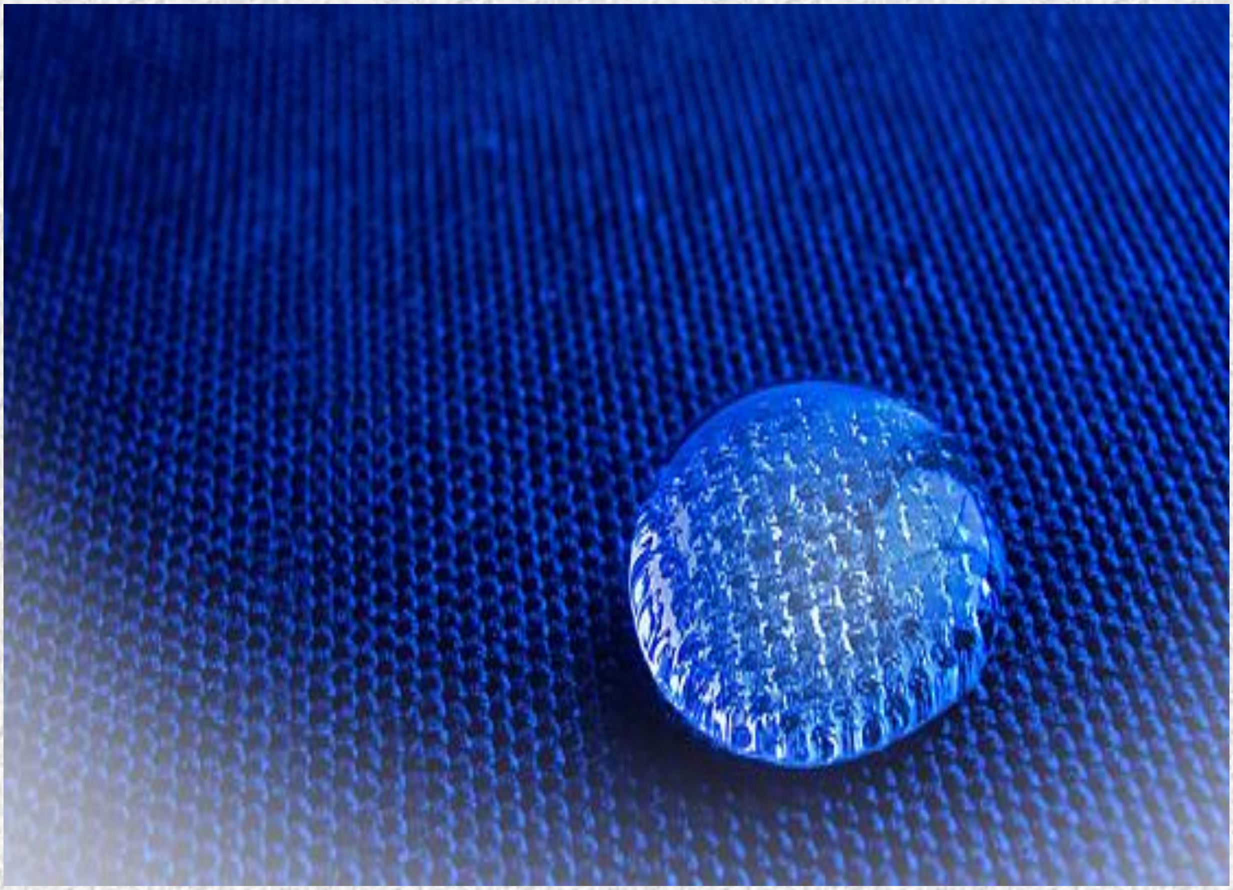

Plasma Treatment in Textiles Applications, Advantages and Surface Functionalization

By: Nikhil Bhosale, Bajirao Jadhav,
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Abstract

"Plasma" derived from the Greek and referring to "something molded or fabricated". Plasma treatments are gaining popularity in the textile industry. Plasma treatment has to be controlled carefully to avoid detrimental action of the plasma onto the substrate. Plasma surface treatments show distinct advantages, because they are able to modify the surface properties of inert materials, sometimes with environment friendly devices. For fabrics, cold plasma treatments require the development of reliable and large systems. Application of "Plasma Technology" in chemical processing of textiles is one of the revolutionary ways to enhance the textile wet processing right from pretreatments to finishing. Treatments on natural, wool and cotton, and on synthetic polymers to improve wetting are shown. Hydrophilic-hydrophobic treatments, dirt-repellent coatings are presented. Low-pressure and atmospheric pressure glow discharge systems are also discussed.

