Journal of Fashion Technology & Textile Engineering

Mini Review

A SCITECHNOL JOURNAL

Multifunctional Textile Fabric and Their Application

Sukanta Pal, Sourav Mondal, Ajit Das, Debasish Mondal, Bholanath Panda, Jayanta Maity*

Abstract

In both fundamental research and industrial applications, multifunctional textile textiles with unique wettability have piqued interest. The latest developments of various methodologies and strategies for constructing superhydrophobic coatings on textile materials are described in detail in this review.

Keywords: Textile, Cotton, Superhydrophobic, Nanotechnology, Review

Introduction

Multifunctional superhydrophobic textiles materials have attracted extensive worldwide attention in recent decades. Superhydrophobic materials have applications in fundamental research and potential applications in the fields of self-cleaning [1], anticorrosion [2], oil-water separation [3], water collection [4], anti-icing [5], drag reduction [6], energy conversation [7] antibacterial [8] and fire protective [9]. The common multifunctional superhydrophobic materials such as metallic mesh [10], filter paper [11], foam polyurethane [12], fabric [13], carbon-based materials [14], and ceramic membranes [15] have been extensively studied in current research. Among textile fabrics, cotton fabric is the most popular material used by various consumers and professional apparel due to its comfort, elastic-plastic nature, non-hazards, and a moisture absorbing good strength in both wet and in a dry condition, perfect dimension stability, and excellent wearing properties. The cellulosic hydroxyl group in cotton fiber makes it a tremendous water-loving adsorbent. This excessive water absorbability allows cotton textiles to be easily stained and dirtied. Sometimes cotton textiles are also wetted and contaminated by blood, oil, and even bacteria, which are undesirable in their use as cloths particularly in hospital settings. Thus, the development of non-wettable cotton textiles with high water contact angle values and dirt-resistant cotton textiles has long been an interesting subject to research. To achieve this goal surface modification of cotton fabric is necessary. Nowadays such smart textile surfaces are prepared by tailoring the surface morphology using techniques such as dip coating [16], hydrothermal [17], layer-by-layer (LBL) coating techniques [18], UV-Irradiation [19], chemical vapor deposition (CVD) techniques [20], admicellar polymerization [21], etc. have been employed to improve its water-loving character.

Recent Progress in Multifunctional Finishing Textiles

Recently, Tudu et al. [22] prepared superhydrophobic cotton fabric using TiO_2 nanoparticles and PFDTS via a simple dip-coating approach, which showed excellent chemical durability, laundering durability, antibacterial, and oil-water separation. Mondal et al [23] fabricated fluoropolymer adhered bio-inspired hydrophobic, chemically durable cotton fabric for dense liquid removal and self-cleaning application. Superhydrophobic and antibacterial active cotton textiles were successfully fabricated via a simple in situ coating method using silver nanoparticles followed by hydrophobization with Hexadecyltrimethoxysilane (HDTMS) [24]. The superhydrophobic nature of modified cotton textile fabric was investigated by contact angle measurement having a water contact angle of 157º and show water droplets roll easily on the cotton fabric surface. Microwave irradiation technique was applied for the fabrication of nanoparticles coated superhydrophobic antibacterial cotton fabric via a thiol modification followed by nanoparticle deposition. Series of nanoparticles such as FeNPs, MnNPs, CoNPs, and CuNPs were used for cotton surface modification [25]. A simple and facile fabrication approach was applied for the synthesis of ZnO nanoparticles coated textile substrate to improve some novel properties such as biosensor for pesticide detection, Photocatalytic degradation of organic dyes, and antibacterial activity [26]. Cotton fabric was modified via the sol-gel method by the nanocrystalline TiO_2 and cross-linking agent 1, 2, 3, 4-butane tetracarboxylic acid (BTCA) as a spacer [27]. The bonding mechanism, chemical bonding, and the physical adsorption of the TiO_2 nanoparticles to the fabric surface were confirmed by SEM and FT-IR results. Laundering durability silver nanoparticles functionalized antibacterial active cotton fabric fabrics were prepared by radiation-induced co-incident reduction and graft polymerization approach [28]. Karimi and co-workers [29] examined a simple inventive approach to the development of the multifunctional application of cotton fabric based on graphene oxide/titanium dioxide coating. Modified samples were assessed for various applications such as electrical resistance, self-cleaning, UV blocking, and antimicrobial properties. Khajavi et al. [30] reported modifying the superhydrophobic and antibacterial active cotton fabric by doping copper nanoparticles with silica-based sols. Enhancement of hydrophilicity and antibacterial activity the GTAC/3-MPTMS/AgNPs modification was applied successfully on cotton fibers surface [31]. The QA/AgNPs treated cotton fabric showed higher moisture regain and antibacterial properties than raw cotton fabric. Surface modification of cotton fabric was performed by laser exposure of cotton followed by silver nanoparticles coating [32]. The presence of carboxylic acid groups on the laser-treated cotton fabric was examined spectrophotometrically by dye absorption capability of Methylene blue dye. A facile hydrothermal deposition method [33] was presented for the synthesis of Ag/TiO2 coated cotton fabrics. The coated cotton fabric displayed sustainable antibacterial reduction and durable UV-protection activity (UPF) before and after laundering.

