The Study of Thermal properties In Polystyrene/Clay nanocomposites

Student：Huei-Kuan Fu **Advisor：Dr. Feng-Chih Chang**

Institute of Applied Chemistry

National Chiao Tung University

Abstrate

Nanoclay-filled polymeric systems offer the prospect of greatly improving many of the properties of their mother polymers. In the recent literature, there have been reports of nanoclay-filled polymeric systems that display significant improvements in tensile and thermal properties, heat distortion temperature, and resistance to flammability and reduced permeability to small molecules and reduced solvent uptake. A common observation emerging from these studies is that the magnitude of improvement depends strongly on the state of dispersion of the clay layers in the polymer matrix. The experiment work in this dissertation was divided into three areas：

1. We have prepared polystyrene/clay nanocomposites using an emulsion polymerization technique. The nanocomposites were exfoliated at up to a 3 wt % content of pristine clay relative to the amount of polystyrene (PS). We used two different surfactants for the

montmorillonite: the aminopropylisobutyl polyhedral oligomeric silsesquioxane (POSS) and the ammonium salt of cetylpyridinium chloride (CPC). Both surfactants can intercalate into the layers of the pristine clay dispersed in water prior to polymerization. Although the *d* spacing of the POSS-intercalated clay is relatively smaller than that of the CPC-intercalated clay, PS more easily intercalates and exfoliates the POSS-treated clay than the CPC-treated clay. IR spectroscopic analysis further confirms the intercalation of POSS within the clay layers. We used X-ray diffraction (XRD) and transmission electron microscopy (TEM) to characterize the structures of the nanocomposites. The nanocomposite prepared from the clay treated with the POSS containing surfactant is exfoliated, while an intercalated clay was obtained from the CPC-treated surfactant. The molecular weights of polystyrene (PS) obtained from the nanocomposite is slightly lower than the virgin PS formed under similar polymerization conditions. The value of T_g of the PS component in the nanocomposite is 8 °C higher than the virgin PS and its thermal decomposition temperature (21 °C) is also higher significantly. The presence of the POSS unit in the MMT enhances the thermal stability of the polystyrene.

2. We synthesized intercalation agent APB and prepared polystyrene/clay nanocomposites using an emulsion polymerization technique. We used

two different intercalation agents to treat clay：the phosphonium salt （APP）and the ammonium salt（APB）.We expected that the intercalation agent APB containing rigid adamantane group also has high thermal stability besides phosphonium group. The molecular weights of polystyrene（PS） obtained from the nanocomposites is slightly lower than the virgin PS formed under similar polymerization conditions. The coefficient of thermal expansion（CTE） was obtained from thermomechanical analysis. A 44~55 ％ decrease of CTE is observed for APB- and APP-intercalated clay nanocomposites relative to pure PS.

3. We have prepared polystyrene/clay nanocomposites using an emulsion polymerization technique. The nanocomposites were exfoliated at 3wt% content of pristine clay relative to the amount of polystyrene (PS). We employed two surfactants for the montmorillonite: cetylpyridinium chloride (CPC) and the CPC/α-CD inclusion complex. Prior to polymerization, each surfactant intercalates into the layers of the pristine clay dispersed in water. The inclusion complex was characterized by X-ray diffraction, ^{13}C CP/MAS NMR spectra, and ^{1}H NMR spectroscopy, and TGA. X-Ray powder patterns of the CPC/α-CD complex indicate that the α-CDs units form channels. The ^{13}C CP/MAS NMR spectrum of the complex suggests that a CPC chain is included in the channel formed by the α-CDs. The ^{1}H NMR

spectra of the complexes indicate that the stoichiometry of the complexes is 1:2 (i.e.,one CPC molecule and two α-CD units). The TGA reveals that the inclusion complex has higher thermal stability relative to the virgin CPC. We employed both X-ray diffraction (XRD) and transmission electron microscopy (TEM) to characterize the structures of the nanocomposites. The value of T_g of the PS component in the nanocomposite is 6 °C higher than that of the virgin PS and its thermal decomposition temperature is 33 °C higher. The CPC/α-CD-treated clay is more effective than is virgin CPC-treated clay at enhancing the thermal stability of polystyrene.