Introduction

Partially ionized gas composed of electrons, ions, photons, atoms and molecules, with negative global electric charge. It is called as Plasma Technology. Irving Langmuir first used the term plasma in 1926. Describe the inner region of an electrical discharge. Plasma, as a very reactive material, can be used to modify the surface of a certain substrate typically known as plasma activation or plasma modification. Recent development in the plasma treatment of textile materials has revealed that it has an enormous potential as an alternate technology for the textile processing in terms of cost saving, water saving and ecofriendliness. The individually charged plasma particles respond to electric and magnetic fields and can therefore be manipulated and contained. The atmospheres of most stars, the gas within the glass tubing of neon advertising signs, and the gases of the upper atmosphere of the earth are examples of plasmas. On the earth, plasmas occur naturally in the form of lightning bolts and in parts of flames. Thus, any ionized gas that is composed of nearly equal numbers of negative and positive ions is called plasma.

Aims & Object of Plasma Treatment

- It is a simple process which could be easily automated and perfect parameter control.
- It is applicable to most of textile materials for surface treatment.
- It is dry textile treatment processing without any ex-penses on effluent treatment.

- It is applied for different kinds of textile treatment to generate more novel products to satisfy customer's need and requirement.

Application of Plasma on Textile Fibre

Low-temperature, low-pressure plasma (LTLPP): Low temperature plasmas can generally be subdivided into thermal and non-thermal plasmas here have not, however, been many applications for the treatment of fibre and textile materials. LTLPP technology has been widely investigated for the surface modification of textiles and an overview of such plasma treatments has been published by Morentetal.

- *Natural Fibers (Wool, Silk, cotton, Jute, Flax)*

Anti Felting Treatment on Wool and Water Repellent Finishing on Cotton: An effective method to modify the surface of natural polymers without changing their bulk properties. Plasma and corona treatment provides new promising features and properties of fibres and fabrics like "fineness" and crease resistance (e.g. Figure 1). Plasma and corona treatment provides new promising features and properties of fibres and fabrics like "fineness" and crease resistance

- *Artificial Fibers (Viscose, Lyocell)*

Separate and dispose of patients' plasma and supply fresh plasma: Plasma treatment of viscose fibres increases the kinetics of water sorption of chemical treatment. The swelling time of plasma in comparison to untreated plasma is reduced by the factor of 0.54 and intensity change time by the factor of 0.4.

APPLICATION	MATERIAL	TREATMENT
Hydrophilic finish	PP, PET, PE	Oxygen plasma, Air plasma
Hydrophobic finish	Cotton, P-C blend	Siloxane plasma
Antistatic finish	Rayon, PET	Plasma consisting of dimethyl silane
Reduced felting	Wool	Oxygen plasma
Crease resistance	Wool, cotton	Nitrogen plasma
Improved capillarity	Wool, cotton	Oxygen plasma
Improved dyeing	PET	SiCl4 plasma
Improved depth of shed	Polyamide	Air plasma
Bleaching	Wool	Oxygen plasma
UV protection	Cotton/PET	HMDSO plasma
Flame retardancy	PAN, Cotton, Rayon	Plasma containing phosphorus

Figure 1. Various Application of Plasma in Textile

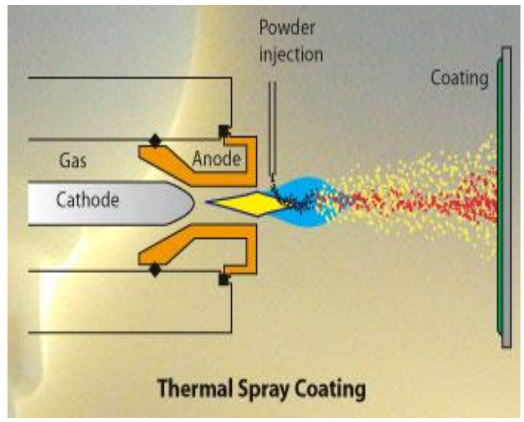
- *Synthetic Fibers (Polyamide, Polyester, Nomex, Glass Fiber ,Kevlar, Acrylics, Polypropylene)*

Metal-coated organic polymers are used for a variety of applications. Plasma treatment on polyamide is main1y dye ability, wet ability and surface properties. Oxygen and air plasma are used to increase wet ability and dye ability polyethyl-eneterephthalate (PET) (e.g. Figure 1) fibers are used as an enforcing material for a polyethylene (PE) (e.g. Figure 1) matrix, the hydrophobization of the PET fibers using ethylene plasma is quite impressive since the adhesion strength can be increased from 1 to 2.5 N/mm.

