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Preparation of Durable Hydrophobic Silicone Rubber Coating for Treating Cotton Fabric

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Abstract

IGH demand exists for performance fabrics that shield people from various environmental hazards and dangers. The development of functionalization technology and the use of sophisticated materials have turned this field of study into a research priority. Without considerably compromising comfort, this study employs silicone rubber to examine superomniphobic surfaces on cotton clothing. In terms of appearance, morphology, handling, thickness, and chemical components, cotton textile surfaces have changed over time. The development and design of the subsequent generation of performance textiles with a balance between performance and comfort might benefit from this study. Transfer printing would be used to imprint finished textiles; our job includes and examines all necessary dimensions.

Keywords Cotton; Silicon rubber; Photoluminescent; Antimicrobial.

Introduction

To assist people survive dangers and threats from the environment (cold, heat, wind, water, dirt, gas, etc.) or other sources, protective gear has been designed (fire, explosion, corrosive chemicals, pollution, etc.).[1, 2] Comfortability, simplicity of use, and favourable mechanical qualities for indoor or outdoor usage are the hallmarks of cotton materials. They lose their tensile strength and impermeability as they adapt to external circumstances like temperature and wetness, which create an ideal environment for the development of microorganisms, especially for sports, military, and work apparel.. [3-7]

A kind of silicone rubber that cures at room temperature is RTV silicone (room-temperaturevulcanized silicone). In comparison to mould rubbers, RTV silicone rubber has good release qualities, which is especially helpful for producing resin castings (polyurethane, polyester, and epoxy). The absence of a releasing agent eliminates the need for post-production cleaning. Additionally, silicones are resistant to chemicals and high temperatures (above 205°C, or 400°F). A waterproofing substance having a silicon-oxygen basis is silicone rubber. It has typical elastomeric characteristics as a form of rubber, including great flexibility and tensile strength. It is often vulcanised at room temperature for waterproofing purposes and can undergo a chemical reaction to create resin in a substrate devoid of alkali or silica. Silicone rubber is able to efficiently waterproof relatively porous surfaces because of this.. [8]

Finishing is directed in our work to practical suits which is made of cotton and went throw several technological treatments that help cleaning workers to perform their work with higher productivity to protect them from risks and dieses. Additionally, several antibacterial substances (both organic and inorganic) have been utilised to increase the suit's microbial resistance. The finished fabrics will be

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printed with Long-lasting luminescent materials such as strontium aluminate. [9, 10]

In the present work, finishing cotton fabrics is investigated using silicon rubber, to impart water, soil, oil resistance proprieties. All the required measurements are included in the paper.

Materials, Methods and Measurements Materials

Cotton fabric (100%) was kindly obtained from El-Mahala Company for Spinning and Weaving, El-Mahala, Egypt.

Room temperature vulcanized silicone rubber (RTV), and toluene are obtained from Sigma Aldrich, Egypt

Lanthanide-doped strontium aluminate phosphor (Photo luminescent pigment) was purchased from technoglow (china)

Methods

Padding of Cotton Fabric with Silicone Rubber

20 g Silicon rubber

180 g Toluene

Luminous pigment X = (1, 5, 10) g

Specimens size: 15 cm x 15 cm

To make solutions with three distinct concentrations of luminous pigment that ranged from 1 weight percent (RTV-1), 5 weight percent (RTV-5), and 10 weight percent (RTV-10) of luminous pigment, silicon rubber was dissolved in toluene (weight of silicon to volume of toluene).

After that, the samples were dried by air for 15 minutes on a spotless flat surface to remove the solvent. Curing of the samples is carried out at $65 \degree C$ for 10 min.

Cotton specimens are then printed using DTF Transfer Printing device provided from Areej Company, Egypt.

Measurements

The Antimicrobial Activity

The disc agar diffusion technique was utilised to determine the antibacterial activity. Escherichia coli ATCC 25933 (Gve), Candida albicans ATCC 10231 (yeast), Staphylococcus aureus ATCC 6538-P (G+ve), and Aspergillus niger NRRL-A326 were the four typical test organisms (fungus).

In the case of bacteria and yeast, nutrient agar plates were severely injected on a regular basis with 0.1 ml of 105-106 cells/ml. To calculate the antifungal activity, 0.1ml (106 cells/ml) of the fungal inoculum was seeded onto potato dextrose agar plates.

The inoculation plates were covered with 15mm-diameter textile-treated discs. To allow for maximum dispersion, plates were then held at a low temperature (4°C) for 2-4 hours. The plates were then incubated for the bacteria at 37°C for 24 hours and for the organisms to develop as much as possible at 30° C for 48 hours in an upright position.

