Bismaleimide Composites: Unusual Processing Techniques

by

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Abstract

Bismaleimide resins, BMIs in short, belong to the class of thermosetting polyimides. Their main uses include composite resins, adhesives, coatings and moulding compounds for a wide range of applications. The chemistry of BMI resins varies widely in order to meet stringent mechanical and electrical properties. However, modifications are also necessary to meet the processing characteristics of established composite manufacturing processes, sometimes at the expense of the resin properties. Within this paper we discuss BMI composite manufacturing techniques that allow BMI resins to be used in solution as powders or films.

Tow prepreg (towpreg) filament winding is a technology that combines the advantages of low cost manufacturing techniques and the use of high performance matrix resins. The fibre impregnation typically is performed by a solvent coating process, followed by a drying step to strip off the solvent and to advance the resin so that a flexible but dry product is obtained. Towpregs may also be manufactured in a hot-melt operation, but with the loss of the resin formulation latitude inherent in the solvent process. The Towpreg width and thickness, resin content and flexibility can be varied widely and be designed according to the intended end use. The process is advantageous for BMI formulated resins. Resin blends including BMI/thermoplastic mixtures may be employed to increase toughness. Towpreg bobbins can be stored cold for months similar to tape prepregs before use. A serious advantage is the fact that resin handling and tow impregnating can be kept safe in the hands of specialists, separately from the filament winding operation. The present paper highlights the main aspects to the BMI towpreg processing.

The resin processing properties such as viscosity, pot life, gel time, etc. are to a major extend dictated by the parameters of the composite manufacturing process. Resins are tailored to meet these requirements, but very often at the expense of optimum physical properties of the cured resin. The BMI resins, possessing outstanding properties are in most cases solids at ambient and even at elevated temperatures, owing to optimize molecular weight of a pre-polymer. Therefore, more sophisticated techniques employ powdered BMI resins instead of solutions or hot melts. The use of aqueous powder dispersions for fibre/fabric impregnation has been successfully demonstrated. Glass fabric laminates moulded at pressures up to 10 bars show mechanical properties equivalent to or better than solution-based systems. In particular, the high temperature physical properties are improved due to the absence of any plasticizing residual solvent. Another strong argument for prepregging and moulding techniques employing aqueous powder suspensions is the elimination toxic solvents increasingly raising environmental and health safety concerns.

An interesting although not widely used technology, is the so-called film-stacking. The reinforcement (preferably as fabrics) and the resin film are stacked alternating, and the lay-up is moulded afterwards in a heated press at high temperature. This technique initially was developed for thermoplastic resins; therefore, high pressure and high temperature are required to achieve sufficient flow during moulding. Instead of thermoplastics it is possible to use thermoplastic/BMI blends in the form of films. Such BMI/thermoplastic blend systems, with an excess of thermoplastic resin, allow the manufacture of very tough laminates; their processing temperature is significantly lower as for neat thermoplastic resins, because the BMI part of the blend contributes to higher flowability and lower cure temperature. The paper discusses the constituent requirements, film preparation and laminate moulding for selected high temperature BMI/thermoplastic systems.