Plasma Spraying Technique

- *Thermal Spray plasma Process*

Thermal plasma is a viscous, electrically and thermally con-ducting fluid. The unique feature of the thermal plasma jet that distinguishes it from other heat resources is its high power density. The energy density of thermal plasma devices is of the order of several GW/m2, which is 10-100 times the power density of conventional oxy-fuel flames. Although higher power densities are obtainable with electron and laser beams, the source strengths available with these devices, especially laser devices, are not high enough for large-scale material processing applications.



- *Atmospheric pressure plasma jets (APTJ)*

Atmospheric pressure plasma jets (APTJ) are well-known in the plasma chemistry community because of their novel applications. They are most flexible of all the thermal spray processes, with sufficient energy to melt any material and excellent control of coating thickness and surface characteristics such as porosity and hardness. The atmospheric plasma spray process is used for wear and corrosion protection, thermal insulation, repair, and restoration. As it is the most flexible of all thermal spray processes coatings, can be applied onto all suitable base materials with the widest variety of powders In this contribution, an APPJ will be used to modify the surface of non-woven textiles. The pretreatment and finishing of textiles by plasma technologies becomes more and more applied as a surface modification technique since it possesses several advantages over conventional chemical processes. In this work, an atmospheric pressure plasma jet (APPJ) in pure argon will be used to modify the surface of PET non-woven textiles.

Afterwards, the influence of water vapor addition on these plasma characteristics will be briefly mentioned. Plasma treatment can result in changes of a variety of surface characteristics, for example, chemical, tri-biological, electrical, optical, biological, and mechanical.

- *Multi Coat System Platform for Plasma Spray*

Multi Coat Plasma runs plasma single and triple cathode guns. Our specialized software interfaces with your work piece data-base, data logging, and maintenance schedules to configure and optimize the hardware for your specific process. Runs two parallel plasma processes simultaneously Upgrades with enhancements to monitoring, controlling, safety, and quick spray gun changing. It accommodates a wide range of plasma spray guns, material feeders, and power sources.

Application of Plasma in Textile Processing

Plasma technology has been used textile materials, resulting in improvements to textile products. It can improve the functionality of textile materials such as:

1. *Improved Pretreatment Process*: Plasma can be applied to grey fabric which makes subsequent removal of impurities easier. Desizing efficiency of cotton would increase by application of atmospheric plasma treatment.

2. *Improvemed Dyeing and printing*: capillarity in wool and cotton, with treatment in oxygen plasma. Improved dyeing polyester with $SiCl_4$-plasma and for polyamide with plasma.

3. *Enhance Wet ability*: Surface Modification of Fabrics Using a One-Atmosphere Glow Discharge Plasma to Improve Fabric Wet ability. Improvement of surface wetting in synthetic polymers (PA, PE, PP, PET PTFE) with treatment in O_2-, air-, NH_3-plasma.There are a lot of investigations on plasma treatment of some textile fibres for changing their wet ability properties. For examples, polyester, polypropylene, wool that plasma treatment can improve the ability of these fibres to retain moisture or water droplets on their surface.

4. *Hydrophobic finishing*: The treatment of cotton fibre with identified plasma gas such as hexamethyl disiloxane(HMDSO) leads to a smooth surface with increased contact angle of water. The treatment gives strong effect of hydrophobization of treated cotton fibre.

5. *Product quality*: Felting is an essential issue of wool garment due to the fibre scales. Conventional antifelting gives negative effects on hand feel and environmental issues. Oxygen plasma gives anti-felting effect on wool fibre without incurring traditional issues.

6. *Applications in Biology and Medicine*: Fabric favoring overgrowth with cells for cell culture tests, fermentation or implants. Fabric not favoring over-growth with cells for catheters, membranes, enzyme immobilization, sterilization.

7. *Improvemed Dyeing and printing*: capillarity in wool and cotton, with treatment in oxygen plasma. Improved dyeing polyester with SiCl4-plasma and for polyamide with Arplasma.

