Crimson Publishers
Wings to the Research

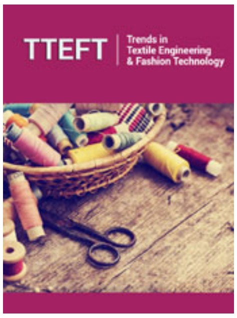
Mini Review

A Review of Cold Plasma Treatment on Textile Fibre

Ramyaranjan Das, Chinmayee Dash and Dillip Kumar Bisoyi*

Department of Physics and Astronomy, National Institute of Technology Rourkela, Rourkela-769008, India

ISSN: 2578-0271



***Corresponding author:** Dillip Kumar Bisoyi, Department of Physics and Astronomy, National Institute of Technology Rourkela, Rourkela-769008, India

Submission: November 28, 2022
Published: January 20, 2023

Volume 7 - Issue 5

How to cite this article: Ramyaranjan Das, Chinmayee Dsh, Dillip Kumar Bisoy. A Review of Cold Plasma Treatment on Textile Fibre. Trends Textile Eng Fashion Technol. 7(5). TTEFT. 000675. 2023. DOI: 10.31031/TTEFT.2023.07.000675

Abstract

This paper briefly reviews the effect of cold plasma treatment on textile fibre. The primary goal is to investigate the effect of cold plasma on the structural properties of natural fibre, particularly emphasizing the significance of plasma technology in the textile industry. Plasma processing technology is used in textile fibre for enhancing self-cleaning properties, wetting properties, anti-microbial activity, and surface hydrophobization of the fibre.

Keywords: Textile fibre; Cold plasma; Surface modification; Functional groups

Introduction

Currently, plasma technology has achieved enough attention from the textile industry as it is bio-friendly and economical. Plasma treatment provides textile finishing and improves adhesion properties without changing its key textile properties [1]. Basically, the Textile industry is concerned with the development of technology, the production of textile products from raw materials and converting them to final finishing with some modification techniques. The Surface of the fibre must have to modify to alter its surface properties. Plasma is a partially ionized gas which is also considered the fourth state of matter. It can be categorized into low-temperature/ cold plasma and high-temperature/thermal plasma [1]. Only cold plasma is applicable in the textile fibre industry for the modification of polymer fibre because it provides thermal stability to the fibre [1]. Plasma surface treatment on natural textile fibre can be carried out at low as well as high vacuum pressure. The highly energetic electron and low energetic radicals initiate the cold plasma reaction on textile fibre without heating the specimen [2]. Cold plasma treatment is a versatile modification technique, where chemically active functional groups can be introduced on fibre surface and the surface of the fibre can be modified at micro and Nano order length scales [2]. Cold plasma carries many reactive species, electrons, ions, and photons in the ultraviolet range. On the specimen surface, these species initiate chemical reactions [1]. Such chemical modifications are confined up to a depth of a few Nano-meters [1]. Textile fibre surface modification by cold plasma treatment is governed by several factors, such as power, time of exposure, purse gas, and frequency [1]. The most common application of plasma treatment is surface coating and surface cleaning. It also improves the wettability and adhesion properties of the fibre [1]. It enhances the electrical conductance, increases the antibacterial activity of textile fibre, imparts hydrophobic-oleophilic properties, and modifies the shrink properties of wool, silk, cotton etc., [3]. Plasma treatment can be used for chemical grafting, interfacial adhesion, surface polymerization, activation, and surface cleaning. People employ cold plasma technologies to change the surface of metals, plastics, ceramics, resins, papers, biomaterials, and textile materials [4]. Under cold plasma, the physical and chemical properties of textile materials are greatly affected. The surface morphology and surface chemistry are also affected [4]. The specific surface area increases significantly with the increase in surface corrosion after plasma treatment [4]. Plasma treatment on natural fibre forms new functional groups such as -COOH, which in turn increases fibre wettability [4]. Rough fibre surfaces and different functional groups also increase cross-linking between fibre and matrix at the interface [5]. Plasma treatment on textile fibre imparts different functionality such as antibacterial finish, flame retardancy, UV protection, self-cleaning, and surface modification at micro and Nano order without changing the bulk properties of the fibre.

Plasma surface interaction

When the specimen is subjected to cold plasma, its surface is bombarded with ions, electrons, radicals, neutrons, and various energetic UV photons. Some of the energetic active species dislocate the chemical bonds and initiate some chemical reactions on the textile fibre surface [1]. For textile fibre the depth is confined to 10nm. For porous fibre such as kapok fibre, and cotton fibre the reaction is confined up to 100nm [1]. Purse gas of mixture of gases used for modification of textile fibre are Argon, oxygen, helium, Nitrogen, carbon dioxide, ammonia.

Antibacterial activity of plasma treatment

Plasma treatment on textile fibre is also an efficient sterilizing tool to avoid cross-contamination of pathogenic bacteria. The free radicals and UV radiation weaken the outer cell wall of microorganisms. The antibacterial activity of textile fibre can be easily accessed by the sputtering of Cu ions on fibre surface. -C=0 functional group also creates antibacterial activity on textile fibre [4]. Shahidi et al. [4] studied the potential effect of low-pressure oxygen plasma on bacterial colonies in cotton fabric.

