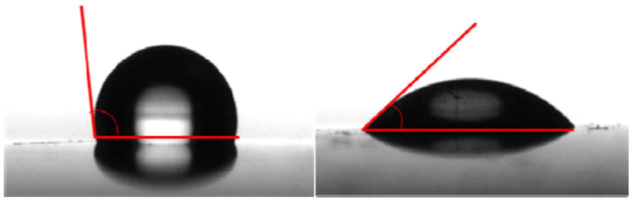


Figure 6: Before the plasma treatment (Hydrophobic) After the plasma treatment (Hydrophilic)

Fig. 5 shows the variation in the contact angle of the air and Argon PVC films for different treatment times. The initial contact angle values of the untreated PVC are 115.6 and 109.5 for water and ethylene glycol as test liquids, respectively. Beyond 3min, the decrease of contact angle of PVC in the argon plasma is more than that in the after air plasma treatment under the same conditions. For 18 mins treatment time, the reduction in the water contact angle for Argon plasma treated PVC films are 45.3(water) 43.2(ethylene glycol) and for air plasma treated PVC films are 51.9 (water), 49.6 (ethylene glycol) respectively, while the decrease of air plasma contact angle is smaller. However, the difference is rather small in the different exposure time. The decrease of contact angle suggests that the formation of hydrophilic groups on the plasma treated polymer film surfaces which may be explained as follows: the plasma creates radical species on the polymer surface, mainly through polymer chain scission or hydrogen abstraction by bombardment of plasma particles. This species can combine with oxygen in the air, thus also contributing to increase the amount of polar groups such as such as –OH, C O, COOH and COO– on the plasma treated polymer surfaces. The exposure of the polymer to the inert gas plasma (in the present case argon) is sufficient to abstract hydrogen and to form free radicals *[10]* than the air plasma or near the surface which then interact to form the cross-links and unsaturated groups with the chain scission. The argon plasma also removes the low-molecular weight materials or converts them to a high-molecular- weight by cross-linking reactions. As a result, the weakly bound layers formed by the low-molecular weight materials are removed. Hence these argon plasma treatment make the polymer surfaces become more hydrophilic compared to the air plasma treated and untreated polymer surface. *[15-17]*

3.5 T-peel analysis

The T-peel strength was measured as a function of different plasma exposure time and different gas (air, argon) to understand the effect of adhesive strength of PVC film surfaces. The values of peel strength are plotted against time of exposure in Fig. 12. It is seen that the peel strength increases linearly for different exposure time and exhibits better adhesive nature than the untreated PVC film surface. It is clearly seen that the adhesive transferred on unmodified film is 0.61Nm^{-1} and for longer exposure times (20 min) it is 1.53 Nm^{-1} (Air), 1.64 Nm^{-1} (Argon) Plasma treatment of polymeric surface is commonly believed to be effective because it creates wettable polar surfaces on which the adhesive may spread spontaneously and thus provide extensive interfacial contact. It is known that extensive interfacial contact is a necessity, but not a sufficient condition for forming strong joints. The primary function of surface oxidation techniques is to remove the weak boundary layer. In fact, if the surface oxidation alone occurred without the removal of a weak boundary layer, only weak adhesive joints would be obtained *[18]* Treatment of polymer film in a argon plasma environment incorporates more hydrophilic groups, which contribute to the increase in wettability and adhesive properties. As a result, the adhesive layer spreads on the surface more easily for argon treatment. Moreover, when these functionalities come in contact with adhesive material, it forms a weak bond due to van der Waals force. This force of attraction between the plasma treated polymer surface and adhesive material contributes to the observed increase in bonding strength. As seen from the AFM photographs, the surface becomes rough and hence the effective surface area increases after air and argon plasma treatment. Thus, the adhesion will be facilitated by all these factors.

