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Development of Wrinkle Free and Self-Cleaning Finishing of Cotton and Polyester Fabrics

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Wrinkle-free and self-cleaning finishes are widely used in the textile industry to impart multi-functional properties to fabrics. To achieve the anti-wrinkle function, cotton fabrics were treated with silicone rubber, while polyester fabrics were treated with zinc oxide nanoparticles to impart the self-cleaning finish. All The parameters and required measurements are included and investigated.

Keywords: Cotton and polyester fabrics, wrinkle resistance, nanoparticles, zinc oxide, citric anhydride

Introduction

Recently, both research and industrial applications have given great attention to self-cleaning coatings. The benefits of self-cleaning coatings include everything from lower maintenance costs to pollution prevention. [1] In application procedures, several traditional and modern organic and inorganic chemicals are thus utilised. ZnO has already gained recognition as a chemical agent for textile functionalization within the latter group. The US Food and Drug Administration has classified bulk ZnO as a chemical that is generally recognised as safe (GRAS), which is a significant benefit (FDA). [2, 3]

Zinc oxide is a significant alternative oxide semi-conductor; it has been demonstrated that its mechanism is comparable to that of TiO2. ZnO offers a number of benefits, including affordability, a large number of active sites with high surface reactivity, and high absorption. [4-16]

Silicone rubber is an organic material. It decomposes under different environmental conditions. The most important characteristic is hydrophobicity. Hydrophobicity is the formation of water beads on the surface of the insulator. [13, 17-22]

The characteristic of fabric that enables it to recover from folding deformations is known as wrinkle resistance. The look of the cotton fabric is significantly impacted by these creases and shrinkages. The anti-wrinkle characteristic of cotton textiles may be effectively enhanced by crosslinking of the cellulose hydroxyl groups. [23] Dimethyloldihydroxyethylene urea (DMDHEU) and other N-methylol compounds are now the most widely utilised crosslinking agents for anti-wrinkle finishing because to their high efficacy and cost-effectiveness. [24]

As an effective alternative to formaldehyde-based crosslinking agents, citric acid was found, and the process conditions for applying citric acid finishing treatment to cotton fabric were enhanced. [5, 25, 26] One of these polycarboxylic acids is a naturally occurring, low-cost product that offers effective anti-wrinkle performance through a straightforward pad-dry-cure finishing procedure. The process parameters for the citric acid finishing treatment of cotton fabric were also improved to prevent the release of formaldehyde. [25, 27-33]

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In the present work, the finishing of polyester and cotton fabrics is carried out using the pad-dry-cure technique. Silicone, as well as ZnO nanoparticles, are used to impart self-cleaning and anti-wrinkle properties to fabrics, respectively all the required measurements are carried out and demonstrated in detail in our work.

Experimental

Materials

We gratefully received 100% cotton and 100% polyester fabrics from El-Mahalla Company for Spinning and Weaving, El-Mahalla, Egypt.

Room-temperature vulcanized silicon rubber (Pyrovatex CP New) and zinc oxide nanoparticles (nanopowder, ≤50 nm particle size; >97%) were purchased from Sigma-Aldrich, Egypt.

Hexane, citric acid LR anhydrous, disodium hydrogen phosphate, and di-hydrate, are all of the laboratory grades and are supplied by El Gomhoureya Pharmaceutical Company, Egypt.

Methods

Self-Cleaning Finish

Using beakers free of any invisible water droplets, silicone rubber and hexane were mixed with an ultrasonic cleaner. After that, adding ZnO nanoparticles, which were it's divided into different concentrations as follows: (0, 0.25, 0.5) g/l in the beakers, then samples of polyester fabric with stirring for a quarter of an hour. After that, we take out the samples and put them on a padder device to distribute the mixture on the sample in a good way.

- 4 gm Polyester sample
- 400 ml Hexane
- 60 gm Silicon rubber (Pyrovatex CP New)
- 1 gm Zinc oxide nanoparticles

Anti- Wrinkles Finish

Distilled water, citric acid LR (anhydrous), and disodium hydrogen phosphate are added to Cotton fabric using a stirrer, then we take out the sample and put it in an oven at 85 ° C for 20 minutes, and then put it in same solution for 15 minutes. So that it absorbs as much of the solution as possible. Then put it back in the oven at 85°C for 20 minutes.

