Characterization of the Degree of Cure of Thermosetting Resins by DSC

Keywords: Differential Scanning Calorimetry (DSC)

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DSC measures the temperatures and heat flows associated with transitions in materials as a function of temperature or time in a controlled atmosphere. This technique provides quantitative and qualitative information about physical and chemical changes that involve endothermic or exothermic processes, or changes in heat capacity.

The below plot demonstrates the DSC's ability to detect the glass transition temperature and residual cure in a thermosetting resin. The two most common means of analyzing degree of cure are: 1) quantifying residual cure in the as-received material and 2) measuring the shift in the glass transition temperature.

By knowing the heat of reaction of the 100% unreacted material, the degree of cure of the sample can be calculated using the following equation:

% Cure = 1 - (ΔH Residual Cure / ΔH Full Cure) * 100

The solid curve represents the data for the material exhibiting optimum physical properties. The heat of reaction of a completely uncured material is 320 J/g in this case. By quantifying the residual cure (79J/g) and the Tg (-5 °C) of this material, the optimum cure level is established. The dashed curve is the same material cured differently (75%). The dashed curve is easily identified as an "under cured" material because of the lower Tg (-12 °C) and higher residual cure (145J/g). This example clearly shows how DSC can be used to characterize degree of cure of thermosetting resins.

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