Plasma activation and functionalisation of carbon fibres for improved carbon fibre/ polymer matrix interfacial bonding

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ABSTRACT

Carbon fibres (CFs) are leading reinforcements in composite materials because of their excellent mechanical performance to weight ratio [1,2]. Currently the main weakness of fibre-based composites is the intrinsic poor interfacial adhesion between the carbon fibre surfaces and the polymer molecules. The weak fibre/matrix interfacial adhesion and hence low interfacial shear strength (IFSS) could be related to the hydrophobicity and chemical inertness of CFs due to their surface graphitic nature and to the polarity difference between the two components. This will cause the initiation of interface cracks and accelerate their propagation, thus leading to a failure of the composite structures.

Surface treatment of fibre reinforcement has been proved in laboratory to be an efficient way to overcome this weakness. This is because surface treatment of CFs can potentially modify their surface microstructure (surface roughness, surface morphology and their surface area), introduce new chemical groups to their surface, and change the surface free energy of the fibres and their wettability. To this end, an innovative plasma surface engineering technology based on active-screen plasma (Fig.1) has been developed to activate and multi-functionalise HTA40 carbon fibre surfaces (ASPN1, ASPN2 & ASPN3).

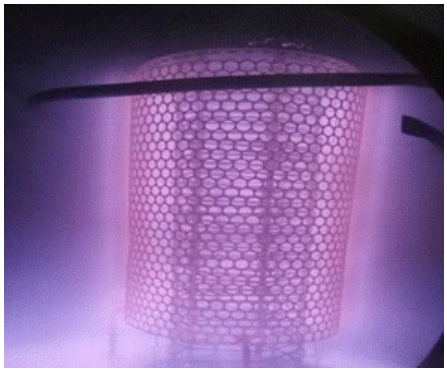

Fig.1 Plasma treatment of CFs

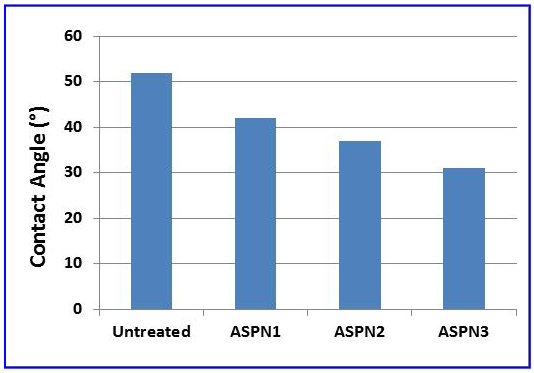

Fig.2 Improved contact angle between CFs and matrix

Systematic surface characterisation of the modified CFs was carried out using SEM, AFM, XPS and contact angle measurements. It has been demonstrated that the plasma treatment can increase surface roughness, remove weakly bonded layers, alter their surface chemistry and enhance their wettability (Fig.2). Nano-indentation push-out and fragmentation tests on the composite samples made with pristine and plasma modified CFs provided the evidence of improved carbon fibre/ polymer matrix interfacial bonding strength.

References

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