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Plasma polymers used for controlled interphase in polymer composites

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The performance of fiber-reinforced composites is strongly influenced by the functionality of composite interphases. Sizing, i.e. functional coating (interlayer), is therefore tailored to improve the transfer of stress from the polymer matrix to the fiber reinforcement by enhancing fiber wettability, adhesion, compatibility, etc. The world market is dominated by glass reinforcement in unsaturated polyester, which comprises almost 90% of the total market. Commercially produced sizing is heterogeneous with respect to the thickness and uniformity, the molecules of silane coupling agents have a tendency towards self-condensation, forming siloxane oligomers rather than complete bonding with the glass surface, and the low density of siloxane bonds with the surface decreases if water molecules diffuse to the interface since this type of bond is hydrolytically unstable. Only 10–20% of the total sizing is bonded to the fiber surface and this amount is directly related to the composite interfacial strength. Technology centers in glass companies search for new ways of solving the above problems. One of the alternative technologies is plasma polymerization. Plasma polymer films of hexamethyldisiloxane, vinyltriethoxysilane, and tetravinylsilane in a mixture with oxygen gas were engineered as compatible interlayers for the glass fiber/polyester composite. The interlayers of controlled physico-chemical properties were tailored using the deposition conditions with regard to the elemental composition, chemical structure, and Young’s modulus in order to improve adhesion bonding at the interlayer/glass and polyester/interlayer interfaces and tune the cross-linking of the plasma polymer. The optimized interlayer enabled a 6.5-fold increase of the short-beam strength compared to the untreated fibers. The short-beam strength of GF/polyester composite with the plasma polymer interlayer was 32% higher than that with industrial sizing developed for fiber-reinforced composites with a polyester matrix. The progress in plasmachemical processing of composite reinforcements enabled us to release a new conception of composites without interfaces.

Keywords
thin films
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