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SURFACE MODIFICATION OF POLYCARBONATE BY ATMOSPHERIC PRESSURE COLD ARGON/AIR PLASMA JET

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ABSTRACT
In this paper, atmospheric pressure plasma jet and its application for polymer surface modification is reported. Atmospheric pressure plasma jet sustained in Argon/Air mixture has been used to modify the surface properties of polycarbonate (PC). The surface properties of the untreated and plasma treated PC samples were characterized by contact angle measurement with water and glycerol. The contact angles were used to determine the surface energy and its polar and dispersion components. The effect of treatment time, frequency of the applied voltage, distance of the sample from the nozzle on the wettability of the sample was studied. It was found that the contact angle of water in untreated PC sample is 89^o while it decreases to 35^o after 5 minutes of treatment time. Moreover, it was found that, the best plasma treatment can be obtained with frequency 27 kHz and a distance of 1 cm between surface of samples (PC) and plasma jet's nozzle. Our result showed that atmospheric pressure non thermal plasma can be effectively used to enhance the surface wettability and surface energy of PC.

KEYWORDS: Atmospheric Plasma, Plasma Jet, Surface Modification, Contact Angle, Surface Energy

INTRODUCTION
Polymers have been attractive business article due to their low cost, superior performance, good breakage resistance, transparency and low inflammability. However, its low hardness, low scratch resistance and degradation by UV radiation made surface modification necessary. Because of their poor chemical reactivity, low surface energy and presence of weak cohesion layer on the surface, polymer surface are difficult to wet and offer poor adhesion to their contiguous material. Therefore, it is essential to improve the surface properties without changing its bulk properties. Atmospheric pressure cold Ar/air plasma jet treatment of polycarbonate brings an effective and versatile surface modification by removing volatile impurities, increasing surface roughness, breaking of C-C and C-H bonds to form the stable linking surface structure and generating certain functional groups such as carbonyl (-C=O), carboxyl (-COOH) and

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hydroxyl (-OH) on the polymer surface which contributes to increase the wettability. After treatment by plasma jet, contact angles effectively decreased and surface energy is found to be increased [1]-[4].

EXPERIMENTAL

The schematics of the experimental setup are show in fig. 1. The setup consists of a hollow cylindrical tube of inner diameter about 2mm in which two copper electrodes is attached as show in figure and is connected to high frequency and high voltage power supply. Argon gas is fed as a working gas from top of the tube. The jet length can be varied up to 6 cm by using power supply and flow rate of Argon. The polycarbonate samples are cleaned using ultrasonic cleaner for 10 minutes and subjected for treatment under plasma jet at distance of 1 cm from the nozzle at 27 kHz and 7 kV for different time period.

The treated sample are characterized by contact angle obtained by sessile drop technique. A Rame-hart Goniometer is used for the purpose. The total surface energy and its polar and dispersive components were also studied using Owens-Wendt-Kaelble two liquid methods as described by equation 1,

$$\gamma_l(1+\cos\theta) = 2(\gamma_l^d \gamma_s^d)^{1/2} + 2(\gamma_l^p \gamma_s^p)^{1/2} \quad (1)$$

where, γ_l, γ_l^d and γ_l^p are the total, dispersive and polar components of the surface energy. γ_s, γ_s^d and γ_s^p are the same values for polycarbonate [4]-[6].

