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Al_2O_3 충전된 에폭시 수지 복합재료계의 후기 경화조건에 따른 열적특성

Effects of Post Cure Conditions on Thermal Characteristics of Al_2O_3 Filled Epoxy Resin Composite System

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Abstract

The effects of post curing conditions on thermal properties of alumina filled epoxy resin system DGEBA/MDA/SN were investigated. As the post curing time increased at 150℃, the glass transition temperature increased from 121 to 124, slightly. As the heating rate increased, high thermal decomposing temperature (T_d) and most decomposing temperature (T_p) increased. For the case of post-cured system at 150℃ for 4 days showed lower values than virgin system. At the post curing condition the system must have been thermally degraded.

Key words : Epoxy resin, alumina, composite, post cure, thermal properties, electrical insulation

1. Introduction

The epoxy resin systems have good combined electrical, mechanical and thermal properties. The applications of the resin are very broad for the electrical insulation. They have been used in types of mold, impregnation, encapsulation, lamella, etc. To enhance its electrical properties, inorganic fillers are incorporated in it. The inorganic filler filled epoxy resin composites have been used for the complex insulator in high voltage electric power systems[1,2]. Many factors affect the properties of composite system. The inorganic filler Al_2O_3 was mixed with DGEBA/MDA/SN system[3]. The effects of post curing conditions such as curing time and curing temperature on thermal characteristics of the system were investigated.

2. Experiment

2-1. Materials

The liquid epoxy resin used was DGEBA

(EPON 828 grade) with epoxy equivalent value of 184. The curing agent and a reactive additive were MDA and SN, respectively. The loading of Al_2O_3 treated with silane coupling agent was from 0 to 10 phr.

2-2 Specimen Preparation

The mixture of DGEBA, MDA, SN and Al_2O_3 was degassed and mechanically stirred at 80℃. The reacting mixture at gel state was cast into the pre-heated mold coated with releasing agent at 80℃. The system was cured at 80℃ for 1.5 hr, firstly, and at 150℃ for 1.0 hr, secondly[3]. The thermally cured specimen at higher temperature than T_g was annealed to the room temperature. It was post cured at 150℃ at the convection oven for 4 days.

2-3. Thermal Analysis

T_g was measured from the DSC curves of cured and post-cured alumina filled DGEBA/MDA/SN system for 4 days at 150℃. Initial decomposition temperature (T_d) and most rapidly decomposing temperature (T_p) were detected by using TGA at the heating rates of 5, 10, 15, 20 ℃/min. The stream rate of ambient nitrogen gas was 80 ml/min[4].

3. Results and Discussion

3-1. DSC Analysis

Fig. 1 shows the DSC thermograms of DGEBA/MDA/SN-Al_2O_3 composite system at the heating rate of 10 ℃/min. The glass transition

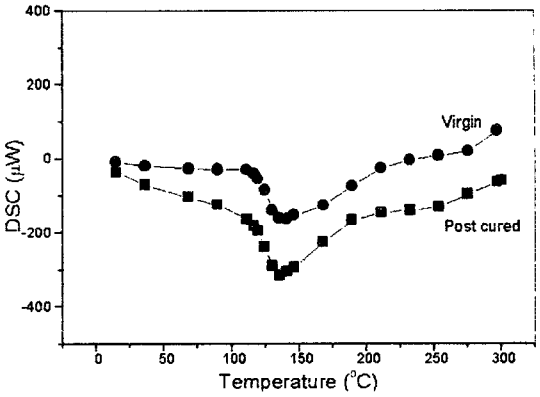

Fig. 1. Effects of post cure on DSC curves of DGEBA/MDA/SN-Al_2O_3 system.

temperatures (T_g) of virgin and pos-tcured system for 4 days at 150℃ were 121 and 124℃, respectively. Under the post curing temperature of 150℃, T_g was not changed apparently. But at higher temperature the value will be increased as observed at the literature[5].

