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Are Silanes the Primary Driver of Interface Strength in Glass Fiber Composites ?

(An exploration of the relationship of chemical and physical parameters in the micromechanical characterisation of the apparent interfacial strength in glass fiber composites)

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It is probably not an overstatement to say that organosilanes are the most important class of chemicals used in the glass fiber, and consequently the composites, industry. One of the best-known assertions about these multifunctional silane molecules is that they promote chemical bonding across the fiber-matrix interface. However, the development of (non-reactive) thermoplastic matrix composites raises questions about the simplistic chemical bridging model of silanes at the interface. Moreover, despite the high level of attention commonly focused on the chemical influences on interfacial adhesion, a growing number of researchers have also commented on the role of residual stress contributing to the stress transfer capability at the fiber-matrix interface.

We will review data on the temperature dependence of the apparent interfacial shear strength (IFSS) in (unsized) glass fiber-polypropylene, a system where there is no *a priori* reasoning to expect any chemical bonding at the interface. The results indicate that the apparent IFSS in thermoplastic composites can be largely explained by the residual thermal stresses. This phenomenon is characterised by a large drop in the measured IFSS when the test temperature is raised above the matrix T_g. We will also present data to show that the same phenomenon is present in the IFSS of glass fiber-epoxy composites, although the magnitude of the measured values of IFSS for epoxy systems cannot be explained by residual thermal stress alone. However, by further considering the possible contribution of the thermoset phenomenon of cure shrinkage we will demonstrate that it is also possible to explain the level of IFSS in this chemically reactive system by physical residual stresses alone. The state of the interface/interphase in epoxy systems is somewhat more complex than for (relatively) non-reactive thermoplastics. This presentation will review our results on the investigation of this complex experimental challenge.

Many of the properties required in the modelling of residual stress in these systems vary with the curing agent to epoxy resin ratio near the interface. Since fibers are often coated with sizings containing reactive groups found in both curing agents and epoxy resins it is likely that the polymerised matrix near the fiber surface will have a different ratio of reactive groups than was mixed in the original liquid resin system. To fully explore this concept it is therefore necessary to characterise both the IFSS and the epoxy matrix properties (such as T_g, modulus, and thermal expansion coefficient) as a function of temperature and stoichiometry.