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Atmospheric pressure plasma and its application in textile and polymers

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Textile industries use huge quantity of water and chemicals for surface treatment in scouring process before dying. This process is hazardous and pollute the environment. Government has zero liquid discharge (ZLD) norms for controlling such discharge. Further, nonthermal plasma treatment of surfaces could be one solution to this problem and it is a dry process. However, there are many challenges and limitations in generation of such nonthermal plasma with economical viabilities.

It is well known that non-thermal plasma can significantly improve the surface properties. Plasma can make the surface hydrophilic and hydrophobic using the suitable particular gas. In non-thermal plasma, electron temperature is of order of 2 to 3eV and gas temperature is maintained much lower than 100 degree C particularly. Such plasmas are generated using Argon or Helium gases easily. However, these gases are costly and thus, use of nonthermal plasma is limited to high end products. Further, the inline treatment may be possible with atmospheric pressure plasma and generation of atmospheric pressure nonthermal plasma involves many complexities.

There are many challenges in generation of nonthermal air plasma at atmospheric pressure using conventional dielectric barrier discharge (DBD) technique. These challenges include requirement of very high voltage for generation of air plasma safely as it is susceptible to breakdown in any dielectric medium, challenges in avoiding localized discharge in the gap due to very high electric field and avoiding the high energy streamers formations, non-availability of feedback technique for control of current in such highly dynamic discharge. Conventional power sources are basically high voltage pulsed DC and high frequency AC sources in which the output current waveform is governed by the geometry of plasma system in which gap, dielectric material and geometry of electrodes and its surfaces, emissivity play very important role in controlling and maintaining the plasma discharge current in nonthermal mode. Since, impedance of air plasma is highly dynamic at atmospheric pressure, controlling of discharge in uniform glow mode to treat larger surface is another complexity. Hence, there is a need to devise a technique in power supply and geometry of electrodes that can be adopted for generating economical viable discharge for all textile treatment not limited to high end product only.

In this direction, very low cost power supply topology was devised by Institute for Plasma Research (IPR) in India that could generate almost uniform glow discharge plasma in air between two cylindrical electrode having dielectric layer at one or both electrodes. Plasma density was observed to be 0.25W/cm2 in air gap at 5kV and 100mA current. A system was built by IPR for treatment of 2.5 meter wide textile at a moderate speed using multiple pair of cylindrical electrodes DBD plasma discharge in air that could be achieved due to low cost of power supply for each electrode pair. The surface energy of PE film was improved significantly from 38 dyne/cm to ˜ 55 dyne/cm. The study performed by IPR in this context will be presented.

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