Evaluation study of water-based polyurethane composite as a coating for various textile fabrics

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Abstract:

Nowadays environmental concerns and impending legislation are in favor of non-solvent containing materials and reduction of VO, so In This invention studied the use of polyurethane binder (water-based) as coating film for different types of fabric at different fixation condition with suitable recipes.

Keywords: Polyurethane binder, water-based, coating.

Research background

Using Polyurethane (water-based) to coating a various textile fabrics that adding different properties to fabrics.

Research objective

Using Polyurethane (water-based) to coating fabrics without organic solvents, harmful to the environment.

Polyurethane considered as one of unique polymers that can achieve special and novel effects when applied as a coating material even in form of water-based, that high adhesion to fabrics and improve a physical properties for fabrics such as tear, tensile, elongation, pilling, abrasion.

Research importance

Water-based Polyurethane Dispersions make excellent Textile coatings. Suitable grades are inherently flexible, have superior tensile properties, and have excellent abrasion resistance. Waterborne polyurethane dispersions can be used by themselves or in conjunction with acrylic emulsions to reach just the right cost/performance balance for your specific application. All of our waterborne polyurethanes for textile coatings resins can be cross-linked to improve their overall properties for very high performance applications.

Methodology

Experimental analytical approach

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Research results

Polyurethane composites were studied as coating material for different types of fabrics 100%Cotton, 50/50% Cotton/Polyester blend, 100%Polyester.

the physical properties for 100%Cotton, 50/50% Cotton/Polyester blend, 100%Polyester without coating were tear strength equal (11.37, 8.90 , 22.55 N) respectively, tensile strength equal (250.86, 237.16 , 558.11 N) respectively, elongation at break equal (16.16, 9.59 , 19.4 %) respectively , pilling grade (2,1, 2-3) respectively, loss weight after abrasion equal (15, 30.3 , 10.6 %) respectively, fabric weight equal (148, 90, 110 gm./m2) respectively

The best recipe was 40/60 % PU/Water, the physical properties for 100%Cotton, 50/50% Cotton/Polyester blend, 100%Polyester coating were tear strength equal (16.37, 13.57, 26.15 N) respectively, tensile strength equal (288, 286, 589 N) respectively, elongation at break equal (18.1, 8.5, 23.4%) respectively , pilling grade (4,4, 4-5) respectively, loss weight after abrasion equal (2.5, 3.2, 2.6%) respectively, fabric weight equal (179, 132, 157 gm./m2) respectively and the fixation condition is at 1800C for 30 Sec.

That mean the polyurethane coating improve the physical and fatness properties of various fabrics

خلفية البحث

استخدام مركب البولى يوريثان المائى فى مجال التغطية للاقمشة المختلفة فيكسبها خصائص مختلفة

أهداف البحث

استخدام مركب البولى يوريثان فى التغطية على الاقمشة بدون استخدام مذيبات عضوية ضاره بالبيئة حيث انه له قدره عالية على الالتصاق بالخامات المختلفة وايضا يحسن من خصائص الخامات النسجية المختلفة مثل زيادة فى قوه الشد والاستطالة والتمزق ومقاومة التوبير والاحتكاك كما انه يعمل على زيادة وزن الخامة .

أهمية البحث

ترجع اهمية البحث فى تحقيق ما يلى :

-استخدام مركب البولى يوريثان غير ضارة بالبيئة ولا يستخدم مذيب عضوى وتلبى الاشتراطات البيئية .

-الحصول على تغطية جيدة تحسن من الخواص الميكانيكية والفيزيائية وتحسين خواص الثبات للالوان للخامات النسجية المختلفة.

منهجية البحث

يتبع البحث المنهج التحليلى التجريبى

نتائج البحث

تم دراسة مركب البولى يوريثان فى تغطية خامات قطن ، مخلوط (قطن وبولى استر) ، بولى استر فتم اختيار نسبة 60/40 % بولى يوريثان/ ماء وتم تثبيتة عند درجة حرارة 180 درجة مئوية لمدة 30 ثانية فوجد انه تم تحسين خواص قوه الشد والاستطالة وقوه التمزق وخصائص التوبير والاحتكاك الثلاث خامات كما انه تم زيادة وزنهم

فنجد انه بالنسبة لقوه الشد النسبة للخامات الثلاثة قبل عملية التغطية (250.86, 237.16 , 558.11) نيوتن وسجلت بعد عملية التغطية (288, 286, 589) نيوتن على التوالى ، اما بالنسبة للاستطالة قبل عملية التغطية سجلت (16.16, 9.59 , 19.4) % وبعد عملية التغطية سجلت (18.1, 8.5, 23.4)% على التوالى .