Conclusion

The latest developments in multifunctional superhydrophobic fabric, as well as their various fabrication methods, are discussed. Incorporation of foreign materials enhances the anti-wetting activity of the fabricated textiles fabrics along with numerous physical properties of textiles in the areas such as water repellent, photo-catalyst, self-cleaning fabrics, UV-protection, antistatic, flame

***Corresponding author:** Jayanta Maity, Polymer and Textile Research Laboratory, Department of Chemistry, Sidho-Kanho-Birsha University, Purulia, West Bengal, 723101, India, E-mail: jayantaptrl@gmail.com

Received: June 08, 2021 **Accepted:** June 25, 2021 **Published:** July 02, 2021

retardant, stain resistant, wrinkle resistance, and drug delivery properties of textile materials. Applications are summarised for each type of fabrication technology, providing state-of-the-art progress and understanding in producing superhydrophobic surfaces.

References

1. Yang Z, Wang L, Sun W, Li S, Zhu T (2017) Superhydrophobic epoxy coating modified by fluorographene used for anti-corrosion and self-cleaning. Appl Surf Sci 401: 146-155.
2. Xiao F, Yuan S, Liang B, Li G, Pehkonen SO (2015) Superhydrophobic CuO nanoneedle-covered copper surfaces for anticorrosion. J Mater Chem A 3: 4374–4388.
3. Xu Z, Zhao Y, Wang H, Zhou H, Qin C, et al. (2016) Fluorine-Free Superhydrophobic Coatings with pH-induced Wettability Transition for Controllable Oil-Water Separation. ACS Appl Mater Interfaces 8: 5661–5667.
4. Wang Y, Zhang L, Wu J, Hedhili MN, Wang P (2015) A facile strategy for the fabrication of a bioinspired hydrophilic–superhydrophobic patterned surface for highly efficient fog-harvesting. J Mater Chem A 3: 18963–18969.
5. Wang L, Gong Q, Zhan S, Jiang L, Zheng Y (2016) Robust Anti-Icing Performance of a Flexible Superhydrophobic Surface. Adv Mater 28: 7729–7735.
6. Cheng M, Song M, Dong H, Shi F (2015) Surface adhesive forces: a metric describing the drag-reducing effects of superhydrophobic coatings. Small 11: 1665-1671.
7. Zhang XF, Chen RJ, Liu YH, Hu JM (2016) Electrochemically generated sol–gel films as inhibitor containers of superhydrophobic surfaces for the active corrosion protection of metals. J Mater Chem A 4: 649–656.
8. Pal S, Mondal S, Maity J (2018) In situ generation and deposition of ZnO nanoparticles on cotton surface to impart hydrophobicity: investigation of antibacterial activity. Mater Technol 33: 555-562.
9. Pal A, Samanta AK, Bagchi A, Samanta P, Kar TP (2020) A Review on Fire Protective Functional Finishing of Natural Fibre Based Textiles: Present Perspective, Curr Trends Fash Techn Text Eng 7(1):.555705.
10. Feng L, Zhang Z, Mai Z, Ma Y, Liu B, et al. (2004) A super-hydrophobic and super-oleophilic coating mesh film for the separation of oil and water. Angewandte Chemie 116: 2046-2048.
11. Satapathy M, Varshney P, Nanda D, Panda A, Mohapatra SS, et al. (2017) Fabrication of superhydrophobic and superoleophilic polymer composite coatings on cellulosic filter paper for oil–water separation. Cellulose 24: 4405-4418.
12. Li A, Sun HX, Tan DZ, Fan W J, Wen SH, et al. (2011) Superhydrophobic conjugated microporous polymers for separation and adsorption. Energy Environ Sci 4: 2062-2065.
13. Pal S, Mondal S, Maity J (2019) Fabrication of thin fluoropolymer adhered cotton fabric surface for efficiently microscopic to macroscopic level oil/water separation. Surf Topogr: Metrol Prop 7: 025001.
14. Yang Y, Tong Z, Ngai T, Wang C (2014) Nitrogen-rich and fire-resistant carbon aerogels for the removal of oil contaminants from water. ACS Appl Mater Interfaces 6: 6351-6360.
15. Su C, Xu Y, Zhang W, Liu Y, Li, J (2012) Porous ceramic membrane with superhydrophobic and superoleophilic surface for reclaiming oil from oily water. Appl Surf Sci 258: 2319-2323.