- 4 gm Canvas material (cotton)
- 50 ml of Distilled water
- 5 gm Citric acid LR anhydrous
- 2.5 gm Disodium hydrogen phosphate

Measurements and Analysis

SEM Evaluation

A concentrated stream of high-energy electrons is utilised by the scanning electron microscope (SEM) to produce a range of signals at the surface of solid objects. In addition to the sample's exterior morphology (texture), chemical composition, and crystalline structure and orientation of its constituent components, the signals resulting from electron-sample interactions also provide information about the sample.

Most often, a portion of the sample's surface is chosen for data collection, and a 2-dimensional picture is created to show the spatial changes in these attributes. SEM methods may be used to photograph regions with widths of around 1 cm to 5 microns in a scanning mode (magnification ranging from 20X to approximately 30,000X, spatial resolution of 50 to 100 nm).

Microbiological Activity

Using the disc agar diffusion technique, the antibacterial properties of polyester and cotton textiles were investigated. Staphylococcus aureus ATCC 6538-P (G+ve) and Escherichia coli ATCC 25933 (G-ve), Candida albicans ATCC 10231 (yeast), and Aspergillus niger NRRL-A326 were the four representative test microorganisms employed (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. The antifungal properties were tested using potato dextrose agar plates inoculated with 0.1ml (106 cells/ml) of the fungal inoculum.

The inoculation plates were covered with 15mm-diameter textile-treated discs. To allow for maximal diffusion, plates were then maintained 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 posture. The diameter of the millimeter-sized zone of inhibition was used to measure the test agent's antibacterial activity (mm). Multiple runs of the experiment were completed, and the mean measurement was reported in relation to (Table 1).

Measurements of Contact Angle

The test material is placed into the goniometer in the form of a strip. One drop of deionized water is dispensed onto the test specimen using the syringe at the top. On a gauge at the Goniometer's end, a larger image of the water drop is projected. The angle between the material and the drop's edge is then measured after adjusting the gauge.

Sample size: To fit in the goniometer, the test material is divided into 15 mm (0.5") wide strips. The maximum specimen thickness is 2.5 mm.

Information: Using a table in ASTM D5946, the test result, which is an angular measurement in degrees, may be transformed into the surface energy of purified DI water.

Results and Discussion

A comparative study was conducted between the best methods to achieve self-cleaning and anti-bacterial properties of polyester fabrics, as well as the anti-wrinkle properties of cotton fabrics.

Scanning Electron Microscope (SEM) Test

SEM (Scanning Electron Microscope) test is applied on polyester and cotton fabrics. The morphology and the microstructure of the treated fabric can be seen in Fig.1.

Contact Angle Test

The angle created when a fabric surface makes contact with a liquid, creating a fabric-liquid interface, is known as the contact angle. The sample's contact angle ranges from 129.5° to 133.0°, which is more than 90°. The contact angles are 129.5° in (a), 131.5° in (b), and 133° in (c). According to Fig. 2, this indicates that the cloth has successfully been treated to be hydrophobic.

Antimicrobial Test

The following table shows the antibacterial activity of polyester textiles against several test microorganisms that represent G+ve bacteria (S. aureus), G-ve bacteria (E. coli), Yeast (C. Albicans), and fungus (A. niger).

Conclusion

This study reviews the most recent studies concerned with functionalized textiles with eco-friendly and cost-effective materials. The treatment of polyester fabric is made by using Zinc oxide and the cotton fabrics by using silicone rubber.

The enhanced hydrophobic performance of the treated polyester textiles, which improved photocatalytic self-cleaning activity, was introduced as a thin coating of nanoparticles. The advantages of applying silicone rubber finishing solution to cotton fabrics include increased softness, anti-wrinkle resistance, and whiteness.

These findings demonstrate that oxide nanoparticles may provide the best multifunctional prints for the manufacture of technical fabrics. Nanocomposites can therefore be used to textile fibres to produce textiles with improved printing capabilities.

