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Printing of Synthetic Fabrics with Hydrochromic Paste and Post-Finishing with Silicone Rubber

Manar Mahmoud [a], Mariam Adel [a], Menna Mohamed [a], Mostafa Ahmed [a], Mostafa Ashraf [a], Dalia Maamoun [a], Hend Ahmed [b*], Tawfik A. Khattab [b]

[a] *Helwan University, Faculty of Applied Arts, Printing, Dyeing and Finishing Department, Giza, Egypt*

[b] *National Research Centre (Scopus affiliation ID 60014618), Textile Research and Technology Institute, Dyeing, Printing and Intermidiate Auxiliaries Department, 33 El-Behouth St. (former El-Tahrir str.), Dokki, P.O. 12622, Giza, Egypt*

Abstract

SILICONE-based materials have been used for textile surfaces to develop water-resistant properties. The most common silicone rubber has been appealing due to its effectiveness in penetrating substrates without compromising the textile characteristics. Because of the urgent need for getting waterproofed clothes in many fields, this research investigates treating polyester as well as polyamide fabrics using silicone/ rubber. Silicone deposits hydrophobic layer on fiber surface, preventing water from penetrating into fibers and, therefore and making it waterproofed. Our fabrics were printed with a hydrochromic paste prior to being finished. The hydrochromic color changes from white to transparent when it becomes wet. All the required measurements were explored.

Keywords Hydrochromic, Silicone Rubber, Polyester Fabric.

Introduction

One of the most widely known synthetic fabrics is polyester. Polyester is essentially a hydrophobic material that doesn't absorb water. There are a few properties of the polyester fibre that is strong, resilient, recyclable, durable, dries very quickly, able to retain heat-set pleats and very resistant to many chemicals. [1-4]

Nylon, also name for polyamide, is a flexible synthetic fibre. The fabric made of polyamide is waterproof and resistant to rubbing., but is prone to degradation by acids and sunlight. Polyamide material is commonly used for sports apparel. [5-8]

Waterproof materials have an extraordinarily high use, with products for everyday clothing, sportswear, and protective clothing for industrial or technical applications. [9] Developing product's water proofing property is an important value-added process that can be helpful in wide range of environmental conditions. The majority of the underwater projects, semi-submerged aquatic settings, and in general weather protection services require waterproofing materials. [10-12]

Silicone based materials are applied over porous surface in order to make it breathable and water-resistant. The most popular types are siloxane and silicone rubber, which are desirable because they penetrate substrates well without sacrificing porousness. [13-17]

These materials are silicon-based, but they also have a variety of other qualities in common, such as a high level of breathability and the ability to be applied to most objects without significantly changing their look. However, despite their similarities, silicone and siloxane rubber products each have unique characteristics that have an impact on how they are made and utilised. Low thermal conductivity, low chemical reactivity, low toxicity, and thermal stability (constancy of properties across a large temperature range of (100 to 250 °C) are only a few of the numerous advantageous traits that silicones display.[18]

Hydrochromic paste is a clever substance that, when exposed to moisture or water, changes colour.

*Corresponding author: Hend Ahmed, e-mail: hend_plasma@yahoo.com
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It's possible for this stimulus-induced colour change process to be reversible or irreversible. [19, 20] The reversible ones are more common, and they normally change their colour from white to transparent (when wet) and return to white when they get dry again. [21] The techniques used to apply the hydrochromic paste are screen printing or spray coating, followed by passing it through a forced hot air tunnel. In textile substrates, studies using hydrochromic materials were printed onto polyester, cotton, polyamide and their blends, as well as elastane and polyester. [22]

In the present work, the authors investigate printing of polyester and polyamide fabrics using a hydrochromic paste. The printed fabrics are treated afterwards with the silicone/rubber. All the required measurements are included in the paper.

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Materials, measurements, and methods

Materials

100 %Polyamide 66 and 100 % polyester fabrics are used in the present study, kindly obtained from El-Mahala Company for Spinning and Weaving, El-Mahala, Egypt.

Acid dye (Sammaron-ORANGE HB 200) Hoechst AG company, Germany, disperse dye (Taiacryl Golden Yellow 2G-T 200%) T&T Industries Corporation, Germany.

Sodium alginate with (low viscosity), glacial acetic acid, sodium lauryl sulphatem, urea and Glycerin, all kindly obtained from El-Gomhouria Pharmaceutical Company, Cairo, Egypt.

The hydrochromic paste used is a commercial water-based (white colour) product sold by Cairo, Egypt-based SPI HC dispersion under the name Water Based Wet & Reveal Ink.

General purpose silicone/rubber, Swedish Co. Decoration, kindly obtained from A.D.M. Chemical Industries (ADIMICO) S.A.E, Egypt.

Methods

Printing of polyamide fabrics with acid dye

Polyamide fabric is printed with the acid dye using the following recipe:

Procedure

Printing→ drying at room temp. → steaming at 100-cold water → soaping with sodium lauryl sulphateB at 60 °C for 15 min.

