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EB-curing of high performance composites: from labscale experiments to industrial implementation

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Abstract

Cross-linking polymerization initiated by high energy radiation is a highly attractive technique for the fabrication of high performance composite materials. The method offers many advantages compared to conventional energy- and time-consuming thermal curing processes. Free radical and cationic chain polymerization have been investigated in some details by various research groups along the last years. A high degree of control over curing kinetics and material properties can be exerted by adjusting the composition of matrix precursors as well as by acting on process parameters.

However, the comparison with state-of-the-art thermally cured composites revealed the lower transverse mechanical properties of radiation-cured composites and the higher brittleness of the radiation-cured matrix. Improving fiber-matrix adhesion and toughening the polymer network are thus two major challenges in this area. We have investigated at the level of labscale experiments gradually transposed to industrial procedures several aspects related to these key issues. We will emphasize in the present paper the modelling of curing kinetics, the reduction of the matrix shrinkage on curing, the design of tailored fiber-matrix interface favoring transverses mechanical properties, and finally the use of thermoplastic toughening agents. Significant improvements were achieved on transverse strain at break by applying original surface treatments on the fibers so as to induce covalent coupling with the matrix. A drastic enhancement of the KIC value exceeding 2 $MPa.m^{1/2}$ was also obtained for acrylate-based matrices toughened with high T_g thermoplastics.