وبالنسبة لقوه الشد للخامات الثلاثة سجلت قبل عملية التغطية (11.37, 8.90 , 22.55) نيوتن وبعد عملية التغطية كانت النتيجة (16.37, 13.57, 26.15) نيوتن على التوالى .

خاصية مقاومة التوبير لخامة القطن والمخلوط والبولى استر قبل عملية التغطية سجلت (2,1, 2-3) وبعد المعالجة بالتغطية سجلت (4,4, 4-5) على التوالى . اما بالنسبة لمقاومة الاحتكاك فنجد انه قبل عملية التغطية نسبة الفقد فى الخامة نتيجة الاحتكاك سجلت (15, 30.3 , 10.6)% وبعد عملية التغطية سجلت (2.5, 3.2, 2.6) على التوالى للخامات الثلاثة .

ولوحظ زيادة فى وزن الخامات الثلاثة حيث سجلت قبل عملية التغطية (148, 90, 110) جم/م2 وبعد عملية التغطية (179, 132, 157) جم/م2 على التوالى .

1. Introduction

Coatings used in the production of technical textiles are largely limited to those products that can be produced in the form of a viscous liquid, which can be spread on the surface of a substrate. (14) Polyurethane considered as one of unique polymers that can achieve special and novel effects when applied as a coating material even in form of water-based.

Water-based Polyurethane Dispersions make excellent Textile coatings. Suitable grades are inherently flexible, have superior tensile properties, and have excellent abrasion resistance. Waterborne polyurethane dispersions can be used by themselves or in conjunction with acrylic emulsions to reach just the right cost/performance balance for your specific application. All of our waterborne polyurethanes for textile coatings resins can be cross-linked to improve their overall properties for very high performance applications.

2. Materials:

2.1 Chemicals

1.1.1 PU —polyurethane binder, Acramin PUD01, Tanatex chemicals, Netherlands.

1.1.2 PU-acrylate thickener, Clariant, Germany.

1.1.3 Dispersing agent, Clariant, Germany.

1.1.3 Blue water-based pigment GA-301, feiyun coating, china.

1.1.4 Activator, Guanzhi chemical, china.

2.2Fabrics:

2.2.1Cotton Fabric

%100scoured bleached cotton fabric plan weave 1/1, 140 g/m2 was supplied by Miser El-mehalla Kubra Company for spinning and weaving Egypt. The fibre properties of this cotton material were presented in the following Table (1)

Table (1) Cotton samples specification of the studied variety

Fibre contact[6]	**Colour**	**Count of yarn[7]**		**Fabric count [8]**	
100 % cotton	White	**Warp**	20/1 Ne	**Warp**	63/inch
		Weft	19/1 Ne	**Weft**	47/inch

2.2.2 Cotton/Polyester Blend Fabric

Blend (cotton/polyester) fabric plane weave 1/1, 90 g/m2 was supplied by Miser El-mehalla Kubra Company for spinning and weaving Egypt. The fibre properties of this blend material were presented in the following Table (2)

Table (2) Blend samples specification of the studied variety

Fibre contact[6]	**Colour**	**Count of yarn[7]**		**Fabric count[8]**	
50 % cotton	Light grey	**warp**	50/1 Ne	**warp**	101/inch
50% polyester		**Weft**	45/1 Ne	**weft**	78/inch

2.2 Polyester Fabric

Polyester fabric plane weave 1/1, 110 g/m2 .The fibre properties of this polyester material were presented in the following Table (3).

Table (3) polyester samples specification of the studied variety

Fibre contact[6]	**Colour**	**Count of yarn[7]**		**Fabric count[8]**	
100% polyester	White	**Warp**	30/1Ne	**Warp**	84/inch
		Weft	30/1 Ne	**Weft**	64/inch

3. EXPERIMENTAL TECHNIQUES

3.1 Coating techniques

All prepared PU samples coating paste water-based composites, were applied onto the various fabrics by silk screen technique using manual printing machine with silk screen mesh 62 and squeegee diameter 80D, The coating was adjusted in the distance between the squeegee on which the polyurethane paste was applied and the silk screen under the squeegee and pushed the paste by squeegee pressure, only one layer, then all samples were left for drying, then all samples were fixed.

3.2 Methodology

PU binder was mixed with water using high speed disperser (1500 rpm), thickener and dispersing agent were added to the mixture with continuous stirrer, the paste was milled using roll-mill laboratory machine until a homogenous paste was obtained, the prepared paste was coloured using 5% blue water-based pigment GA-301, the prepared paste was applied onto various types of fabric, the colour fastness and physical properties for all coated samples were studied.