8. *Adhesion*: plasma technology can increase adhesion of chemical coating and enhance dye affinity of textile materials.

Advantages of Plasma in Textile

- *Advantage of Plasma Desizing:* Desizing with plasma technology involves use of either O2/He plasma or Air/He plasma so there is no need of hot water and chemical.

- *Advantage of Plasma Treatment of Wool*: Plasma treatment can impart anti-felting effect degreasing, improved dyestuff absorption and increasing wetting properties.

- *Advantage of Plasma Dyeing*: It has been re-ported that plasma treatment on cotton in presence of air or argon gas increases its water absorbency which in turn increases both the rate of dyeing and the direct dye uptake in the absence of electrolyte in the dye bath. In the synthetic fibres, plasma causes etching of the fibre and the introduction of polar groups leading to improvement in dye ability.

- *Advantage of Plasma Finishing*: Functionality and properties can be imparted to both natural fibres and polymers, as well as to non-woven fabrics, without having any adverse effect on their internal structures. This leads to produce various types of functional textiles.

Conclusion

Let us conclude telling the extra advantages of plasma treatments. The textile industry is searching for innovative production techniques to improve the product quality, as well as society requires new techniques and this type of high-performance textile will certainly grow in economic importance. Plasma functionalized textile surfaces of Water / oil repellence, Adhesion, Protection. The finished textile shows better performance and improved color fastness properties. Plasma treatment has scope in growing future applications such as special selective innovation, value creation, biocompatibility, and growing of biological tissues.

References

1. Abidi N. and Hequet E., Cotton fabric copolymerizationusing microwave plasma, Universal attenuated total reflectance-FTIR study, Journal of Applied Polymer Science, 93, 145-154 (2004).

2. Kan C.W., et al, Plasma Pretreatment for Polymer deposition- Improving antifelting properties of wool, Plasma Sciences, IEEE Transactions, 38(6), 1505-1511 (2010).

3. Textilelearner.com/2012/04/application-of-plasmatechnology-in (2012).

4. Anita Desai, Plasma technology: a review, Indian textile Journal, January (2008).

5. E. M. Liston, L. Martinu, M. R. Wertheimer. J. Adhesion Sci. Technol. 7, 1091 (1993).

6. D. Hegemann, H. Brunner, C. Oehr. Nucl. Instr. Methods Phys. Res., Sect. B 208, 281 (2003).

7. D. Hegemann, E. Körner, S. Guimond. Plasma Process. Polym. 6, 246 (2009).

8. M. M. Hossain, D. Hegemann, G. Fortunato, A. S. Herrmann, M. Heuberger. Plasma Process. Polym. 4, 471 (2007).

9. M. M. Hossain, A. S. Herrmann, D. Hegemann. Plasma Process. Polym. 4, S1068 (2007).

10. F. Truica-Marasescu, M. R. Wertheimer. Plasma Process. Polym. 5, 44 (2008).

11. K. S. Siow, L. Britcher, S. Kumar, H. J. Griesser. Plasma Process. Polym. 3, 392 (2006).

12. H. Seo, J. H. Kim, K. H. Chung, J. Y. Kim, S. H. Kim, H. Jeon. J. Appl. Phys. 98, 043308 (2005).

13. J. Ni, W. Wu, X. Ju, X. Yiang, Z. Chen, Y. Tang. Thin Solid Films 516, 7422 (2008).

14. Tusek, L., Nitschke, M., Werner, C., StanaKleinschek, K., and Ribitsch, V. 2001, Colloids and Surfaces A, 195, 81.

15. Chan, C.M., Ko, T.M., and Hiraoka, H. 1996, Surf. Sci. Rep. 24, 1.

16. Chappel, P.J.C., Brown, J.R., George, G.A., and Willis, H.A. 1991, Surf. Interf. Anal. 17, 143.
17. Yip, J., Chang, K., Sin, K.M., and Lau, K.S. 2002, J. Mat. Processing Technology, 123, 5.

18. NV. EUROPLASMA, 2001, Technical Note, Roll to roll ap-plication, Rev. 12.01, Oudenaarde, Belgium.

19. R. d'Agostino et al., 2002, Plasma etching and plasma polymers, at http://www.cscp.ba.cnr.it/ attivric4.htm.

20. Borcia, G., Anderson, C.A. and Brown, N.M.D. 2003, Plasma Sources Sci. Technol., 12, 335.

Image Courtesy:

1. plasmatreat.com

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