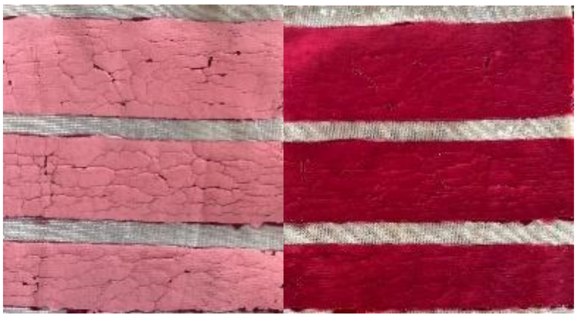
Sodium Alginate (6%)	600-700 gm/kg
Acid Dye	10-60 gm/kg
Urea	50 gm/kg
Glycerin	5 gm/kg
Acetic Acid	20-50 gm/kg
Levelling agent	10-20 gm/kg
Water	X ml/kg
Total	1000 gm

Over- printing of polyamide fabrics with a hydrochromic paste

The printed polyamide fabric is over-printed with a ready-made hydrochromic paste. the overprints first appear transparent but turn white afterwards. They turn transparent when they are submerged in water.

Procedure

Printing→ drying at room temp. → steaming at 100-102°C for 25 minutes.



Pic.1 A dry polyamide sample printed a hydrochromic paste

Pic.2 A wet polyamide sample printed a hydrochromic paste

Printing of polyester fabric with disperse dye

Polyester fabric is printed with the disperse dye using the following recipe

Sodium Alginate (6%)	600-700 gm/kg
Disperse dye	30 gm/kg
Urea	10 gm/kg
Acetic Acid (30%)	20 gm/kg
Dispersing agent	20 gm/kg
Water	X ml/kg
Total	1000 gm

Reduction clearing bath recipe:

L.R	1:50
Wetting agent	2gm/L
Sodium hydroxide	2gm/L
Dodium hydrosulphite	2gm/L

Procedure

Printing→ drying at room temp. → thermofixation at 180 °C for 20 minutes → reduction clearing →washing with running cold water →soaping with sodium lauryl sulphate (2gm/l) at 60 °C for 15 min.

Over- printing of polyester fabrics with a hydrochromic paste

The printed polyester fabric is over-printed with a ready-made hydrochromic paste. the overprints first appear transparent but turn white afterwards. They turn transparent when they are submerged in water.

Procedure

Printing→ drying at room temp. → thermofixation at 180 °C for 20 minutes→ reduction clear bath →washing with running cold water →soaping at 60 °C for 15 min.

Pic.1 A dry polyester sample printed a hydrochromic paste

Pic.2 A wet polyester sample printed a hydrochromic paste

Finishing of 100% polyamide fabrics using silicone/ rubber

The printed polyamide fabric was after treated with a silicone/ rubber solution, using the following padding bath recipe

W.O.S	7.2 gm
Toluene	266.6 ml
Silicone	25 gm
Time	20 min.
Temp.	At room temp.

Procedure

- 266.6ml of toluene is added to baker, then 25 gm of silicon is added to it.
- The solution is stirred in the mixer very well till it becomes ready for the process of adding the sample to it.
- The sample is added in the solution and stirred it for 20 minutes.
- The sample is then padded in the padder becomes saturated with the solution for 20 min at room temp.

Finishing of 100% polyester fabrics with silicone rubber

The printed polyamide fabric was after treated with a silicone/ rubber solution, using the following padding bath recipe:

W.O.S	4.429 gm
Toluene	50 ml
Silicone	20gm
Time	20 min.
Temp.	At room temp.

Procedure

- 50ml of toluene is added, then 20 gm of silicon to the solution.
- Stir the solution in the mixer very well till it becomes ready for the process of adding the sample to it.
- The sample is added in the solution and stir it for 20 minutes.
- Then padding the fabric sample in the padder so the sample becomes saturated with the solution.
- Then test the sample by adding drops of water on it to see what it looks like after finishing.

Measurements

Colour Strength

The colour strength (K/S) of the printed specimens was evaluated by a light reflectance technique at maximum. The spectrophotometer is of the model ICS-Texicon Ltd, USA.

Morphological properties

SEM Quanta FEG-250 (Czech Republic) attached with EDX Unit (Energy Dispersive Xray Analyses), with accelerating voltage 30 kV, magnification 14× up to 1,000,000 and resolution for Gun, FEI company, Netherlands.

Hydrophobicity screening

The water contact angle was measured on OCA-15EC (Data physics, Stuttgart, Germany) with software using 10 µL drops of triple distilled water.

Results and Discussion

Color strength

K/S values and differences obtained for: polyester sample after treated with silicone-rubber (A), polyester dry sample after over-printing with the hydrochromic paste (B) and polyester wet sample after over-printing with the hydrochromic paste (B after).

