An integrated physical-chemical-mechanical approach to study the interfacial compatibility and adhesion in natural fibre thermoplastic composites

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Abstract

Natural fibres commonly extracted from different parts of plants show different surface chemistry properties. Most natural fibres are relatively hydrophilic, have a rough surface and are physico-chemically heterogeneous, which affects the interfacial compatibility and adhesion when used in composite materials. In this study, an integrated physical-chemical-mechanical approach is used to study the interface between natural fibres (specifically coir and bamboo fibres) and various thermoplastic matrices.

Wetting measurements of the fibres and the matrices are carried out to obtain their static equilibrium contact angles in various liquids, which are then used to estimate the surface energies with a three component model. The work of adhesion is calculated for each composite system, accordingly. Next to this, fibre surface chemistry is also studied by X-ray photoelectron spectroscopy (XPS) to obtain more information about functional groups at the fibre surface, which contributes to a deeper understanding of the interactions at the composite interface.

The strength of the composite interfaces is verified using single fibre pull-out and transverse three point bending tests (3PBT), which are performed on UD composites to measure interfacial shear strength and interfacial mode I strength respectively.

With respect to the surface energy analysis, the results show that the work of adhesion of both coir and bamboo fibres with polyvinylidene fluoride is higher than in case of polypropylene and maleic anhydride grafted polypropylene. On the other hand, the results of pull-out test and transverse 3PBT show much higher interfacial adhesion of both fibres (particularly for coir) with both polyvinylidene fluoride and maleic anhydride grafted polypropylene in comparison with that of the fibres with polypropylene. This suggests that the higher interfacial adhesion of coir fibres with polyvinylidene fluoride can be attributed to higher fibre-matrix physico-chemical interaction corresponding with the work of adhesion. While the improvement of interfacial adhesion in case of the fibres with maleic anhydride grafted polypropylene is probably chemical bonding dominated. In agreement with the interface evaluation, the flexural strength in longitudinal direction of the composites is largely in sync with their interfacial adhesion.

Key words: Natural fibres; Wetting; Interfacial adhesion; Surface analysis