3.3 Procedures

3.3.1 Viscosity study

Five different ratios from PU water–based binder (100%, 80%, 60%, 40% and 20%) and water are prepared using high speed disperser (1500rpm) as mentioned in methodology with addition of PU 2% acrylate thickener to adjust viscosity for screen application, ratios with PU concentrations 100%and 80% were achieved applicable viscosity while ratios with 20%, 40% and 60% PU need to add 4%, 3%and1.5% respectively to achieve applicable viscosities.

Results were reported in Table no. (4) & (5)

3.3.2 Fixation Study

3.3.2.1 Studying the fixation temperature onto different ratios of (PU/Water) coating film.

Five samples PU paste (20%, 40%, 60%, 80%, and 100%) were applied into polyester fabric fixed at different temperature (60, 80, 100, 120, 150, 170, 180, 200) 0C for 20 second by using heat press with temperature and time control, then the samples washed out at 40 0C for 10 min. by non-ionic detergent 5gm/L and rinse it 5 min. at 40 0C and rinse it 5 min. on running cold water.

After drying, all samples were subjected to colour reader for measuring total colour difference (ΔE) before and after washing, all results were reported in Table (6).

3.3.2.2Studying the fixation time onto different ratios of (PU/Water) coating film .

Five samples PU paste (20%, 40%, 60%, 80%, and 100%) fixed at different time (10, 20, 30, 40, 50, 60) second at 200 0C by using heat press, after fixation all samples washed out at 40 0C for 10 min. by non-ionic detergent 5gm/L and rinse it 5 min. at 40 0C and rinse it 5 min. on running cold water. After drying, all samples were subjected to colour reader for measuring total colour difference (ΔE) before and after washing, all results were reported in Table (7).

3.3.2.3 Studying the fixation temperature onto different ratios of (PU/Water) coating film with addition of 1.5% activator:

Five samples PU paste (20%, 40%, 60%, 80%, and 100%) with addition of 1.5% activator to each paste and fixed at different temperature (60, 80, 100, 120, 150, 170, 180, 200) 0C for 20 seconds by using heat press, after fixation all samples washed out at 40 0C for 10 min. by non-ionic detergent 5gm/L and rinse it 5 min. at 40 0C and rinse it 5 min. on running cold water.

After drying, all samples were subjected to colour reader for measuring total colour difference (ΔE) before and after washing, all results were reported in Table (8).

3.3.2.4 Studying the fixation time onto different ratios of (PU/Water) coating film with addition of 1.5% activator:

Five samples PU paste (20%, 40%, 60%, 80%, and 100%) with added 1.5% activator to each sample paste prepared and fixed at different time (10, 20, 30, 40, 50, 60) second at 180 0C by using heat press, after fixation all samples washed out at 40 0C for 10 min. by non-ionic detergent 5gm/L and rinse it 5 min. at 40 0C and rinse it 5 min. on running cold water. After drying, all samples were subjected to colour reader for measuring total colour difference (ΔE) before and after washing, all results were reported in Table (9).

3.4 Studying the fastness to (Laundering, Perspiration, Water, Sea water, and Crocking) for the confirmation sample (40/60) PU/Water

The pigmented confirmation samples (100%Cotton, 50%Cotton / 50%Polyester, and 100%Polyester) of (40%/60%) PU/water was printed as mentioned at methodology and fixed at 1800C for 30sec. the sample was washed out at 40 0C for 10 min. by non-ionic detergent 5gm/L and rinse it 5 min. at 40 0C and rinse it 5 min. on running cold water

The fastness to Laundering, Perspiration, Water, Sea water, and Crocking Was tested, all results were reported at Table no. (10).

3.5 Studying the Physical & mechanical Properties (Tear, Tensile, Pilling, Abrasion, and Fabric weight) for the confirmation sample (40/60) PU/Water

The colourless confirmation samples (100%Cotton, 50%Cotton / 50%Polyester, and 100%Polyester) of (40%/60%) PU/water was coated as mentioned at methodology and fixed at 1800C for 30sec. the sample was washed out at 40 0C for 10 min. by non-ionic detergent 5gm/L and rinse it 5 min. at 40 0C and rinse it 5 min. on running cold water.

The Physical & mechanical Properties Was tested, as the following

-tear strength, results were reported at Table no. (11).

-tensile strength and elongation at break, results were reported at Table no. (12) & (13).

-Pilling resistance, results were reported at Table no. (14).

-Abrasion resistance, results were reported at Table no. (15).

-Fabric weight, results were reported at Table no. (16).

4. RESULTS AND DISCUSSION

4.1 Viscosity Study

Different recipes of PU, water and such additives were synthesized, the viscosity of each recipe was measured before applied onto the test fabric, the lower viscosities pastes were adjusted to be applicable by addition of thickener.