K/S values and differences

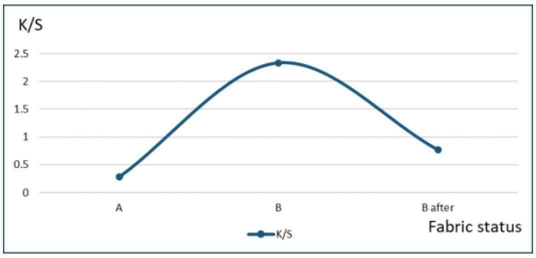
It can be concluded from both the table and the figure that, using the hydrochromic paste affected greatly the K/S of colour strength **values**.

Best results could be obtained by post-finishing of polyester fabrics, then **over**-printing with the hydrochromic paste, then doing measurement tests.

Fabric status	K/S	L	a	b
A	0.28	93.23	-0.02	1.22
B	2.33	78	6	13
B after	0.77	86	3	2

Where "A" refers to the polyester sample after treated with silicone-rubber. "B" refers to the polyester dry sample after over-printing with the hydrochromic paste. "B after" refers to the polyester wet sample after over-printing with the hydrochromic paste.

Fig. 1: K/S values and differences



Finishing with silicone rubber

Scan finished polyester fabric

Scanning Electron Microscope (SEM) images of the treated samples where measured to investigate the effect of the post-treatment of the polyester fabrics on the morphological structure of polyester fibre. It is illustrated that the durability of the polyester fabric isn't affected.

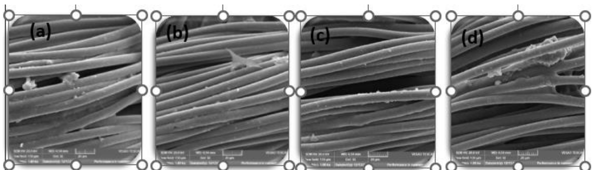


Fig.2: Scanning Electron Microscopic (SEM) images of polyester fabric treated with silicone-rubber

Contact Angle

The water contact angle was measured on OCA-15EC (Data physics, Stuttgart, Germany) with software using 10 µL drops of triple distilled water.

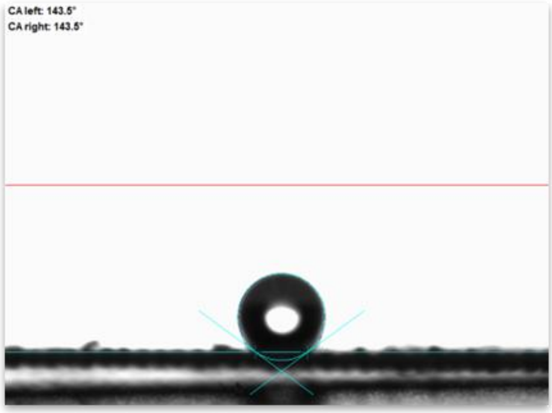


Fig.3: Static water contact angle of the treated polyester fabric

Conclusion

At the end of this research and after the experiments and measurements, a polyester fabric has been printed with the hydrochromic paste which can switch white color and become transparent when it is completely wet. Then shows the original colors of the design then, the printed fabric was padded with the silicone rubber to impart the fabric waterproof finishing property which led to successful results.

Conflict of Interest

There is no conflict of interest in the publication of this article.

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طباعة الأقمشة الصناعية بمعجون هيدروكروميك والتجهيز بمطاط السيليكون

منار محمود [١]، مريم عادل [١]، منة محمد [١]، مصطفى أحمد [١]، مصطفى أشرف [١]، داليا مأمون [١]،هند احمد *[٢]، توفيق احمد خطاب [٢]

[١] جامعة حلوان ـ كلية الفنون التطبيقية ـ قسم طباعة المنسوجات والصباغة والتجهيز ـ الجيزة ـ مصر
[٢] المركز القومي للبحوث (ID Scopus ٦٠٠١٤٦١٨) ، معهد بحوث وتكنولوجيا النسيج ، قسم الصباغة والطباعة والمواد الوسيطة -الجيزة - مصر

المؤلف المراسل: البريد الإلكتروني hend_plasma@yahoo.com :

المستخلص: تم استخدام المواد التي أساسها Tsilicone لأسطح النسيج لتطوير خصائص مقاومة الماء. كان مطاط السيليكون الأكثر شيوعًا جذابًا نظرًا لفعاليته في اختراق الركائز دون المساس بخصائص النسيج. نظرًا للحاجة الملحة للحصول على ملابس مقاومة للماء في العديد من المجالات ، يبحث هذا البحث في معالجة أقمشة البوليستر وكذلك أقمشة البولي أميد باستخدام السيليكون / المطاط. يرسب السيليكون طبقة كارهة للماء على سطح الألياف ، مما يمنع الماء من اختراق الألياف ، وبالتالي يجعلها مقاومة للماء. تشبه الأقمشة الذكية ، فقد تم طباعتها بمعجون هيدروكروميك قبل الانتهاء. يتغير لون الهيدروكروميك من الأبيض إلى الشفاف عندما يصبح رطبًا. يتم تضمين جميع القياسات المطلوبة في هذا العمل.

الكلمات المفتاحية: هيدروكروميك، سيليكون / مطاط، أقمشة بوليستر