International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Plasma Processing of Textiles

Sanchi Meena

Abstract: ***Chemical (wet) methods involve consumption of large amount of energy and water and consequently increase pollution. So, requirement of eco-friendly process occurred which is met by physical methods. Plasma Technology is one of the physical methods. Plasma is a partially ionized gas composed of highly excited atomic, molecular, ionic and radical species with free electrons and photons. Plasma treatments work without any alteration in internal structure and uses no water so no expenses on effluent treatments.***

Keywords: Plasma, Etching, Polymerization, Dielectric.

1. Objectives of Plasma Processing

- It is applicable to the most of the textile materials for surface treatments.
- It enhances surface properties of textile materials without any alteration in their inherent properties.
- It proves to be an eco-friendly dry process which efficiently work with use of fewer chemicals and had no expenses on effluents treatment.
- Different textile treatments like desizing, scouring, dyeing, finishing etc., are made easier because of plasma treatment on textiles.

2. Methodology Used

There is surface treatment methods used to enhance surface properties:

- Chemical (wet) methods
- Physical (dry) methods

Chemical (wet) methods involve consumption of large amount of energy and water and consequently increases pollution. So, requirement of eco-friendly process occurred which is met by physical methods. Plasma Technology is one of the physical methods. Plasma process can be carried out in different manners these are:

1) Substrate can be treated directly in the plasma zone.
2) Remote process- substrate positioned outside the plasma.
3) Substrate can be activated in plasma followed by subsequent grafting.
4) Substrate can be treated with polymer solution or gas then fixed or polymerised by subsequent plasma treatment.

3. Description of Results

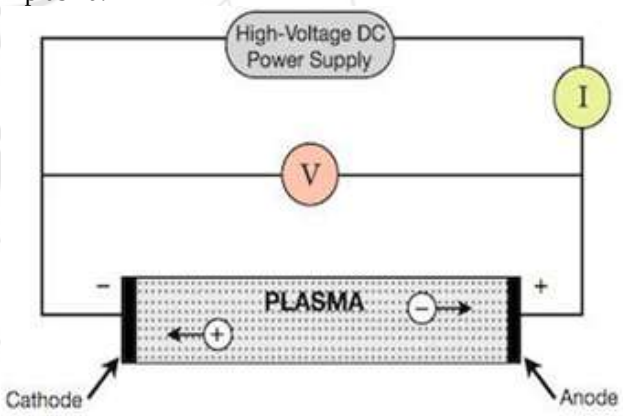
Introduction

Plasma is a 4th state matter first developed by M. Faraday in 1880s and plasma concept was first proposed by I. Langmuir in 1926. Plasma is a partially ionized gas composed of highly excited atomic, molecular, ionic and radical species with free electrons and photons. It is a very reactive material suitable for treatments of any type of textiles with less expenses and less pollution compared to wet chemical processes. Unlike wet chemical treatments, which penetrate deep inside the fibre structure and make changes in internal structure, plasma treatments make changes at surface level only. So, plasma treatments work without any alteration in internal structure and uses no water so no expenses on effluent treatments. Generally, plasma can bring out two types of interactions with the surface, plasma etching and plasma polymerization.

1) Plasma Etching – It is obtained using non-polymerizing gases like helium, argon, oxygen, air and nitrogen. Chain scission on surface occur which results into surface etching, ablation, cleaning or activation.
2) Plasma Polymerization – Carried out using polymerizing gases and precursors like fluorocarbons, hydrocarbons and silicone containing monomers.

Plasma Technology

How a gas becomes plasma? When kinetic energy of a gas rises and becomes equal to its ionisation energy, collisions of gas particles causes a rapid cascading ionisation, resulting in plasma.



Generation of Plasma

When the neutral molecules of a gas are energised, e.g. by exposing to high electric field to a point when some electrons become free and the gas turns into a mixture of electrons, ionised atoms and molecules, photons and residual neutral species. Plasma is generated when an electric current is applied across a dielectric gas or fluid. It is also possible to generate plasma at room temperature. Plasma properties are dependent on the plasma parameters like degree of ionisation, the plasma temperature, the density and the magnetic field in the plasma region.

4. Application of Plasma Technology

Plasma technology is an eco-friendly process used on any type of textile material. It imparts hydrophilicity, hydrophobicity, strength, wettability, adhesion etc properties

of textile fibre enhances because of plasma treatment. Recently, plasma treatments have produced increased moisture absorption in fibres, altered degradation rates of biomedical materials, and deposition of low friction coatings. Some of the applications of plasma are:

- **Desizing –** In desizing sized materials are to be removed by treating the textile material with chemicals and hot water. But now with plasma technology desizing is done using either O2/He plasma or Air/He plasma. In the process the chains of PVA size materials are broken down to smaller chains and more soluble by introducing oxygen or nitrogen owing to greater polarity.
- **Dyeing –** Plasma technology improves dyeing in both natural and synthetic fibres. Reasons of improvement in dyeing are enhancement in wettability, of surface area, creation of reactive sites on the fibre and many more.
- **Finishing –** Various types of finishing is done with this process. Like hydrophobic, hydrophilic finishing, crease resistance, flame resistance, antistatic finish, reduced felting etc.
- Treatment with HMDSO (hexamethyldisiloxane) plasma leads to a smooth surface with increased contact angle of water up to maximum of 130 degree.

5. Outcomes and Analysis

After treatment with plasma surface modifications can be seen and compared with the untreated one. Some of the properties of textile fibre which gets modified after plasma treatment are:

- Improvement in surface wetting of polymers (PA, PP, PET, PE, PTFE) with treatment in O2-, air-, NH3-plasma.
- Softening of cotton and other cellulose based polymers, with a treatment by oxygen plasma.
- Reduced felting in wool by treatment with oxygen plasma.
- Antistatic finish of rayon, with chloromethyl dimethylsilane in plasma.
- Treatment with siloxane- or perfluorocarbon- plasma provides hydrophobic finishing of cotton, cotton/PET.
- Improved dyeing of polyester with SiCl4- plasma and for polyamide with Ar- plasma.
- Plasma technology increase adhesion of chemical coating and enhance dye affinity of textile materials.
- If intensive oxygen plasma treatment is applied to cotton fabric also negative effect can be observed namely a reduced tear and abrasion resistance.
- In case of polyester, cotton and other fibres excluding wool this is not necessary to have enhancement in dye uptake always. Although formation of voids and COOH, OH, CO groups occurs to increase dye uptake but there exist competing processes of increased crystallinity and cross linking on the surface which may not allow the diffusion of dye molecules.

6. Epilogue

Plasma treatment is an eco-friendly process. It is a dry process so expenses on effluent treatment are excluded here. In this process use of chemicals and wastage of water is very less. This process can be applied to different kind of textile treatments to generate more novel products to satisfy customer's need and requirement.

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Annexure

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