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Atmospheric Pressure Plasma and its Application for Surface Treatment of Materials

D. P. Subedi, R. P. Guragain, G.K. Chhetri, A.K. Singh, U.M. Joshi

Department of Physics, School of Science, Kathmandu University, Dhulikhel, Kavre, Nepal

e-mail(speaker): dsubedi@ku.edu.np

Atmospheric pressure plasmas have drawn much attention in the recent years due to their wide range of applications. These plasmas are most widely produced in the form of Dielectric Barrier Discharge (DBD). DBD offers a cost-effective way for generating non-thermal plasma (NTP). The characteristic feature of NTP is the existence of thermal non-equilibrium between the constituent particles i.e. electrons, ions and neutrals. Electrons can have temperature (T_e) of the order of 10^4 K while that of ions and neutrals have the temperature (Ti, Tn) close to the ambient (~300K). This paper presents an experimental study of DBD plasma produced in atmospheric pressure with air/argon as working gas. The plasma was generated in parallel plate electrode system using a high voltage power supply (13 kVrms) operating at line frequency (50 Hz). The characterization of the discharge was made by electrical and optical methods for the determination of electron temperature (T_e) and electron density (n_e). The plasma was applied for the surface treatment of different polymers samples to improve their hydrophilicity. Influence of treatment time, applied voltage and working gas on the properties of the samples were investigated.

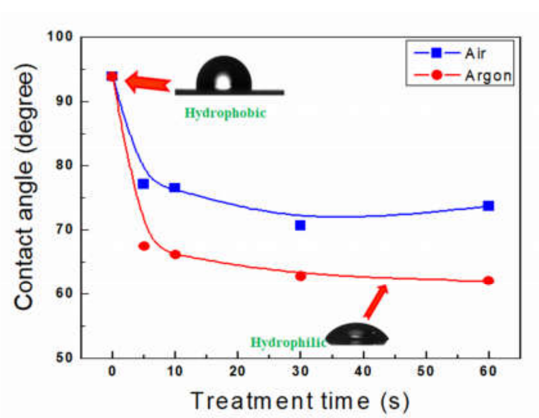

Fig 1. Water contact angle on polypropylene sample as a function of treatment time in DBD.

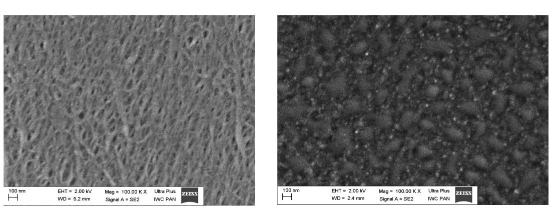

Fig 2. SEM images of untreated (left) and plasma treated (right) samples of polypropylene.

The changes in surface properties of the plasma treated samples were studied by Contact Angle (CA) measurement and surface energy analysis, Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM). The results showed that a significant increase in hydrophilicity can be achieved even after a short treatment time of less than one minute in the plasma. The observed decrease in water contact angle (Fig.1) on the polymers samples following plasma treatment can be attributed to the initial surface modification induced by the plasma exposure. As the polymer surfaces interact with the plasma, they undergo changes such as the introduction of polar functional groups like -OH, C=O, -COOH and surface cleaning, resulting in an increase in surface energy and enhanced wettability. These modifications occur rapidly within the first few seconds of treatment. However, after approximately 30 seconds, the surface properties reached a state of equilibrium, and further exposure to plasma yields no significant variation in the water contact angle.

Additionally, SEM analysis revealed a notable increase in surface roughness (Fig2), attributed to the etching/sputtering effect and introduction of polar functional groups. These findings demonstrate the potential of atmospheric pressure DBD treatment for tailoring the surface properties of polymers for various applications, including improved adhesion and wetting behavior.

References:

[1] D.P. Subedi et al. in Plasma Sci. Technol. Emerg. Econ. An AAAPT Exp., edited by R. Rawat (Springer Singapore, 2017), pp. 693–737

[2] Baniya et al. Reviews of Adhesion and Adhesives, 8(2), (2020).

[3] R.P. Guragain, Reviews of Adhesion and Adhesives, et al., 9, 153 (2021)

[4] D. P Subedi et al, Fundamental Plasma Physics, 10(1), (2024)