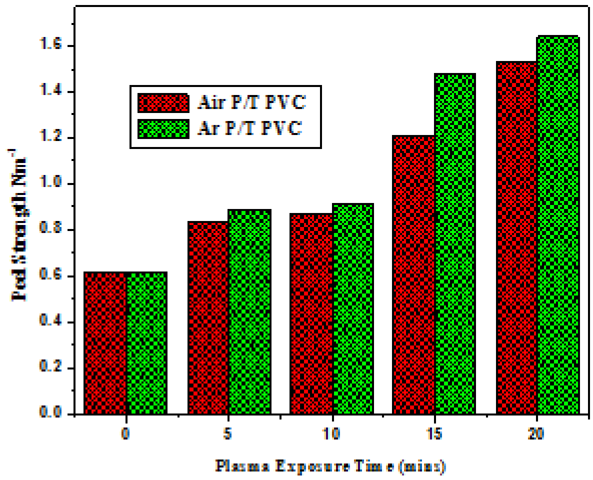
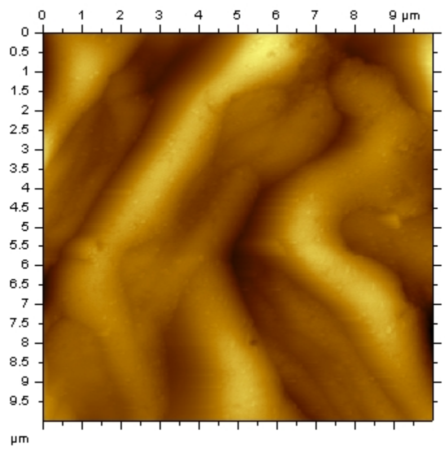


Figure 6: Adhesive properties of plasma-treated PVC film as a function of different exposure time

3.6 Atomic force microscopy

The surface morphologies of untreated and air, argon plasma treated PVC film were characterized by atomic force microscopy (AFM; Nanosurf_ easyScan2, Nanoscience Instruments Inc., AZ, USA) in the tapping mode in air. The average roughness (Ra) was calculated from the AFM images.



(a)

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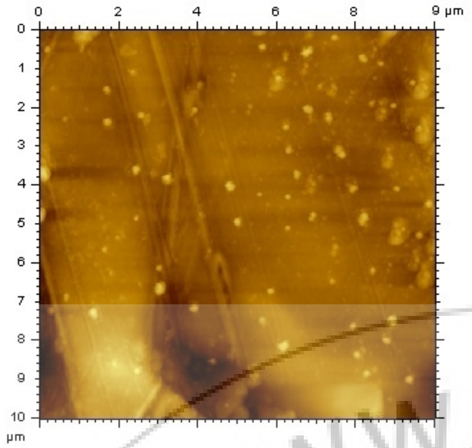
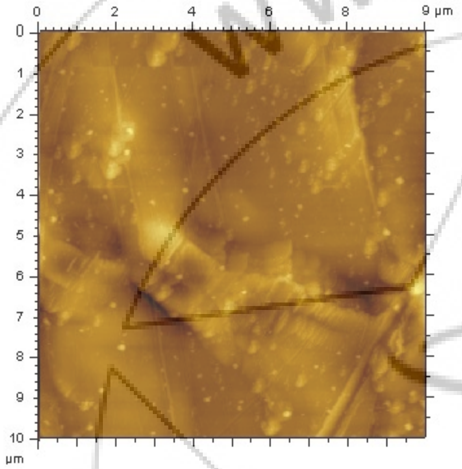


(b)



(c)

Figure 7: AFM image of untreated and plasma treated PVC polymeric film surface (a) untreated (b) air plasma treated (c) argon plasma treated PVC

The PVC surface is analyzed by AFM technique to detect the 2D surface topography and to calculate the changes in surface roughness, and the AFM images of PVC surface before and after 15 mins air and argon plasma treatment are shown in Fig. 7. As shown in Fig. 7(a), the untreated PVC surface is relatively smooth and without specific morphological aspects. A modified morphology after the homogeneous air and Argon plasma treatment is observed in Fig. 7(b), (c) which suggests that the obviously physical effect is induced by the plasma treatment. It can be seen from Fig. 5(c) that after the argon plasma treatments, the surface of PVC film shows rough morphology, and lots of hill-like protuberances than the air plasma treated PVC film surface.

So the results indicates the plasma treatment produce the surface roughness and bonding strength.

4. Conclusion

Air and Argon DC glow discharge plasma was employed to modify the surface of PVC. Both processes can significantly enhance the O to C ratio and oxygen containing functional groups on the surface. However, the optimal conditions for these two processes are different. It has also been observed that the extent of the modification is strongly dependent on the different plasma treatment time and different plasma forming gas used to excite the discharges. Depending on the process conditions, the PVC can become more hydrophilic by argon plasma treated than the air and untreated material.

Acknowledgement

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