Plasma polymerization

In plasma polymerization, organic monomers such as methane and ethane are polymerized to form a thin layer of the polymer coating. The plasma-treated polymerized fibre possesses various properties such as antibacterial finishing, UV protective coating, highly cross-linked, water repellent etc., [1].

Surface activation

Textile fibre surfaces are activated by Cold plasma treatment by introducing some reactive species. The surface activation of textile fibre is performed at a very low vacuum and in a gas environment such as argon, Nitrogen etc. which doesn't polymerize the textile fibre. Basically, reactive plasma species are bombarded on textile fibre to create free radicals. The free radicals react with plasma species to form different functional groups, such as carboxyl, carbonyl, and amine. The nature of the fibre surface depends upon the type of functional groups [4]. Surfaces of textile fibre are activated when the specimen is treated with cold plasma under a non-carbon-containing gas environment such as oxygen, Nitrogen, argon, helium etc., [6].

Surface cleaning

The self-cleaning property is also known as the lotus effect. Surface impurities, such as oils, wax, oxides, and fatty acids, can be removed by cold plasma without changing the bulk characteristics and properties of the fibre. The relatively low cost and inertness of argon gas make it the best choice as purse gas for cleaning of textile fibre surfaces by cold plasma. Plasma treatment increases the self-cleaning properties of the textile fibre by maximizing the ability to repel water.

Effect of cold plasma on fibre

Wong et al. [7] studied that plasma treatment increases the fibre surface roughness of the wool fibre. Boonla et al. [8] also observed the same result after oxygen cold plasma treatment on silk fibre. Anwer et al. [9] also studied effect of low temperature plasma on jute fibre. Sun et al. [10] investigated that high vacuum cold plasma significantly increases the dyeing rate of wool and cotton fabrics. Hartwig et al. [11] Reported that plasma treatment on wool fibre provides shrink resistance to the fibre. Simultaneously, it also provides mechanical strength to fibre and dyeing-printing efficiency to the fibre. The author also studied the hydrophobic effect of plasma-treated cotton fibre. The impact of oxygen cold plasma on the surface morphology, chemical composition, crystal structure, and mechanical characteristics of wool fibre was investigated by Hossein et al. [12] The authors observed that plasma treatment makes the fibre surface rough. It also removes lipids from fibre. At the same time, it also affects the crystallographic structure of the fibre.

One crucial subset of composite materials is natural fibre-reinforced composites. Poor wetting and interfacial adhesion between the fibre and matrix at the interface limit those composite materials' performance. By changing interface properties, cold plasma technique offers the potential to improve composite properties. The interface characteristics of plasma treated fibre reinforced composited materials were described by Mengjin et al. [13]. The impact of cold liquid plasma on the tensile characteristics of coir fiber and its reinforced composites was examined by Andi et al. [14]. The author noticed that after plasma treatment, the composite's mechanical strength is increased.

Conclusion

Cold plasma can potentially reduce the use of chemicals, energy and water in the textile industry for textile finishing. Many environmental issues could potentially be resolved with plasma therapy. It is a practical method for pre-treating textile fibre and possesses the exceptional power to spark an industrial revolution.

References

1. Jelil RA (2015) A review of low-temperature plasma treatment of textile materials. Journal of Materials Science 50(18): 5913-5943.
2. Morent R, De Geyter N, Verschuren J, De Clerck K, Kiekens P, et al. (2008) Non-thermal plasma treatment of textiles. Surface and Coatings Technology 202(14): 3427-3449.
3. Buyle G (2013) Nanoscale finishing of textiles via plasma treatment. Materials Technology 24(1): 46-51.
4. Shahidi S, Ghoranneviss M, Moazzenchi B (2014) New advances in plasma technology for textile. Journal of Fusion Energy 33: 97-102.

5. Das R, Dash C, Behera P, Bisoyi DK (2022) Influence of dewaxing on mechanical properties of kapok fiber-reinforced polymer composite. IOP Conference Series: Earth and Environmental Science 1086: 012054.

6. Sparavigna A (2008) Plasma treatment advantages for textiles.

7. Wong KK, Tao XM, Yuen CWM, Yeung KW (1999) Low temperature plasma treatment of linen. Text Res J 69(11): 846-855.

8. Zheng C, Chen G, Qi Z (2012) Compound finishing of Bombyx mori silk: A study of cold oxygen plasma/titania sols treatments and their influences on fiber structure and performance. Plasma Chem Plasma Process 32(3): 629-642.

9. T Journal and B Impact. IOSR-JAP.

10. Sun D, Stylios GK (2004) Effect of low temperature plasma treatment on the scouring and dyeing of natural fabrics. Text Res J 74(9): 751-756.

11. Höcker H (2002) Plasma treatment of textile fibers. 74(3): 423-427.

12. Barani H, Calvimontes A (2014) Effects of oxygen plasma treatment on the physical and chemical properties of wool fiber surface. 34: 1291-1302.

13. Mengjin WU, Lixia JIA, Suling LU, Zhigang QIN, Sainan WEI, et al. (2021) Interfacial performance of high-performance fiber-reinforced composites improved by cold plasma treatment: A review. Surfaces and Interfaces 24: 101077.

14. Eka Putra AE, Renreng I, Arsyad H, Bakri B (2020) Investigating the effects of liquid-plasma treatment on tensile strength of coir fibers and interfacial fiber-matrix adhesion of composites. Composites Part B: Engineering 183: 107722.