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Properties of siloxane coatings deposited in a reel-to-reel atmospheric pressure plasma system

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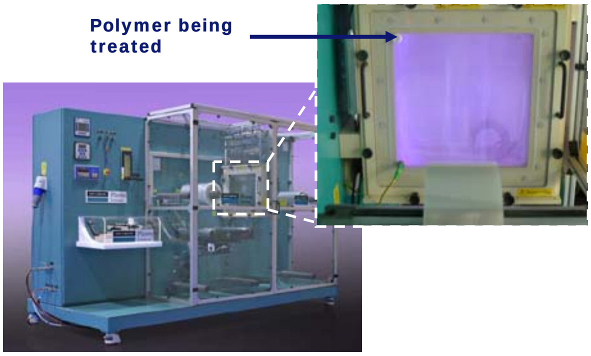
Project Summary

Atmospheric pressure plasmas have been shown to have considerable potential for the surface modification of polymers, due to their low treatment temperatures and continual processing capabilities. Industrial applications of these plasmas include the activation of polymers prior to adhesive bonding within the printing and packaging industries and the deposition of surface coatings. The focus of this project is to use an atmospheric pressure plasma for the deposition of nm thick functional coatings on polymeric webs. The plasma source used was developed by DowCorning (Figure 1). It has the unique ability to maintain the chemical functionality of the precursor liquids, in the deposited coatings. SiOx coatings have been deposited from siloxane precursors in helium or helium/oxygen plasmas. Through careful control of the deposition conditions a range of both hydrophobic or hydrophilic coatings can be obtained.



Polymer being treated

Figure 1: *Atmospheric pressure plasma coating system and uniform glow discharge (insert)*

Experimental Results

The effect of plasma exposure on SiOx coating properties was examined. The SiOx coatings were deposited from a HMDSO (hexamethyldisiloxane) precursor. By decreasing the flow rate of this precursor, while increasing the number of passes through the plasma system, the quantity of coating deposited was kept constant, while its exposure to the plasma was increased. The effect of this increased plasma exposure on elemental concentration is shown by the XPS analysis in Table 1 for coatings deposited between 2 and 10 passes. By curve fitting the silicon (Si 2P) core level it was found that there was an associated increase in Q-type siloxy concentration with the increased exposure (Table 2). As the level of Si-O bonding increased, the polar component of the coating surface energy also increased resulting in a more hydrophilic coating, as illustrated in Figures 2 and 3.

The coatings deposited at both low and high HMDSO precursor flow rates were examined by SEM. At the higher flow rates a large number of particulates were observed in regions of the surface. However, only isolated particles were observed at the lower flow rates. The particulate formation may be due to partial polymerisation of the precursor in the plasma before it arrives on the surface.

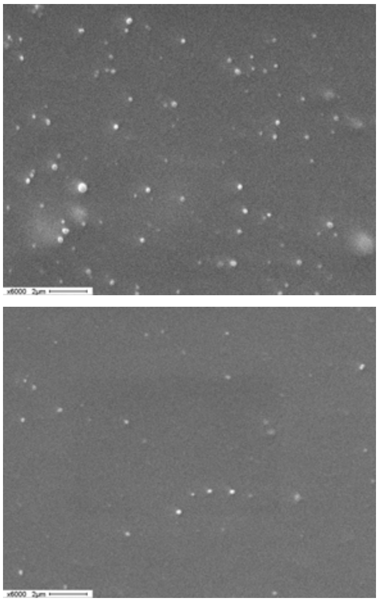


Figure 4: *Particulate formation in the coating observed at high (top) and low (bottom) HMDSO precursor flow rates (2μm scale bar)*

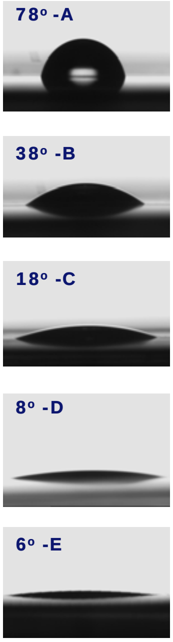


Figure 2: *The effect of increasing plasma exposure time on water contact angle*

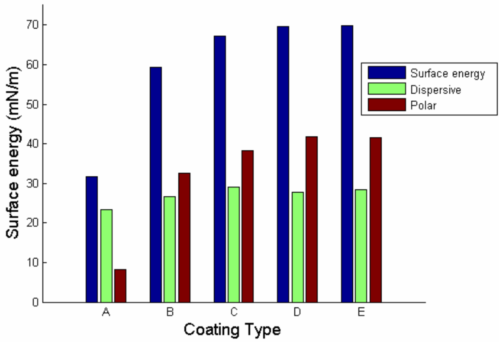


Figure 3: *The change in surface energy as the plasma exposure increases for HMDSO coated PET*

No. of passes (sample ref)	**Relative concentration (%)**		
	O	C	Si
2 (A)	29	46	26
4 (B)	49	21	30
6 (C)	60	8	32
8 (D)	61	7	32
10 (E)	60	8	32

Table 1: *Change in coating elemental composition with increased plasma exposure (from A to E)*

Sample	**Relative concentration (%)**			
	M	**D**	**T**	**Q**
A	9	58	33	0
E	0	2	12	86

Table 2: *Change in silicone chemistry as monitored by XPS with increased plasma exposure time (sample A to E above). Siloxy unit environments: M [$(CH_3)_3SiO_{1/2}$], D [$(CH_3)_2SiO_{2/2}$], T [$(CH_3)SiO_{3/2}$], Q [$SiO_{4/2}$]*