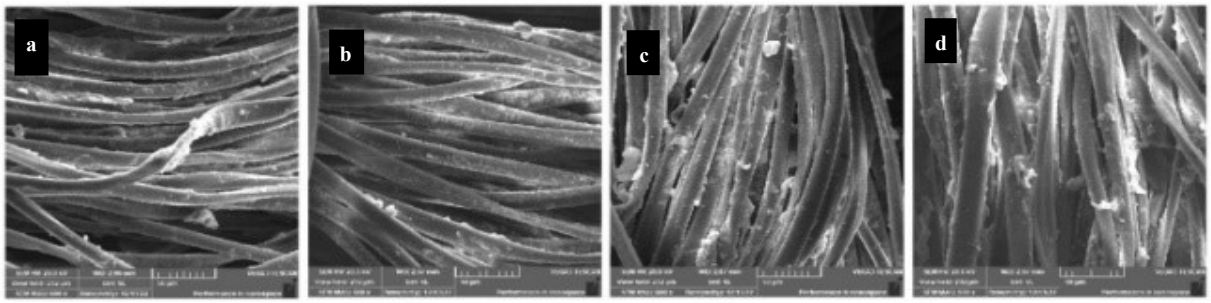

Fig.1. SEM images of treated polyester fabrics with ZnO(a,b). images of treated cotton fabrics with silicone rubber (c,d)

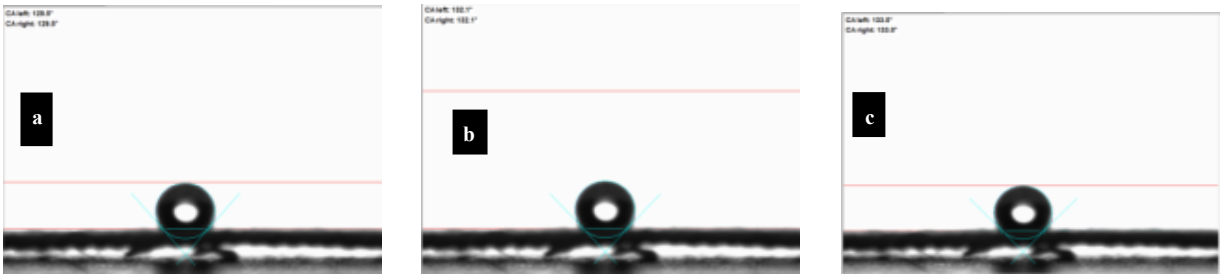

Fig.2. Static water contact angles of the treated polyester fabric.

Clear zone (ϕmm)			
Staphylococcus aureus	***Escheichia coli***	***Candida albicans***	***Aspergillusniger***
15	0	12	0

Conflict of Interest

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

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References

1. Rios, P., Dodiuk, H. and Kenig, S., "Self-Cleaning Coatings". *Surface engineering*, **25**(2) 89-92 (2009)

2. Hackenberg, S., Scherzed, A., Technau, A., Froelich, K., Hagen, R. and Kleinsasser, N., "Functional Responses of Human Adipose Tissue-Derived Mesenchymal Stem Cells to Metal Oxide Nanoparticles in Vitro". *Journal of biomedical nanotechnology*, **9**(1) 86-95 (2013)

3. Diaa, M. and Hassabo, A.G., "Self-Cleaning Properties of Cellulosic Fabrics (a Review)". *Biointerface Research in Applied Chemistry*, **12**(2) 1847 - 1855 (2022)

4. Ibrahim, N.A., Nada, A.A., Hassabo, A.G., Eid, B.M., Noor El-Deen, A.M. and Abou-Zeid, N.Y., "Effect of Different Capping Agents on Physicochemical and Antimicrobial Properties of Zno Nanoparticles". *Chemical Papers*, **71**(7) 1365-1375 (2017)

5. Ibrahim, N.A., Nada, A.A., Eid, B.M., Al-Moghazy, M., Hassabo, A.G. and Abou-Zeid, N.Y., "Nano-Structured Metal Oxides: Synthesis, Characterization and Application for Multifunctional Cotton Fabric". *Advances in Natural Sciences: Nanoscience and Nanotechnology*, **9**(3) 035014 (2018)

6. Lin, H.-F., Liao, S.-C. and Hung, S.-W., "The Dc Thermal Plasma Synthesis of Zno Nanoparticles for Visible-Light Photocatalyst". *Journal of photochemistry and photobiology A: Chemistry*, **174**(1) 82-87 (2005)

7. Mohamed, A.L. and Hassabo, A.G. "Engineered Carbohydrate Based Material/Silane as a Thermo and Ph-Sensitive Nanogel Containing Zinc Oxide Nanoparticles for Antibacterial Textile". in *International Conference on Medical Textiles and Healthcare Products (MedTex 2015)*. Department of Material and Commodity Sciences and Textile Metrology, Faculty of Material Technologies and Textile Design, Lodz University of Technology, Lodz, Poland (2015)

