Innovating Fashion: The Promise of Self-Cleaning Textiles for a Sustainable Future

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ABSTRACT

Self-cleaning clothing which is a new and fast emerging technology in the textile sector holds potential of changing the manner in which garments are washed and taken care of. As the ethical issue of environmental sustainability, water consumption, and the overall effect of the fashion industry gain even greater importance, the emergence of self-cleaning fabrics offers an attractive solution. The paper has given an in-depth discussion of the science of self-cleaning clothes, it's possible uses and limitations, and its future projections concerning the future of clothing production and environmental sustainability.

INTRODUCTION

The textile industry, while a cornerstone of global fashion and economic activity, has long been associated with significant environmental and resource-based challenges. Conventional clothing maintenance, particularly washing and drying, consumes substantial amounts of water, energy, and detergent, contributing to environmental degradation. Furthermore, these processes lead to the degradation of fabrics over time, shortening the lifespan of garments and contributing to excessive textile waste. Recent advancements in self-cleaning clothing offer the potential to address these challenges by significantly reducing the need for laundering while maintaining the appearance and integrity of garments. Self-cleaning clothing refers to textiles that possess inherent

properties or coatings that allow them to either resist staining, actively repel dirt and liquids, or degrade and remove contaminants through chemical or physical processes. Unlike traditional fabrics, which require frequent washing to maintain cleanliness, self-cleaning textiles reduce the need for constant maintenance, contributing to lower environmental footprints and more efficient garment care.

The concept of self-cleaning clothing inspired by the lotus plant, often referred to as the "lotus effect," represents one of the most innovative approaches in textile technology. This principle is based on the unique properties of the lotus leaf's surface, which has the ability to repel water and dirt, allowing the leaf to remain clean in muddy or rainy environments. The lotus effect is achieved through a combination of surface microstructures and hydrophobic (water-repelling) properties, which are now being mimicked in the development of self-cleaning fabrics (Malik *et al*., 2018).

1. Principle of self-cleaning clothing

The principle of self-cleaning clothing is rooted in surface chemistry and the way materials interact with external elements like water, dirt, and light. The key principles include:

1.1 Super hydrophobicity:- This principle is based on the ability of a material to repel water. In self-cleaning fabrics, the surface is engineered to have microscopic structures that reduce the contact area between the fabric and water, causing water to form beads and roll off the surface. This repels not only water but also dirt and contaminants, which are carried away with the water droplets.

1.2 Oleophobicity:- Similar to water repulsion, this principle involves the repulsion of oils and greasy substances. Materials are treated to prevent oils from adhering to the surface, which helps keep the fabric clean by avoiding the formation of stains.

1.3 Photocatalysis: - This principle involves the use of light to activate a chemical reaction on the surface of the fabric, which helps break down dirt, stains, and microorganisms. The reaction is typically triggered by sunlight and helps decompose organic material, keeping the fabric cleaner over time.

2. Manufacturing Methods

The method of creating self-cleaning clothing involves applying advanced techniques and treatments to the fabric that alter its surface properties, making it resistant to dirt, water, oils, and stains. Below are some common methods used to make clothing self-cleaning:

2.1. Fluorocarbon- Fluorocarbons are chemical compounds, which have carbon-fluorine bonds and these bonds are very resistant to water and oils. These compounds when applied to clothes form a thin protective coating on the surface which does not absorb liquid. Rather, oils and water create droplets which roll off the garment, washing away dirt and other impurities. That is what causes the cloth to become hydrophobic (water-repellent) and oleophobic (oil-repellent). The idea of the fluorocarbons is demonstrated by the fact that at a situation in which the critical point of the solid surpasses the surface tension of the liquid, then the liquid will wet the solid. Thus, the water repellency can be attained in case the critical surface tension of the solid is lower than that of liquid (Malik *et al*., 2018).

2.2. Nanotechnology- Nanotechnology is a form of manipulation of materials at the nanoscale (that is, of the scale of atoms and molecules) to modify the surface

properties of fabrics. Fabrics could be made dirt, moisture, and oil resistant by applying nanoparticles, e.g., silica or titanium dioxide (TiO_2). These nanoparticles assist in making the surface rough and textured such that water droplets can form beads and roll off and at the same time the dirt particles do not stick to the surface.

