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A Dynamic Mechanical Thermal T-Peel Test Approach to Characterize Interfacial Behavior of Polymeric Textile Composites

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Abstract : Basic understanding of interfacial mechanisms is of importance for the development of polymer composites. For this purpose, we need techniques to analyze the quality of interphases, their chemical and physical interactions and their strength and fracture resistance. In order to investigate the interfacial phenomena in detail, advanced characterization techniques are favorable. Dynamic mechanical thermal analysis (DMTA) using a rheological system is a sensitive tool. T-peel tests were performed with this system, to investigate the temperature-dependent peel behavior of woven textile composites. A model system was made of polyamide (PA) woven fabric laminated with films of polypropylene (PP) or PP modified by grafting with maleic anhydride (PP-g-MAH). Firstly, control measurements were performed with solely PP matrixes. Polymer melt investigations, as well as the extensional stress, extensional viscosity and extensional relaxation modulus at -10°C, 100 °C and 170 °C, demonstrate similar viscoelastic behavior for films made of PP-g-MAH and its non-modified PP-control. Frequency sweeps have shown that PP-g-MAH has a zero phase viscosity of around 1600 Pa·s and PP-control has a similar zero phase viscosity of 1345 Pa·s. Also, the gelation points are similar at 2.42*104 Pa (118 rad/s) and 2.81*104 Pa (161 rad/s) for PP-control and PP-g-MAH, respectively. Secondly, the textile composite was analyzed. The extensional stress of PA66 fabric laminated with either PP-control or PP-g-MAH at -10 °C, 25 °C and 170 °C for strain rates of 0.001 – 1 s⁻¹ was investigated. The laminates containing the modified PP need more stress for T-peeling. However, the strengthening effect due to the modification decreases by increasing temperature and at 170 °C, just above the melting temperature of the matrix, the difference disappears. Independent of the matrix used in the textile composite, there is a decrease of extensional stress by increasing temperature. It appears that the more viscous is the matrix, the weaker the laminar adhesion. Possibly, the measurement is influenced by the fact that the laminate becomes stiffer at lower temperatures. Adhesive lap-shear testing at room temperature supports the findings obtained with the T-peel test. Additional analysis of the textile composite at the microscopic level ensures that the fibers are well embedded in the matrix. Atomic force microscopy (AFM) imaging of a cross section of the composite shows no gaps between the fibers and matrix. Measurements of the water contact angle show that the MAH grafted PP is more polar than the virgin-PP, and that suggests a more favorable chemical interaction of PP-g-MAH with PA, compared to the non-modified PP. In fact, this study indicates that T-peel testing by DMTA is a technique to achieve more insights into polymeric textile composites.

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