The diameter of the inhibition zone, stated in millimetres, was used to measure the test agent's antimicrobial activity (mm). The experiment was run many times, and the average reading was recorded.[3]

Contact Angle Test

Using the OCA 15EC System, slide and water contact angles were calculated (Germany) While the cotton textiles were mounted to a glass coverslip using adhesive stripes in accordance with ASTM D7334 standard procedure, triple-distilled water was used to measure the water contact and sliding angles.[11, 12]

Ultraviolet Shielding Test

The AATCC 183 2010 UVA standard technique was used to calculate the ultraviolet protection factor (UPF). [13]

Results and Discussion

All the following measurements are carried out on cotton fabrics treated with 20 g of silicone rubber, 180 g toluene and Luminous pigment X=(1, 5, 10) g

The Antimicrobial Activity

Table 1 lists the percentage of antibacterial activity brought on by cotton textiles with spray coatings.

While spray-coated substrates shown a high resistance to the aforementioned pathogens, the blank cotton fabric showed no inhibitory impact on the decrease percentage. [14]

Table 1 reflects The antibacterial activity against several test microorganisms including yeast (C. albicans), fungi, G+ve bacteria (S. aureus), and G-ve bacteria (E. coli) (A. niger).

Contact Angle

Because cotton materials are hydrophilic, a droplet of water may quickly penetrate and sink into them.

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To examine the treated cotton materials' ability to resist water, the static water contact angle (WCA) was evaluated. It appears that the new coating has rendered the materials water resistant.

The WCA of the sample was determined by measuring WCAs five times and recording the results. [15-17]

Table 1 lists the antibacterial efficacy against several test microorganisms, including yeast (C. albicans), fungi, G+ve bacteria (S. aureus), and G-ve bacteria (E. coli) (A. niger).

Clear Zone (ømm)						
Staphyloco ccus Aureus	Escheichia Coli	Candida Albicans	Aspergillu s Niger			
13	0	14	0			
	4					



Figure 1 contact angles of treated cotton fabric with silicone rubber

The sessile drop technique was used to calculate WCAs in air at 25°C. The water contact angle (WCA) for the modified super hydrophilic cotton increased from 139.4° as shown in Figure 1 (e)&(f) (before modification) to 140.0° (c)&(d) and reached the highest value 144.3° as shown in (a)&(b).

Ultraviolet Shielding

The UV shielding effect of a certain substrate is frequently evaluated using the ultraviolet protection factor (UPF). Table 2 provides a summary of the spray-coated textiles' UV protection factor.

 Table 2 The ultraviolet protection factor of the spray

 coated cotton fabrics using silicon rubber

	K/S	L*	a*	b*
Before U.V	1.66	79	-3	22
After U.V	2.89	68	-17	11

In Figure 2 it can be concluded that cotton substrates are arranged between good to excellent. This may be attributed to the lanthanide-doped strontium aluminium oxide's high absorption capacity, which is a result of the phosphor's electrical structure and makes it suitable for UV shielding. [14]



Figure 2 K/S values before and after ultraviolet test



Figure 3 Specimens under the UV shielding device after treated with luminous pigment

Scanning Electron Microscope (SEM)

SEM testing was used to examine the morphological studies of RTV immobilised on cotton surface. The extremely hydrophobic, conductive, and photoluminescent features of the spray-coated cotton samples might be explained by comparing the fibre morphology of the uncoated cotton fabric with those of the samples. RTV silicon rubber was sprayed onto cotton textiles to create a uniformly dispersed extremely hydrophobic layer. This procedure logically enhanced the water resistance of coated cotton fibres. In comparison to cotton fabric that was not coated, this approach increased the fabric's surface roughness, which produced a fabric that was very hydrophobic. [12]

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Figure 4 scanning electron microscoping (SEM) micrographs of both uncoated RTV (a,b) and spraycoated RTV (c,d) cotton fabrics

Conclusions

In summary, RTV silicon rubber coated cotton fabric to provide a strong and superomniphobic surface., in order to enhance its antimicrobial activity by the disc agar diffusion method to improve its water, oil, soil repellency and enable its antimicrobial function. The outcomes showed that the materials' water repellency qualities had improved.. The fabrics demonstrated resistance to dirt, oil, chemicals, aqueous liquids, and water. Because cotton textiles have coated layers on their surface, coated fabrics are more comfortable than uncoated cotton fabrics. [16]

