	,3754	1,0313
	Acetone	,2358(*)	,07561	,021	,0284	,4432
	DMF	,0425	,07561	,942	-,1649	,2499

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,5744(*)	,11549	,000	-,8614	-,2875
	1:50	-,6467(*)	,11549	,000	-,9336	-,3597
1:10	None	,5744(*)	,11549	,000	,2875	,8614
	1:50	-,0722	,06173	,481	-,2256	,0812
1:50	None	,6467(*)	,11549	,000	,3597	,9336
	1:10	,0722	,06173	,481	-,0812	,2256

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,7961(*)	,11549	,000	-1,0831	-,5091
	10 s	-,4250(*)	,11549	,003	-,7120	-,1380
5 s	None	,7961(*)	,11549	,000	,5091	1,0831
	10 s	,3711(*)	,06173	,000	,2177	,5245
10 s	None	,4250(*)	,11549	,003	,1380	,7120
	5 s	-,3711(*)	,06173	,000	-,5245	-,2177

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.43 Tukey multiple comparisons of abrasion resistance test results (G2PU1)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	,0775	,13468	,939	-,2920	,4470
	DMF	-,0858	,13468	,919	-,4553	,2836
	Ethanol	-,0042	,13468	1,000	-,3736	,3653
Acetone	None	-,0775	,13468	,939	-,4470	,2920
	DMF	-,1633	,08518	,245	-,3970	,0703
	Ethanol	-,0817	,08518	,774	-,3153	,1520
DMF	None	,0858	,13468	,919	-,2836	,4553
	Acetone	,1633	,08518	,245	-,0703	,3970
	Ethanol	,0817	,08518	,774	-,1520	,3153
Ethanol	None	,0042	,13468	1,000	-,3653	,3736
	Acetone	,0817	,08518	,774	-,1520	,3153
	DMF	-,0817	,08518	,774	-,3153	,1520

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	,0572	,13011	,899	-,2661	,3805
	1:50	-,0656	,13011	,870	-,3889	,2578
1:10	None	-,0572	,13011	,899	-,3805	,2661
	1:50	-,1228	,06955	,201	-,2956	,0500
1:50	None	,0656	,13011	,870	-,2578	,3889
	1:10	,1228	,06955	,201	-,0500	,2956

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,0556	,13011	,905	-,3789	,2678
	10 s	,0472	,13011	,930	-,2761	,3705
5 s	None	,0556	,13011	,905	-,2678	,3789
	10 s	,1028	,06955	,318	-,0700	,2756
10 s	None	-,0472	,13011	,930	-,3705	,2761
	5 s	-,1028	,06955	,318	-,2756	,0700

c

Based on observed means.

* The mean difference is significant at the ,05 level.

Table B.44 Tukey multiple comparisons of abrasion resistance test results (G2PU2)

(a;chemical type, b;concentration rate, c;duration time)

(I) Chemical Type	(J) Chemical Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	Acetone	-,4483(*)	,13230	,011	-,8113	-,0854
	DMF	-,4442(*)	,13230	,012	-,8071	-,0812
	Ethanol	-,5958(*)	,13230	,001	-,9588	-,2329
Acetone	None	,4483(*)	,13230	,011	,0854	,8113
	DMF	,0042	,08368	1,000	-,2254	,2337
	Ethanol	-,1475	,08368	,313	-,3771	,0821
DMF	None	,4442(*)	,13230	,012	,0812	,8071
	Acetone	-,0042	,08368	1,000	-,2337	,2254
	Ethanol	-,1517	,08368	,290	-,3812	,0779
Ethanol	None	,5958(*)	,13230	,001	,2329	,9588
	Acetone	,1475	,08368	,313	-,0821	,3771
	DMF	,1517	,08368	,290	-,0779	,3812

a

(I) Concentration Rate	(J) Concentration Rate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	1:10	-,4028(*)	,12782	,011	-,7204	-,0852
	1:50	-,5894(*)	,12782	,000	-,9071	-,2718
1:10	None	,4028(*)	,12782	,011	,0852	,7204
	1:50	-,1867(*)	,06832	,029	-,3564	-,0169
1:50	None	,5894(*)	,12782	,000	,2718	,9071
	1:10	,1867(*)	,06832	,029	,0169	,3564

b

(I) Duration Time	(J) Duration Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
None	5 s	-,4506(*)	,12782	,004	-,7682	-,1329
	10 s	-,5417(*)	,12782	,001	-,8593	-,2241
5 s	None	,4506(*)	,12782	,004	,1329	,7682
	10 s	-,0911	,06832	,390	-,2609	,0787
10 s	None	,5417(*)	,12782	,001	,2241	,8593
	5 s	,0911	,06832	,390	-,0787	,2609

c

Based on observed means.

* The mean difference is significant at the ,05 level.