The reported results at Tables no. (4), (5).

Showing that the viscosity increased as the percentage of PU binder increased, as 20% showing the lower viscosity value 75 CP, while 100% PU showing the higher value of viscosity 3947 CP. (15)

As the percentage of 20% PU still showing low viscosity, more thickener was recommended to achieve applicable viscosity, 6% thickener was the best percentage as cleared at Table no. (5).

Table (4): Studying the viscosity of different ratios between (PU/Water(

Coating Paste					
PU Binder (%)	**20**	**40**	**60**	**80**	**100**
Water (%)	**80**	**60**	**40**	**20**	**Zero**
Thickener (%)	**2**	**2**	**2**	**2**	**2**
Surfactant (%)	**1**	**1**	**1**	**1**	**1**
Viscosity (CP)	**75**	**85**	**250**	**3940**	**3947**
Silk screen print (observed)	**N/A**	**N/A**	**N/A**	**A**	**A**
N/A = Not Applicable A = Applicable					

Table (5): studying the Viscosity of (PU/Water) after addition of thickener

Coating paste			
PU Binder (%)	**20**	**40**	**60**
Water (%)	**80**	**60**	**40**
Thickener (%)	**6**	**5**	**3.5**
Viscosity (CP)	**3954**	**3951**	**3949**

4.2 Fixation Study

4.2.1 Studying the fixation temperature onto different ratios of (PU/Water) coating film.

The coated fabrics with different recipes of PU concentrations (20%, 40%, 60%, 80%, and 100%) were cured at different curing temperatures (60, 80, 100, 120, 150, 170,180, 200) 0C for 20 sec.

From Table no.(6) found that, the total colour difference (ΔE) between the test fabric before and after washing decreased as the temperature increased at all recipes, the best temperature fixation for all formulations was at 2000C.

Also found that the total colour difference (ΔE) decreased as the percentage of PU increased at same curing temperature as the PU dispersion with concentration 100% for example showing the lower (ΔE) at all curing temperature values starting from 600C until 2000C and showed the curing temperature that achieve a good results of colour fastness for all samples was at 2000C.

The best results of colour-fastness to washing for different PU concentrations (20, 40, 60, 80, and 100) % which achieve total colour difference values (4.54, 4.56, 4.11, 4, and 2.59) respectively were obtained at 200 0C.(16).

Table (6) Studying the fixation temperature onto different ratios of (PU/Water) coating film.

PU/Water paste	Total Colour Difference (ΔE)							
	60^0C	80^0C	100^0C	120^0C	150^0C	170^0C	180^0C	200^0C
(20/80)%	30.61	26.04	21.47	21.38	18.60	17.38	15.08	4.54
(40/60)%	20.23	15.37	15	14.68	13.68	12.36	10.46	4.56
(60/40)%	17.25	13.45	12.39	12.21	12.12	12	10.30	4.11
(80/20)%	17.18	12.31	11.92	11.10	10.90	10.60	9.10	4
(100/0)%	16.17	11.92	8.53	8.21	7.43	7.07	5.80	2.59

4.2.2 Studying the fixation time onto different ratios of (PU/Water) coating film .

The coated test samples with composites of water based PU dispersion binder with concentration of (20%, 40%, 60%, 80%, and 100%) were fixed at (2000C) for different fixation time (10, 20, 30, 40, 50, and 60) sec. to determine the suitable fixation time for each recipe.

The results were reported at Table (7) all results showing a decrease of total colour difference ΔE with the increase of fixation time also a decrease of ΔE noticed at same fixation time as the PU concentration increased.

For example a coated fabrics with composites of PU with concentration of 20% achieved ΔE equal 10.2 when fixed at (2000C) for 10 sec, while 4.2 was achieved when fixed at same fixation temperature for 50 sec, and noticed that the total colour difference ΔE decreased in

the same way at PU concentration of 40% as the fixation time increased to achieve ΔE equal 9.8 when fixed for 10 sec. while ΔE equal 4 was achieved when fixed for 50 sec.

All synthesized composite with water-based PU dispersion showed the same results.

Also if at fixation time more than 50 sec. a reversible action occurred as ΔE value increased with the increase of fixation time that due to the yellowing of the test fabric by the action of high temperature (2000C) and long fixation time , that is why the fixation condition must be studied with addition of an activator to achieve an acceptable colour fastness at mild curing condition.

