Structural Modification of Carbon Fibers by Plasma Immersion Ion Implantation (PIII) and Atmospheric Dielectric Barrier Discharge (DBD) – a Comparison

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Abstract

Plasma Immersion Ion Implantation (PIII) is an advanced surface modification technique, which has been widely employed for improving material surface properties. It has been successfully applied on different substances such as, metals, alloys, semiconductors, polymers etc. However, some industrial processes require a plasma technology that can be implemented in continuous production line. Therefore the atmospheric plasma treatments have immerged as an alternative tool for material surface modification. The dielectric barrier discharge (DBD) has attracted special attention due to the ability to produce large volume of non-thermal plasma, easy scale-up and low cost.

This work deals with surface modification of carbon fibers (CFs) by using two different plasma techniques: PIII and DBD. Carbon fibers have been frequently utilized as reinforcement in the thermoplastic composites. However, to obtain superior composites it is necessary to provide good adhesion on the fiber/matrix interface.

The PIII system consists of a 600-liters vacuum camera, a sample holder, a glow discharge plasma source and a high-voltage pulser. CF specimens were PIII-treated with air for 20 minutes. The DBD reactor used in this work consists of two planar circular stainless-steel electrodes covered by a 2-mm-thick glass plate. Plasma treatment time was set at 30, 60, 120 and 180 seconds. Following the treatments the CFs were characterized by Raman spectroscopy, Scanning Electron Microscope (SEM) and Atomic Force Microscopy (AFM).

The Raman spectra of PIII-treated CFs presented different ID/IG ratios for the untreated sample and treated samples. On the other hand, no significant changes were detected into Raman spectra upon the DBD treatment. This observation confirms the DBD processing

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is limited on the CF surface. SEM images of all PIII-treated CF fibers exhibit many thin tracks and small particles distributed over their entire surface. The DBD process induced significant damages on the CF surface, which is represented by trenches and vales, whose number increases with the time of treatment. AFM analysis demonstrated that all treated samples (by PIII and DBD) have rougher surface than the untreated sample. This finding suggests that both plasma treatments of CFs may contribute for adhesion enhancing on the fiber/matrix interface.

Keywords: Carbon fibers, Plasma Immersion Ion Implantation, Dielectric Barrier Discharge, Surface Modification