Conflict of Interest

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

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5. References

- Li, S., Huang, J., Chen, Z., Chen, G. and Lai, Y., "A Review on Special Wettability Textiles: Theoretical Models, Fabrication Technologies and Multifunctional Applications". *Journal of Materials Chemistry A*, 5(1) 31-55 (2017)
- Owen, M.J. and Dvornic, P.R., "Silicone Surface Science". Advances in Silicon Science, 4(2012)
- Popescu, C., Vinokur, R., Hassabo, A.G., Beginn, U. and Möller, M., "Phase Change Materials (Pcm) for Textiles", in 4th Aachen-Dresden International Textile Conference: Dresden, Germany (2010)
- Hassabo, A.G. and Mohamed, A.L., "Enhancement of Thermo-Regulating Textile Materials Using Phase Change Material (Pcm)". Evolution in Polymer Technology Journal, 2(1) 180009 (1-11) (2019)
- Ali, M.A., Seddik, K.M. and Hassabo, A.G., "Polyester Fibres Enhanced with Phase Change Material (Pcm) to Maintain Thermal Stability". *Egyptian Journal of Chemistry*, 64(11) 6599 - 6613 (2021)
- Hassabo, A.G., Mohamed, A.L., Wang, H., Popescu, C. and Moller, M., "Metal Salts Rented in Silica Microcapsules as Inorganic Phase Change Materials for Textile Usage". *Inorganic Chemistry: An Indian Journal*, 10(2) 59-65 (2015)
- Ali, M.A., Hassabo, A.G., Seddik, K.M., yahia, s. and Mohamed, N., "Characterization of the Thermal and Physico-Mechanical Properties of Cotton and Polyester Yarns Treated with Phase Change Materials Composites". *Egyptian Journal of Chemistry*, - (2022)
- Khattab, T.A., Mohamed, A.L. and Hassabo, A.G., "Development of Durable Superhydrophobic Cotton Fabrics Coated with Silicone/Stearic Acid Using Different Cross-Linkers". *Materials Chemistry and Physics*, 249(122981)(2020)
- Hassan, M.S., Attia, M.K. and Attia, R., "Antimicrobial Properties of Cotton Fabrics Coated with Silicone Rubber/Zno Nanocomposites under the Effect of Uv Irradiation". *Journal of Industrial Textiles*, 52 15280837221119836 (2022)
- 10. Sanzheeva, E.B., Kozlova, O.V., Odintsova, O.I. and Zelenkova, T.N., "Transfer Printing

on Cotton Knits". *Russian Journal of General Chemistry*, **92**(3) 485-488 (2022)

- ASTM Standard Test Method (D7334 08 (Reapproved 2013)), "Standard Practice for Surface Wettability of Coatings, Substrates and Pigments by Advancing Contact Angle Measurement", ASTM International: West Conshohocken, PA (2016)
- Alzahrani, H., Munshi, A., Aldawsari, A., Keshk, A., Asghar, B., Osman, H., Khalifa, M. and El-Metwaly, N., "Development of Photoluminescent, Superhydrophobic and Electrically Conductive Cotton Fibers". *Luminescence*, 36(2021)
- 13. AATCC Test Method (183-2004), "Transmittance or Blocking of Erythemally Weighted Ultraviolet Radiation through Fabrics", in *Technical Manual Method* American Association of Textile Chemists and Colorists. 317-321 (2010)
- Khattab, T.A., Fouda, M.M.G., Abdelrahman, M.S., Othman, S.I., Bin-Jumah, M., Alqaraawi, M.A., Al Fassam, H. and Allam, A.A., "Development of Illuminant Glow-in-the-Dark Cotton Fabric

Coated by Luminescent Composite with Antimicrobial Activity and Ultraviolet Protection". *Journal of fluorescence*, **29**(3) 703-710 (2019)

- 15. Chruściel, J.J., "Modifications of Textile Materials with Functional Silanes, Liquid Silicone Softeners, and Silicone Rubbers-a Review". *Polymers (Basel)*, **14**(20)(2022)
- Hassan, M., Attia, M. and Attia, R., "Improving of Thermal Stability and Water Repellency of Cotton Fabrics Via Coating with Silicone Rubber under the Effect of Electron Beam Irradiation". Journal of Industrial Textiles, 51 152808372110466 (2021)
- Moiz, A., Padhye, R. and Wang, X., "Durable Superomniphobic Surface on Cotton Fabrics Via Coating of Silicone Rubber and Fluoropolymers". *Coatings*, 8(3) 104 (2018)

تحضير طلاء مطاط السيليكون الهيدروليكي لمعالجة الاقمشة القطنية

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المستخلص: هناك طلب كبير على منسوجات الأداء التي تحمي الإنسان من التهديدات والمخاطر البيئية المختلفة. جعل التقدم في تكنولوجيا التشغيل جنبًا إلى جنب مع استخدام المواد المتقدمة هذا مجالًا من مجالات التركيز البحثي. تستخدم هذه الدراسة مطاط السيليكون لفحص الأسطح شديدة المقاومة للملابس القطنية دون التضحية بشكل كبير بالراحة. قامت المنسوجات القطنية الآن بتغيير الأسطح من حيث الشكل والتشكل والتعامل والسماكة والمكونات الكيميائية. من شأن هذا العمل أن يفيد في تطوير وتصميم الجيل القادم من المنسوجات ذات الأداء المتوازن والراحة. هذا هذا الجاهزة بطباعة النقل ؛ يتم تضمين جميع القياسات المطلوبة والتحقيق فيها في عملنا

الكلمات المفتاحية: قطن ، مطاط السيليكون ، إنارة الصور ، مضادات الميكروبات