The effect of different fixation time (10, 20, 30, 40, 50, and 60) respectively onto different PU films that showing a decrease of total colour difference ΔE with the increase of fixation time and the fixation time of 50 sec. achieved the best ΔE values (4.25, 4.01, 3.95, 3.61, and 2.61) to recipes of (20%, 40%, 60%, 80%, and 100%) of PU at 2000C .

Table (7): Studying the fixation time onto different ratios of (PU/Water) coating film at 2000C

PU/Water paste	Total Colour Difference (ΔE)					
	10 sec.	20 sec.	30 sec.	40 sec.	50 sec.	60 sec.
(20/80)%	10.20	4.90	4.49	4.31	4.25	5
(40/60)%	9.81	4.72	4.32	4.16	4.01	4.19
(60/40)%	8.52	4.10	4.02	3.88	3.95	3.96
(80/20)%	7.63	4.01	3.75	3.55	3.61	3.69
(100/0)%	6.05	2.88	2.65	2.51	2.59	2.61

4.2.3 Studying the fixation temperature onto different ratios of (PU/Water) coating film with addition of 1.5% activator:

To avoid the yellowing of coated film with PU water-based composite an addition of activator was suggested to increase the rate of reaction crosslinking at mild fixation condition. (17)(18(%1.5of activator was added to each studied ratios (20%, 40%, 60%, 80%, and 100%) the coated films were different temperatures, (60, 80, 100, 120, 150, 170,180, 200) 0C for 20 sec. From reported results at Table (8) noticed that the total colour difference ΔE was decreased with the addition of activator at all ratios, PU with concentration of 20% achieve ΔE equal 21.99 at 60 0C and 1.53 at 200 0C, PU with concentration of 40% achieve ΔE equal 18.89 at 60 0C and 1.45 at 200 0C, PU with concentration of 60% achieve ΔE equal 16.96 at 60 0C

and 1.25 at 200 0C, PU with concentration of 80% achieve ΔE equal 11.72 at 60 0C and 0.81 at 2000C, PU with concentration of 100% achieve ΔE equal 4.76 at 60 0C and 0.75 at 200 0C. These results meaning that the addition of an activator improve the colour fastness to washing of all ratios at all temperature, while at fixation temperature 600C the colour fastness showing a forbidden colour fastness even with addition of activator this is due to the lower temperature degree which is not sufficient to achieve complete crosslinking so no acceptable colour-fastness was observed.

Also it's clear decrease of total colour difference with the increase of PU concentration with the addition of an activator, typically the ΔE values decrease with the increase of PU concentrations even without or with the addition of activator.

The best fixation temperature that achieved the lowest value of ΔE was at 1800C without affecting the test fabric colour shade, and the values of ΔE (2.36, 2.26, 2.16, 1.75, and 1.01) with PU concentration of (20, 40, 60, 80, and 100%) respectively at 1800C.

Table (8) Studying the fixation temperature onto different ratios of (PU/Water) coating film with addition of 1.5% activator.

PU/Water paste	Total Colour Difference (ΔE)							
	60^0C	80^0C	100^0C	120^0C	150^0C	170^0C	180^0C	200^0C
(20/80)%	21.99	20.12	19.49	18.72	17.20	12.76	2.36	1.53
(40/60)%	18.89	13.26	12.90	12	11.56	11.20	2.26	1.45
(60/40)%	16	12.14	11.66	11.26	10.63	10.12	2.16	1.25
(80/20)%	11.72	10.67	8.76	7.02	5.39	4.24	1.75	0.81
(100/0)%	4.76	4.45	3.92	3.48	3.33	2.24	1.01	0.75

4.2.4 Studying the fixation time onto different ratios of (PU/Water) coating film with addition of 1.5% activator

To achieve an acceptable colour fastness to washing at mild conditions an activator was suggested to minimize the fixation time, 1.5% activator was added to all recipes then different fixation times were studied.

Table (9) shows the total colour difference ΔE was decreased in case of addition activator at same concentration of PU water based composites compared with the values of ΔE without addition of activator at same temperature.

As PU composite with concentration 20% achieved ΔE equal 10.2 when fixed at (2000C) for 10 sec, while with addition activator achieved ΔE equal 2.49 when fixed at (1800C) for 10sec.,By the same way all ΔE values showing very good results with all PU concentrations with the addition of activator in same cases ΔE achieved value less than 1.

the excellent result of colour difference ΔE for PU concentration of 20% at fixation conditions 60 sec. at 1800C as it achieve 1.91while without catalyst achieve 4.25 at fixation conditions (50sec. at 2000C), the excellent result of colour difference ΔE for PU concentration of 40% at fixation conditions 50 sec. at 1800C as it achieve 1.81while without catalyst achieve 4.01 at fixation conditions (50sec. at 2000C), the excellent result of total colour difference ΔE for PU with concentration of 60% at fixation conditions 40 sec. at 1800C as it achieved 1.25 while without catalyst achieve 3.88 at fixation conditions (40sec. at 2000C), the excellent result of total colour difference ΔE for PU concentration of 80% at fixation conditions 40 sec. at 1800C as it achieve 1.07 while without catalyst achieve 3.55 at fixation conditions (40sec. at 2000C), and the excellent result of colour difference ΔE for PU concentration of 100% at fixation conditions 30 sec. at 1800C as it achieve .99 while without catalyst achieve 2.65 at fixation conditions (50sec. at 2000C).