16. Bae GY, Min BG, Jeong YG, Lee SC, Jang JH, et al. (2009) Superhydrophobicity of cotton fabrics treated with silica nanoparticles and water-repellent agent. J Colloid Interface Sci 337: 170–175.
17. Pal S, Mondal S, Maity J (2018) In situ generation and deposition of ZnO nanoparticles on cotton surface to impart hydrophobicity: Investigation of antibacterial activity. Mater Technol 33: 555–562.
18. Zhao Y, Xu ZG, Wang XG, Lin T (2012) Photoreactive azido-containing silica nanoparticle/polycation multilayers: Durable superhydrophobic coating on cotton fabrics. Langmuir 28: 6328–6335.
19. Li G, Zheng HT, Wang YX, Dong H, Dong QB, Bai R (2010) A facile strategy for the fabrication of highly stable superhydrophobic cotton fabric using amphiphilic fluorinated triblock azide copolymers. Polymer 51: 1940–1946.
20. Ma ML, Mao Y, Gupta M, Gleason KK, Rutledge GC (2005) Superhydrophobic fabrics produced by electrospinning and chemical vapor deposition. Macromolecules 38: 9742–9748.
21. Mondal S, Pal S and Maity J (2018) Transparent and double sided hydrophobic functionalization of cotton fabric by surfactant assisted admicellar polymerization of fluoromonomers. New J Chem 42: 6831–6838.
22. Tudu B K, Sinhamahapatra A, Kumar A (2020) Surface Modification of Cotton Fabric Using TiO2 Nanoparticles for Self-Cleaning, Oil–Water Separation, Antistain, Anti-Water Absorption, and Antibacterial Properties. ACS omega 5: 7850-7860.
23. Mondal S, Pal S, Chaudhuri A, Maity J (2021) Fluoropolymer adhered bioinspired hydrophobic, chemically durable cotton fabric for dense liquid removal and self-cleaning application. Surf Eng 37: 299-307.
24. Xuea CH, Chena J, Yina W, Jia ST, Ma JZ (2012) Superhydrophobic conductive textiles with antibacterial property by coating fibers with silver nanoparticles. Appl Surf Sci 258: 2468–2472.
25. Gouda M, Aljaafari A, Al-Fayz Y and Boraie WE (2015) Preparation and characterization of some nanometal oxides using microwave technique and their application to cotton fabrics. J Nanomater 9: 1–9.
26. Hatamie A, Khan A, Golabi M, Turner APF, Beni V, et al. (2015) Zinc oxide nanostructure-modified textile and its application to biosensing, photocatalysis, and as antibacterial material. Langmuir 31: 10913–10921.
27. Galkina OL, Sycheva A, Blagodatskiy A, Kaptay G, Katanaev VL, et al. (2014) The sol–gel synthesis of cotton/TiO2 composites and their antibacterial properties. Surf Coat Technol 253: 171–179.
28. Liu H, Lv M, Deng B, Li J, Yu M, et al. (2014) Laundering durable antibacterial cotton fabrics grafted with pomegranate-shaped polymer wrapped in silver nanoparticle aggregations. Sci Rep 4: 5920–5928.
29. Karimi L, Yazdanshenas, ME, Khajavi R, Rashidi A, Mirjalili M (2015) Functional finishing of cotton fabrics using graphene oxide nanosheets decorated with titanium dioxide nanoparticles. J Text Inst 7: 1122–1134.
30. Berendjchi A, Khajavi R, Yazdanshenas ME (2011) fabrication of superhydrophobic and antibacterial surface on cotton fabric by doped silica-based sols with nanoparticles of copper. Nanoscale Res Lett 6: 594–601.
31. Kang CK, Kimb SS, Kim S, Lee J, Lee JH, et al. (2016) Antibacterial cotton fibers treated with silver nanoparticles and quaternary ammonium salts. Carbohydr Polym 151:1012–1018.
32. Nourbakhsh S, Ashjaran A (2012) Laser treatment of cotton fabric for durable antibacterial properties of silver nanoparticles. Mater 5: 1247–1257.
33. Li S, Zhu T, Huang J, Guo Q, Chen G, et al. (2017) Durable antibacterial and UV-protective Ag/TiO_2@fabrics for sustainable biomedical application. Int J Nanomedicine 12: 2593–2606.

Author Affiliations

Polymer and Textile Research Laboratory, Department of Chemistry, Sidho-Kanho-Birsha University, Purulia, West Bengal, 723101, India