8. El-Naggar, M.E., Hassabo, A.G., Mohamed, A.L. and Shaheen, T.I., "Surface Modification of Sio2 Coated Zno Nanoparticles for Multifunctional Cotton Fabrics". *Journal of Colloid and Interface Science*, **498** 413-422 (2017)

9. Hassabo, A.G., El-Naggar, M.E., Mohamed, A.L. and Hebeish, A.A., "Development of Multifunctional Modified Cotton Fabric with Tri-Component Nanoparticles of Silver, Copper and Zinc Oxide". *Carbohydrate Polymers*, **210** 144-156 (2019)

10. Zayed, M., Othman, H., Ghazal, H. and Hassabo, A.G., "Psidium Guajava Leave Extract as Reducing Agent for Synthesis of Zinc Oxide Nanoparticles and Its Application to Impart Multifunctional Properties for Cellulosic Fabrics". *Biointerface Research in Applied Chemistry*, **11**(5) 13535 - 13556 (2021)

11. Hassabo, A.G., Ragab, M.M. and Othman, H.A., "Ultraviolet Protection of Cellulosic Fabric". *Journal of Textiles, Coloration and Polymer Science*, **19**(1) 51-61 (2022)

12. Kamel, M.Y. and Hassabo, A.G., "Anti-Microbial Finishing for Natural Textile Fabrics". *Journal of Textiles, Coloration and Polymer Science*, **18**(2) 83-95 (2021)

13. Mohamed, A.L., El-Naggar, M.E. and Hassabo, A.G., "Preparation of Hybrid Nano-Particles to Enhance the Electrical Conductivity and Performance Properties of Cotton Fabrics". *Journal of Materials Research and Technology*, **12** 542-554 (2021)

14. Yansheng, L., Zhenhua, J., Nan, Y. and Hong, G., "Regeneration of Nano-Zno Photocatalyst by the Means of Soft-Mechanochemical Ion Exchange Method". *Journal of Environmental Sciences*, **21** S69-S72 (2009)

15. Behnajady, M., Modirshahla, N. and Hamzavi, R., "Kinetic Study on Photocatalytic Degradation of Ci Acid Yellow 23 by Zno Photocatalyst". *Journal of hazardous materials*, **133**(1-3) 226-232 (2006)

16. Chen, L., Shen, Y., Bai, J. and Wang, C., "Novel Symmetrical Coralloid Cu 3d Superstructures: Solid-State Synthesis from a Cu-Carboxylate Mof and Their in-Situ Thermal Conversion". *Journal of Solid State Chemistry*, **182**(8) 2298-2306 (2009)

17. Mohamed, A.L., El-Naggar, M.E., Shaheen, T.I. and Hassabo, A.G., "Laminating of Chemically Modified Silan Based Nanosols for Advanced Functionalization of Cotton Textiles". *International Journal of Biological Macromolecules*, **95** 429–437 (2017)

18. Hassabo, A.G. and Mohamed, A.L., "Novel Flame Retardant and Antibacterial Agent Containing Mgo Nps, Phosphorus, Nitrogen and Silicon Units for Functionalise Cotton Fabrics". *Biointerface Research in Applied Chemistry*, **9**(5) 4272 - 4278 (2019)

19. Mohamed, A.L. and Hassabo, A.G., "Review of Silicon-Based Materials for Cellulosic Fabrics with Functional Applications". *Journal of Textiles, Coloration and Polymer Science*, **16**(2) 139-157 (2019)

20. Fahmy, H.M., Okda, H.M.Y., Hassabo, A.G., El-Rafie, M.H. and Youssef, M.A., "Synthesis of New Silicone-Based Adducts to Functionalize Cotton Fabric". *Silicon*, (2021)

21. Mohamed, A.L. and Hassabo, A.G., "Cellulosic Fabric Treated with Hyperbranched Polyethyleneimine Derivatives for Improving Antibacterial, Dyeing, Ph and Thermo-Responsive Performance". *International Journal of Biological Macromolecules*, **170** 479-489 (2021)

22. Mohamed, A.L. and Hassabo, A.G., "Modified Cellulose Acetate Membrane for Industrial Water Purification". *Egyptian Journal of Chemistry*, **65**(13) 53-70 (2022)