Also it's clear decrease of total colour difference with the increase of PU concentration with the addition of an activator except 100%PU the total colour difference increased again because the fabrics yellowing, So the best fixation time of 30 sec. achieved ΔE values (2.06, 1.90, 1.81, 1.10, and 0.99) with the addition of 1.5% catalyst to recipes of (20%, 40%, 60%, 80%, and 100%) of PU at 1800C .

Table (9): Studying the fixation time onto different ratios of (PU/Water) coating film with addition of 1.5% activator at 1800C

PU/Water paste	Total Colour Difference (ΔE)					
	10 sec.	20 sec.	30 sec.	40 sec.	50 sec.	60 sec.
(20/80)%	2.49	2.30	2.06	2.01	1.95	1.91
(40/60)%	2.31	2.10	1.90	1.85	1.81	1.86
(60/40)%	2.25	2.06	1.81	1.25	1.28	1.30
(80/20)%	2	1.69	1.10	1.07	1.12	1.20
(100/0)%	1.60	1.05	0.99	1.10	1.15	1.25

4.3 Confirmation test

From previous results a composite of PU concentration of 40% showed an excellent result as it achieved a total colour difference ΔE at (1800C for 30 sec.)(19(

A confirmation test was done at the best fixation conditions (1800C for 30 sec.) onto 100%Cotton, 50%/50% Cotton/Polyester Blend and 100% Polyester fabrics with the prepared composite of 40% PU concentration, ΔE achieved values of 1.90, 1.85, and 1.87 respectively, as reported in Table (10).

Table (10): ΔE before & after washing out for (40%PU,60%Water) coating films for various fabric

Fabric		100% Cotton	(50%Cotton & 50% polyester)	100% Polyester
(40/60)% PU/Water	ΔE	1.88	1.87	1.91

4.4 Studying the fastness to (Laundering, Perspiration, Water, Sea water, and Crocking) for the confirmation sample (40/60) PU/Water

The confirmed result with PU concentration 40% at fixation condition with temperature 1800C for 30 sec. was applied onto 100%Cotton, 50%/50% Cotton/Polyester Blend and 100% Polyester fabrics, the fastness to laundering at 400C was tested, the results reported at Table no. (11).

The laundering result showing that the coated fabrics achieved a very good colour fastness as the evaluated colour difference achieved grade 4 using grey-scale while 4.5 grade was achieved using staining grey-scale (transferred colour to multi-fiber).

Also the fastness to perspiration, water, and sea-water achieved good results as it showed grade 4.5 at both grey scale and staining grey scale.

The confirmed sample also achieved a good rubbing fastness as the dry rubbing showed grade 4 while the wet rubbing showed grade 4.5 evaluated by staining grey scale.

The confirmation test ensure that the coated film with 40% PU at fixation condition of 1800C for 30 sec. is the best result as it achieved an acceptable colour fastness to washing, rubbing, water, laundering, sea-water and perspiration.

Table (11): Studying the fastness properties for the confirmation sample (40/60) PU/Water

Fastness properties		Laundering[9] 40^0C			Perspiration fastness[10]			Water fastness[11]			Sea water fastness[12]			Crocking fastness[13]		
Coated Fabric		C	B	P	C	B	P	C	B	P	C	B	P			
Change of colour		4	4	4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5			
staining	Acetate	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	Dry crocking cloth	C	4
	Cotton	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5		B	4
	Nylon	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5		P	4
	Silk	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	Wet crocking cloth	C	4.5
	Viscose	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5		B	4.5
	Wool	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5		P	4.5
C = COTTON FABRIC , B = BLEND (COTTON/POLYESTER) FABRIC , P = POLYESTER FABRIC																

4.5 Studying the Physical & mechanical Properties (Tear, Tensile, Pilling, Abrasion, and Fabric weight) for the confirmation sample (40/60) PU/Water

Tear strength (1)

The tear strength of uncoated 100% cotton fabrics (blank sample) achieved values of 11.95 N at warp direction and 15.71 N at weft direction, while the coated test sample (100% cotton) with 40% PU composite achieved values of 17.03 N at warp direction and 15.71 at weft direction.