Fig 2: Plasma Jet in Lab at KU

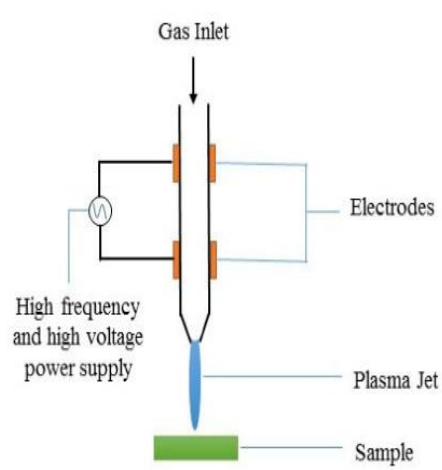

Fig 1: Schematic diagram of the experimental setup

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RESULTS & DISCUSSION

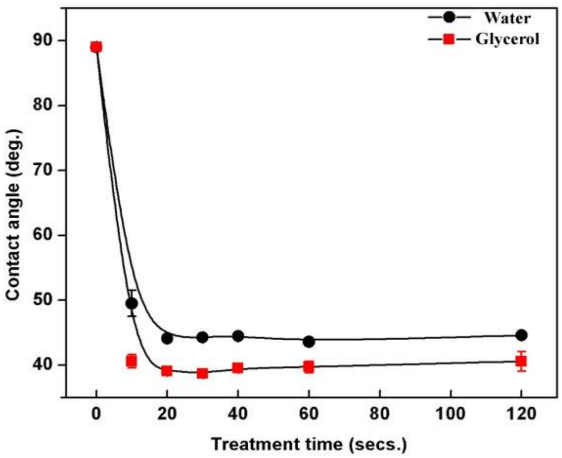

Fig 3: Variation of contact angle of water and glycerol with treatment in air

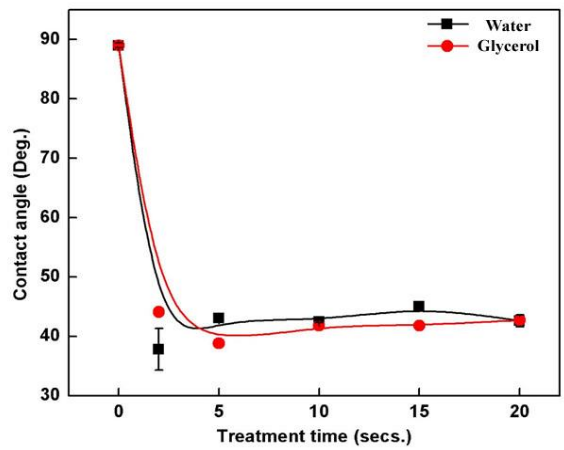

Fig 4: Variation of contact angle of water and glycerol with treatment in argon

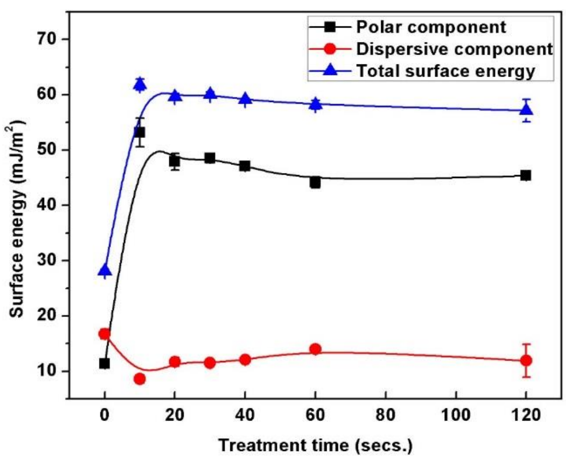

Fig 5: Variation of surface energy with treatment in air

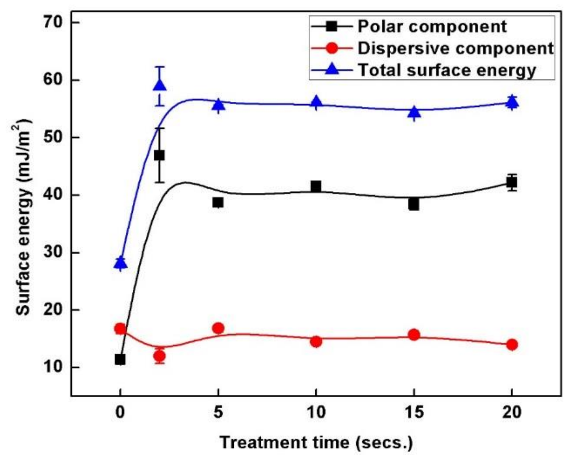

Fig 6: Variation of surface energy with treatment in argon

The variation of contact angle of water and glycerol for treatment on air and argon atmosphere as shown in figure 3 and figure 4 respectively shows significant improvement in wettability of polycarbonate sample. For treatment in air, the values of contact an gle dropped significantly till 20 seconds of treatment time and remained almost constant for further treatment. Whereas, in case of argon gas, the values of contact angle dropped significantly after 3 seconds of treatment time and further treatment showed almost no change in contact angle values.

Similarly, figure 5 and figure 6 shows the variation of surface energy of polycarbonate for treatment in air and argon respectively. Treatment of polycarbonate in air shows significant

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increase in wettability after 20 seconds of treatment time whereas, in case of argon it is achieved after 3 seconds of treatment time.

These results depict significant improvement in wettability of polycarbonate after plasma treatment. Treatment in argon is seen well than treatment in air for improving the wettability of the sample. This may be due to the bombardment of energetic particles which results in increase in surface area and formation polar groups on the surface of polycarbonates [4], [7], [8].

CONCLUSION

The treatment of polycarbonate by plasma jet in argon/air caused decrease in contact angle and increase in surface energy. It is mainly due to addition of polar functional groups on surface of the sample. This shows that improvement of wettability of polycarbonate strongly depends on the treatment time/ etching rate.

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