3-2. TG Analysis

The TG curves of the composite at the heating rates of 5, 10, 15 and 20 ℃/min are shown in Fig. 2. On the TG thermograms, the weight of the sample is almost stable below 325℃ depending on the heating rates and above the temperature, the weight loss rate increases rapidly during the short temperature range due to the removal of low molecular weight components produced by the pyrolysis of the polymeric main chain at high temperature. The thermograms shift toward higher temperature as

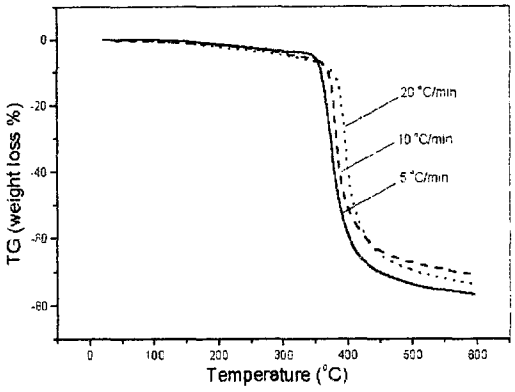

Fig. 2. Effects of heating rates on TG thermograms of DGEBA/MDA/SN system filled with Al_2O_3.

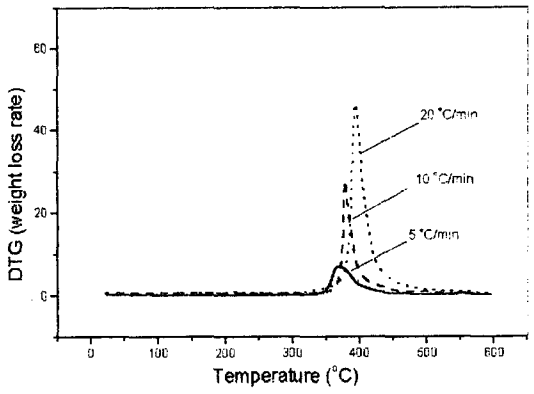

Fig. 3. Effects of heating rates on DTG thermograms of DGEBA/MDA/SN system filled with Al_2O_3.

the heating rate increased. The initial decomposing temperature (T_d) increased with the increment of heating rate. These values at 5, 10, 15 and 20 ℃/min were 359.7, 372.4, 378.1 and 382.5, respectively.

3-3. DTG Analysis

Fig. 3 shows the DTG thermograms of DGEBA/MDA/SN-Al_2O_3 at various heating rates. As the heating rate increased the thermograms shift toward right and the peak temperature where the polymeric insulator was decomposed most rapidly increased. On the DTG curve, it is clear that the sample degraded in one stage and the peak temperature of the curve increased with the increment of heating rate. These values at 5, 10, 15 and 20 ℃/min were 365.1, 377.2, 389.4, and 392.1, respectively. On the DTG curves, one stage weight loss curve was observed.

3-3. Post-curing Time on TG and DTG

Fig. 4. shows the effects of post curing condition on thermal decomposing temperature. As the heating rates increased the initial decomposing temperature and most decomposing temperature (T_p) increased.

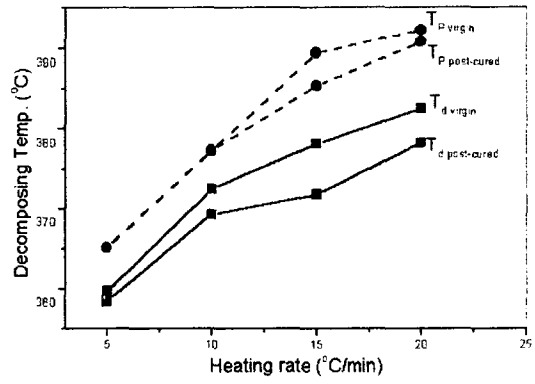

Fig. 4. Effects of post curing period on thermal properties of DGEBA/MDA/SN system filled with Al_2O_3.

To increase the thermal stability of Al_2O_3 filled epoxy resin system for the application of high power electric equipment under high thermal stress, we are concentrating on the optimum curing condition, mixing ratio and surface treatment of the filler[6]. The detail things will be presented next.

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