The uncoated fabric (blank sample) of 50/50 Polyester/Cotton Blend fabric achieved values of 9.5 N at warp direction and 8.30 N at weft direction, while the coated sample with 40%PU composite achieved values of 14.90 N in the warp direction and 12.25 N in the weft direction.

The uncoated fabric (blank sample) of 100% Polyester fabric achieved values of 26.06 N at warp direction and 19.11 N at weft direction, while the coated sample with 40% PU composite achieved values of 30.10 N at warp direction and 22.21 N at weft direction.

From tearing study noticed that the tearing results were improved for all coated fabric even for 100% cotton, 50/50 cotton /polyester blend fabric or 100% polyester fabrics due to the high adhesion power of PU composite, as clarify at Table no. (12).

Table (12): Tear strength of uncoated & PU coated fabrics samples

Fabric	Tear Strength (N)			
	Warp		Weft	
	Blank	Coated	Blank	Coated
Cotton	11.95	17.03	10.80	15.71
Blend	9.5	14.90	8.30	12.25
Polyester	26.06	30.10	19.11	22.21

Tensile strength and elongation to break (2)

The Tensile strength of uncoated 100% cotton fabrics (blank sample) achieved values of 288.61 N at warp direction and 213.12 N at weft direction, while the coated test sample (100% cotton) with 40% PU composite achieved values of 11.95 N at warp direction and 15.71 N at weft direction, while the coated test sample (100% cotton) with 40% PU composite achieved values of 17.03 N for the warp direction and 15.71 for weft direction .

The Tensile strength of uncoated 50/50 Cotton/Polyester Blend fabric (blank sample) achieved values of 241.86 N at the warp direction and 232.46 N at the weft direction, while the coated test sample 50/50 Cotton/Polyester Blend fabric with 40% PU composite achieved values of 313 N at warp direction and 259 N at weft direction.

The Tensile strength of uncoated 100% polyester fabric (blank sample) achieved values of 633.08 N at warp direction and 648 N at weft direction, while the coated test sample 100% polyester fabric with 40% PU composite achieved values of to 648 N at warp direction and 259 N at weft direction .

From the reported results and clarify at Table no (13) found that an increase of tensile strength was achieved for all coated samples with 40% PU composite even 100% cotton, 50/50 cotton/polyester blend fabric or 100% polyester fabric that due to the high adhesion power of polyurethane and the fixation condition which not affect the tensile of the test fabrics. (20(

Table (13): Tensile strength of uncoated & PU coated fabrics samples

Fabric	Tensile Strength (N)			
	Warp		Weft	
	Blank	Coated	Blank	Coated
Cotton	288.61	334	213.12	242
Blend	241.86	313	232.46	259
Polyester	633.08	648	483.14	530

The elongation of uncoated 100% cotton fabrics (blank sample) achieved values 16% at warp direction and 15.5% at weft direction, while the coated test sample of (100% cotton) with 40% PU composite achieved values of 19.2% at warp direction and 17% at the weft direction . The elongation of uncoated 50/50 Cotton/Polyester Blend fabric (blank sample) achieved values of 10.05% at warp direction and 9.01% at weft direction, while the coated test sample with 50/50 Cotton/Polyester Blend fabric with 40% PU composite achieved values of 18.20% at warp direction and 17.9% at weft direction.

The elongation of uncoated 100% polyester fabric (blank sample) achieved values of 20.5% at warp direction and 18.30% at weft direction, while the coated test sample 100% polyester fabric with 40% PU composite achieved values of 26% at warp direction and 20.8% at weft direction.

From the results reported at Table (14) noticed that the elongation of the test fabrics increased when the fabrics were coated with PU composite with concentration 40% that due to the elastic nature of polyurethane polymer. (21) (22(

Table (14): Elongation of uncoated & PU coated fabrics samples

Fabric	Elongation (%)			
	Warp		Weft	
	Blank	Coated	Blank	Coated
Cotton	16.83	19.2	15.5	17
Blend	10.05	18.20	9.01	17.9
Polyester	20.5	26	18.30	20.8

Pilling resistance [(4)]

The confirmed result with PU concentration 40% at fixation condition of temperature 1800C for 30 sec. was applied onto Cotton, Cotton/Polyester Blend and Polyester fabrics, the Pilling results reported at Table (15).

Pilling resistance of uncoated & coated PU fabrics after different number of rubs, (125, 500, 1000, 2000, 5000, and 7000 Rubs) showing that:

%100uncoated cotton fabric (blank sample) achieved values starting from grade 4.5 at 152 rubs to grade 2 at 7000 rubs , while after coating achieved values from grade 5 at 125 rubs to grade 4 at 7000 rubs.