23. Sahin, U.K., Gursoy, N.C., Hauser, P. and Smith, B., "Optimization of Ionic Crosslinking Process: An Alternative to Conventional Durable Press Finishing". *Textile research journal*, **79**(8) 744-752 (2009)

24. Luo, X., Shao, D., Xu, C., Wang, Q. and Gao, W., "An Eco-Friendly Way to Whiten Yellowish Anti-Wrinkle Cotton Fabrics Using Tbcc-Activated Peroxide Low-Temperature Post-Bleaching". *Cellulose*, **26** 3575-3588 (2019)

25. Grant, W.B., Moan, J. and Reichrath, J., "Comment on “the Effects on Human Health from Stratospheric Ozone Depletion and Its Interactions with Climate Change” by M. Norval, Ap Cullen, Fr De Gruijl, J. Longstreth, Y. Takizawa, Rm Lucas, Fp Noonan and Jc Van Der Leun, Photochem. Photobiol. Sci., 2007, 6, 232". *Photochemical & Photobiological Sciences*, **6** 912-915 (2007)

26. Hebeish, A., Shaarawy, S., Hassabo, A.G. and El-Shafei, A., "Eco-Friendly Multifinishing of Cotton through Inclusion of Motmorillonite/Chitosan Hybrid Nanocomposite". *Der Pharma Chemica*, **8**(20) 259-271 (2016)

27. Hegazy, B.M., Othman, H. and Hassabo, A.G., "Polycation Natural Materials for Improving Textile Dyeability and Functional Performance". *Journal of Textiles, Coloration and Polymer Science*, **19**(2) 155-178 (2022)

28. Hegazy, B.M., Othman, H.A. and Hassabo, A.G., "Polyanion Biopolymers for Enhancing the Dyeability and Functional Performance of Different Textile Materials Using Basic and Natural Dyes". *Egyptian Journal of Chemistry*, **65**(8) 177 – 196 (2022)

29. Zayed, M., Ghazal, H., Othman, H.A. and Hassabo, A.G., "Synthesis of Different Nanometals Using Citrus Sinensis Peel (Orange Peel) Waste Extraction for Valuable Functionalization of Cotton Fabric". *Chemical Papers*, **76**(2) 639-660 (2022)

30. Ebrahim, S.A., Othman, H.A., Mosaad, M.M. and Hassabo, A.G., "Eco-Friendly Natural Thickener (Pectin) Extracted from Fruit Peels for Valuable Utilization in Textile Printing as a Thickening Agent". *Textiles*, **3**(1) 26-49 (2023)

31. Hassabo, A.G., Ebrahim, S., Othman, H.A. and Mosaad, M.M., "Using Pectin to Enhance the Dyeability Performance and Antimicrobial Activity Using Different Dyes on Modified Proteinic and Synthetic Fabrics". *Biointerface Research in Applied Chemistry*, **13**(5) BRIAC135.467 (2023)

32. Hassabo, A.G., Reda, E., Ghazal, H. and Othman, H., "Enhancing Printability of Natural Fabrics Via Pre-Treatment with Polycationic Polymers". *Egyptian Journal of Chemistry*, (2023)

33. Mohamed, A.L., Shaarawy, S., Elshemy, N., Hebeish, A. and Hassabo, A.G., "Treatment of Cotton Fabrics Using Polyamines for Improved Coloration with Natural Dyes Extracted from Plant and Insect Sources". *Egyptian Journal of Chemistry*, **66** - (2023)

التجهيزات المقاومه للتجعد والتنظيف الذاتي لأقمشة القطن والبوليستر

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المستخلص: تُستخدم اللمسات النهائية الخالية من التجاعيد والتنظيف الذاتي على نطاق واسع في صناعة النسيج لإضفاء مقاومة التجاعيد ومظهر نظيف للأقمشة. لتحقيق وظيفة مقاومة التجاعيد ، تمت معالجة الأقمشة القطنية بمطاط السيليكون ، بينما تمت معالجة أقمشة البوليستر بجزيئات أكسيد الزنك النانوية لإضفاء لمسة التنظيف الذاتي. يتم تضمين جميع المعلمات والقياسات المطلوبة والتحقيق فيها

الكلمات المفتاحية: أقمشة قطنية وبوليستر ، مقاومة التجعد ، جزيئات النانو ، أكسيد الزنك ، أنهيدريد الستريك.