3. Applications of self-cleaning fabrics

The fact that self-cleaning clothes resist dirt, stains, and bacteria is associated with a vast number of applications in different industries. In clothes, they make it unnecessary to wash them regularly, which contributes to enhancing their durability and water savings, especially in athletic apparel and outdoor apparel. Home textiles such as curtains, bedding and upholstery are also made of these fabrics, thus making them easy to maintain by keeping off dirt and stains. They improve hygiene in medical dressings, sheets and hospital gowns in the healthcare sector. Self-cleaning materials on car interiors save the automotive industry and save time of protective workwear on construction and other sectors. Self-cleaning fabrics are also used in the aerospace to make airplane interiors, in military uniforms so they can withstand adverse conditions, and in the city to apply on the facades of buildings so it can help de-pollute the air. They are also utilized in smart clothes in the more sophisticated uses, including medical and environmental monitoring. In general, these materials have great sustainability, durability and hygiene benefits in a variety of industries.

4. Limitations of Self-Cleaning Fabric

Although the self-cleaning fabrics are innovative, it has a number of limitations that can affect their general use. The longevity of the self-cleaning properties is one of the major weaknesses because these fabrics usually depend on the coating or treatments which may be deteriorated with time when these fabrics are exposed to such factors as washing, UV rays, or severe conditions in nature. Moreover, they may not be as efficient in severe conditions, as hard stains or strong dirt still can exist and need some conventional means of cleaning.

CONCLUSION

Self-cleaning clothes are a wonderful innovation that has the possibility of changing the relationship with fashion, washing, and nature. Self-cleaning fabrics have many advantages, which can transform a more convenient and sustainable lifestyle since they decrease the frequency of washing, enhance hygiene, and provide durability. Although issues are still present in relation to costs, durability, and functionality, the future of self-cleaning apparel is bright since researchers keep perfecting and enhancing the technology of such smart fabrics.

REFERENCES

Ahmad, I. and Kan, C. W. Visible-light-driven, dye-sensitized TiO_2 photo-catalyst for self-cleaning cotton fabrics. 2017; Retrived from (PDF) Visible-Light-Driven, Dye-Sensitized TiO2 Photo-Catalyst for Self-Cleaning Cotton Fabrics.

Latthe, S. S., Sutar, R.S., Kodag, V. S. Bhosale, A.K., Kumar, A. M. Sadasivuni, K. K., Xing, R. and Liu, S. (2019). Self – cleaning superhydrophobic coatings: potential industrial applications. *Progress in Organic Coatings*, 128: 52-58.

Mahadik, S. A., Parale, V., Vhatkara, R. S., Mahadik, D. B., Kavale, M. S., Wagh, P. B., Gupta, S. and Gurav, J. (2013). Superhydrophobic silica coating by dip coating method. *Applied Surface Science,* 277: 67-72.

Malik, T., Nogja, S. and Goyal,P. Self-cleaning textile - an overview. 2018; Retrieved from (PDF) SELF CLEANING TEXTILE-AN OVERVIEW Self cleaning textile-an overview.

Pakdel, E.; Daoud, W.A.; Wang, X. (2013). Self-cleaning and super-hydrophilic wool by TiO2/SiO2 nanocomposite. *Applied Surface Science,* 275: 397–402.

Saad, S. R., Mahmed, N., Abdullah, M. M. A. B. and Sandu, A.V. (2016). Self-cleaning technology in Fabric: A Review. *Material science and Engineering*, 133:1-10.

Suryaprabha, T., Heebo, H., Hwang, B. and Sethuraman, M. G. (2023). Self-cleaning, superhydrophobic, and antibacterial cotton fabrics with chitosan-based composite coatings. *International Journal of Biological Macromolecules*, 250: 1-10.

Tan, B., Gao, B., Guo, J., Guo, X. and Long, M. (2013). A comparison of TiO2 coated self-cleaning cotton by the sols from peptizing and hydrothermal routes. *Surf. Coat. Technol,* 232: 26–32.