50/50Cotton/ Polyester blend uncoated fabrics (blank sample) achieved values starting from grade 4.5 at 125 rubs and grade1 at 7000 rubs, while after coating achieved values from grade 5 at 125 rubs to grade 4 at 7000 rubs.

%100uncoated Polyester fabric (blank sample) achieved values from grade 5 at 125 rubs to grade 2-3 at 7000 rubs, while after coating achieved values from grade 5 at 125 rubs to grade 4-5 at 7000 rubs.

From the results of Pilling Study reported at Table (14) and illustrated figures found that the PU composite has a positive effect onto the pilling of test fabrics, as before coating the appearance show dense surface fuzzing and severe pilling, pills of varying size and density covering the whole of the specimen surface, while after coating the appearance show slight surface fuzzing and partially formed pills .

Table (15): Pilling resistance of uncoated &PU coated for various fabrics

Fabrics		Cotton		Blend		Polyester	
		Blank	Coated	Blank	Coated	Blank	Coated
Number of Rubs	After 125 Rubs	4-5	5	4-5	5	5	5
	After 500 Rubs	4-5	5	4	5	4-5	5
	After 1000 Rubs	3-4	5	4	4-5	4-5	5
	After 2000 Rubs	3	4-5	2	4-5	4	5
	After 5000 Rubs	2-3	4	2	4-5	3-4	4-5
	After 7000 Rubs	2	4	1	4	2-3	4-5

Abrasion resistance [3]

The confirmed result with PU concentration 40% at fixation condition of temperature 1800C for 30 sec. was applied onto Cotton, Cotton/Polyester Blend and Polyester fabrics, the Abrasion results reported at Table (16) showing that:

The abrasion resistance of uncoated cotton, blend, and polyester fabric (blank samples) reach the end point (breakdown) after (25,000 / 21,000 / 35,000) Rubs, loss weight (15, 30.3, 10.6) % respectively, while after coating with PU the weight loss records (2.5, 3.2, 2.6.% (

It's clear that decrease of weight loss of coated samples than that of blank samples, meaning that the coating of PU composite improves abrasion resistance.

Table (16): Abrasion resistance of uncoated & PU coated for various fabrics

Fabric	Results of specimen breakdown					
	Cotton		Blend		Polyester	
	Blank	Coated	Blank	Coated	Blank	Coated
AVG. of Rubs to End point	25,000 Rubs	More than 50,000	21,000 Rubs	More than 42,000	35,000 Rubs	More than 70,000
Loss weight	After 25,000		After 21,000		After 35,000	
	15%	2.5%	30.3%	3.2%	10.6%	2.6%
Pressure Applied: 9KPa.						

Fabric weight [5]

The confirmed result with PU concentration 40% at fixation condition of temperature 1800C for 30 sec. was applied onto 100% Cotton, 50/50 Cotton/Polyester Blend and 100%Polyester fabrics, Fabric weight was studied for coated and uncoated fabrics, the results reported at Table (17).

The coated samples showing an increase of Mass Per unit area for all test samples (100% Cotton, 50/50 Cotton/Polyester Blend and 100%Polyester fabrics) as it achieved values of (176, 132, 157) gm/m2, while the uncoated samples achieved values of (148, 90, 157) gm/m2 respectively.

From the study found that the mass Per unit area increased after coating with PU composite, 100% cotton fabric increased by 10.79%, 50/50 Cotton/Polyester Blend increased by 31.81% and 100%Polyester fabric increased by 29.9%.

Table (17): Fabric weight for uncoated& PU coated various fabrics

Fabrics	Cotton		Blend		Polyester	
	Uncoated (Blank)	Coated	Uncoated (Blank)	Coated	Uncoated (Blank)	Coated
Mass Per Unit (GM/M^2)	148	176	90	132	110	157

Conclusion

Polyurethane composites were studied as coating material for different types of fabrics 100%Cotton, 50/50% Cotton/Polyester blend, 100%Polyester.

The best recipe was 40/60 % PU/Water, the physical properties for 100%Cotton, 50/50% Cotton/Polyester blend, 100%Polyester were tear strength equal (16.37, 13.57, 26.15 N) respectively, tensile strength equal (288, 286, 589 N) respectively, elongation at break equal (18.1, 8.5, 23.4%) respectively , pilling grade (4,4, 4-5) respectively, loss weight after abrasion equal (2.5, 3.2, 2.6%) respectively, fabric weight equal (179, 132, 157 gm./m2) respectively and the fixation condition is at 1800C for 30 Sec.

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