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Rheological Behavior and Modeling of Bismaleimide Resin for RTM Processing

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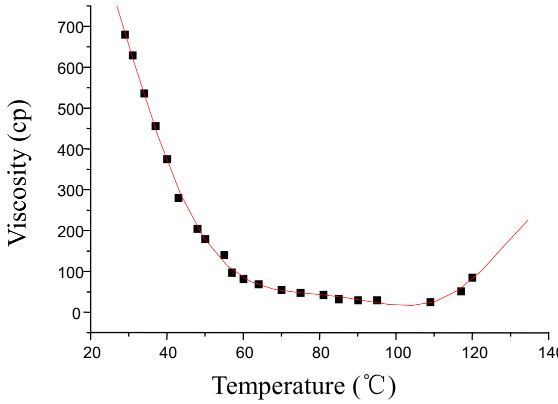
Resin transfer molding (RTM) is considered the most attractive solution for high quality, affordable and environment friendly manufacturing process of composite materials for both civilian and military applications. In order to get high quality products from RTM processes, a particular designed resin formulation with very low viscosity during mold filling should be employed. For instance, the viscosity of the resin should be less than 300 cP for the processes when the fiber volume of composites is more than 55%. The accurate and fast determination of the low viscosity window of the resin is important for processing parameter design and optimum. In this research, the rheological behaviors of bismaleimide (BMI) resin for RTM processes are studied with DSC and viscosity measurements. Fig. 1 and Fig. 2 are the viscosity-temperature and viscosity-time relationships of the BMI resin. A rheological model based on dual Arrhenius equation is established and used to model the rheological behaviors of the resin. It is shown that a two-pieces viscosity model should be employed to describe the viscosity characteristics of the resin because the different curing mechanisms of the resin at different temperatures. The developed model is shown in Table 1. In the table, η is the viscosity of the resin and η_0 is the initial viscosity of the resin; a and n are the parameters of the model. Another important feature is that the influences of temperature on η_0、 a and n parameters can be well described by Arrhenius equations. The estimated viscosity of the models is in good agreement with that of the experiments. The low viscosity plaque and a processing window of the resin are determined based on the developed models which is shown in the Fig. 3. The optimum processing parameters of the BMI resin for RTM processes is 80℃ at which the viscosity of the resin will be less than 300cP within 71 minutes. The developed viscosity models will be important for processing simulation and quality control for high performance composites of RTM processes.



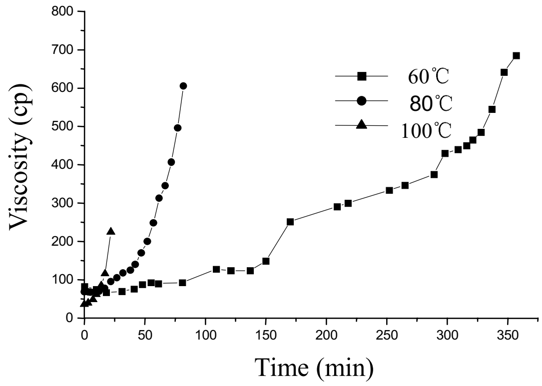


Fig.1 Viscosity-temp. curve of the BMI resin

Fig.2 Viscosity-time curve of the BMI resin

Table 1 Two-pieces viscosity model of the BMI resin

model	Parameter of the model	Temp.(℃)
$\frac{\eta}{\eta_0} = a\exp(nt)$	$a = 65.314\exp\left(\frac{-1619.804}{T}\right)$ $n = 6.5881\times10^{-9}\exp(0.0438T)$	T⩾80
	$a = 5.314\times10^{-4}\exp\left(\frac{2517.65}{T}\right)$ $n = 9.33\times10^{-15}\exp(0.08194T)$	T<80

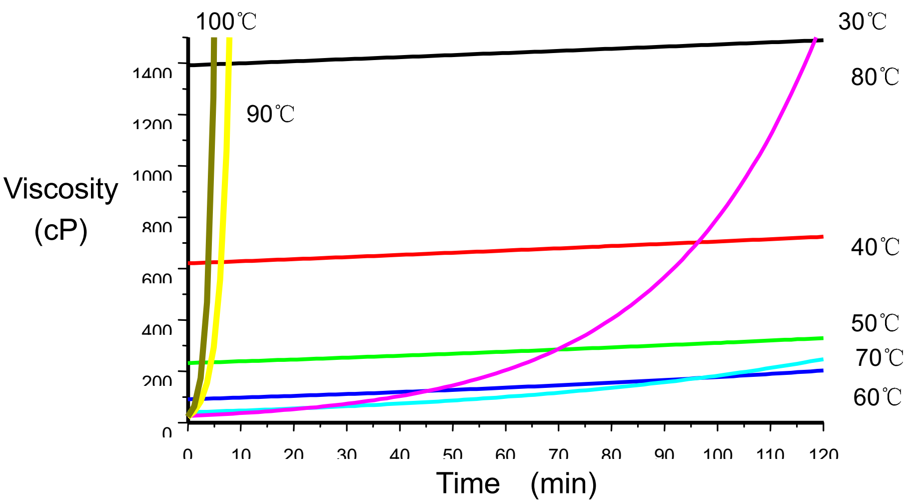


Fig. 3 The rheological modeling of the BMI resin