

STRUCTURE-PROPERTY RELATIONSHIPS OF POLYSTYRENE/LAYERED SILICATE NANOCOMPOSITES AS A FUNCTION OF THEIR PREPARATION

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In the past decade, polymer nanocomposites have attracted great attention because of their excellent physical-mechanical properties [1-2]. The exfoliation of layered silicate (LS) particles in thermoplastic matrices was found extremely effective to improve their thermal and mechanical properties. Note that pristine layered silicates, being hydrophilic in nature, have low interaction with polymers. Accordingly, no intercalation/exfoliation take place and the resulting material is a micro- instead of the targeted nanocomposite. In order to support the intercalation/exfoliation of LS, they have to be modified. This occurs via cation exchange in aqueous slurry using suitable cationic tensides as organophilic modifiers. This modification makes the organophilic LS to an expensive “nanofiller”. The question is whether it is possible to use pristine layered silicate to produce thermoplastic nanocomposites. The basic idea is that water may serve as “modifier” for the LS as water swells them and thus increase the gallery distance between the layers. This project was aimed at producing polystyrene (PS)-based nanocomposites by various methods and compare their properties. In case of the masterbatch method pristine LS was added to a PS-latex, the resulting material dried and then melt mixed with additional PS granules in a heated kneader prior to hot pressing. For comparison propose a PS composite was produced by incorporating the LS in the PS melt (termed direct melt mixing). The mechanical and thermo-mechanical properties of the PS composites with varying LS contents were determined and the differences traced to the dispersion state of the LS.

Sodium fluorohectorite with an interlayer distance of 0.94 nm served as LS. PS latex with 50 wt% dry content was used as LS swelling agent. Granulated PS was utilized as polymeric matrix for all composite systems. A scheme of the masterbatch technique is given in Figure 1. After evaporation of the water at room temperature for 48 h and in an air circulated oven for 12 h it was introduced in the PS melt in a Brabender Plasticorder. Sheets were produced by hot press. TEM observations revealed that melt compounding did not result in delamination of the LS. On the other hand, the masterbatch technique resulted in a far better dispersion of the LS particles – cf. Figure 2. The effect of composite preparation is obvious when plotting the storage moduli of the materials as a function of temperature at various LS contents – cf. Figure 3. One can recognize that the stiffness of those composites which were prepared by direct melt compounding always inferior to those prepared by the masterbatch technique. This is due to the better dispersion of the LS in the related systems in accordance with the TEM results (cf. Figure 2). Figure 4 collates the creep compliance values for the neat PS and its composites produced by direct melt mixing and masterbatch methods. The shape of the creep curves of the nanocomposites is very similar to that of the unfilled PS, but their creep compliance values are much smaller compared to the unfilled PS. For the composites containing 4.5 wt% LS the creep compliance was reduced by ca. 40 % and 10 % compared to the neat PS when produced by the masterbatch and direct melt compounding, respectively. This creep behavior is a signature of the better intercalation/exfoliation achieved through the masterbatch technique.

In this work, we have demonstrated that pristine layered silicate (LS) can be easily and well dispersed in polystyrene (PS) by a masterbatch technique. The latter means that LS is “predispersed” in a PS latex. Improvements in the thermo-mechanical behavior (increased

stiffness, reduced creep) when compared with results achieved on direct melt compounded systems were attributed to the better dispersion of the LS. This was evidenced by TEM results.

References:

[1]Zhang, M. Q., Rong, M. Z. and Friedrich, K.: Processing and properties of nonlayered nanoparticle reinforced thermoplastic composites in “*Handbook of Organic-Inorganic Hybrid Materials and Nanocomposites*” (Ed.: Nalwa, H. S.), Am. Sci. Publ., Los Angeles, CA, 2003, Vol.2, pp. 113-150.
 [2]Karger-Kocsis, J. and Zhang, Z.: Structure-property relationships in nanoparticle/semicrystalline thermoplastic composites in “*Mechanical Properties of Polymers Based on Nanostructure and Morphology*” (Eds.: Michler, G.H. and Baltá Calleja, F.J.), CRC, Boca Raton, FL, (2005), Ch. 13, pp. 553-602.

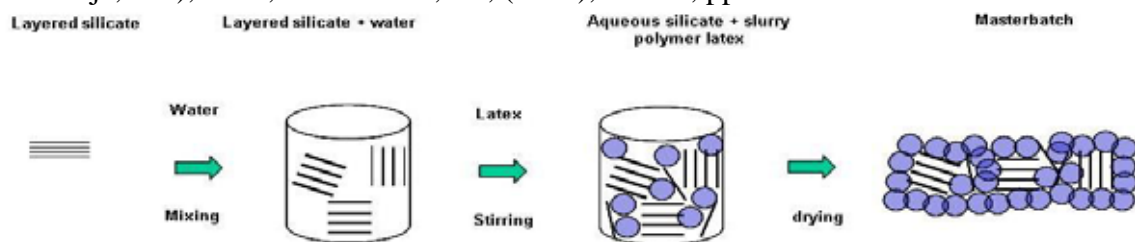


Figure 1: Scheme of PS/silicate nanocomposite preparation by masterbatch technique.

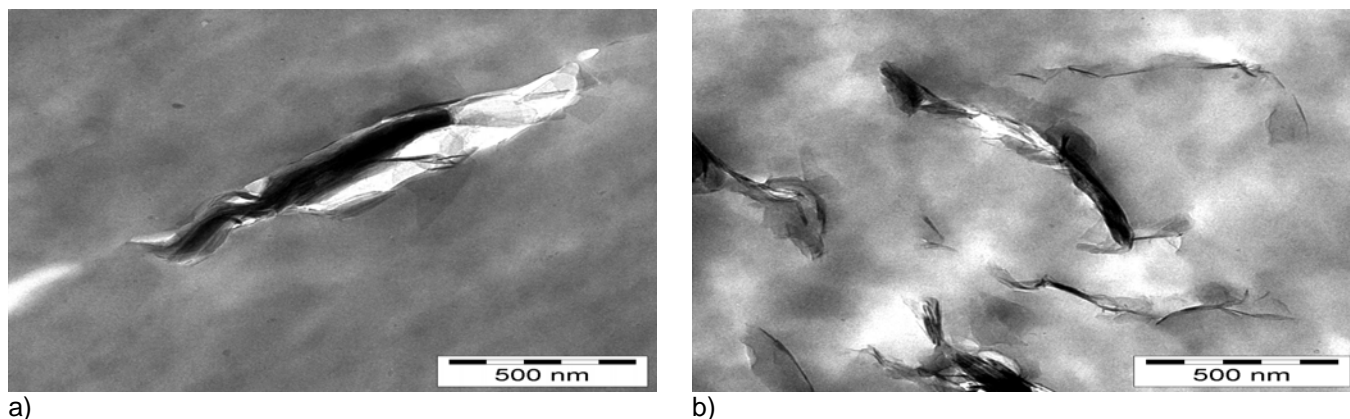


Figure 2: TEM micrographs of PS+4.5 wt% silicate prepared by different methods a) direct melt mixing b) masterbatch technique

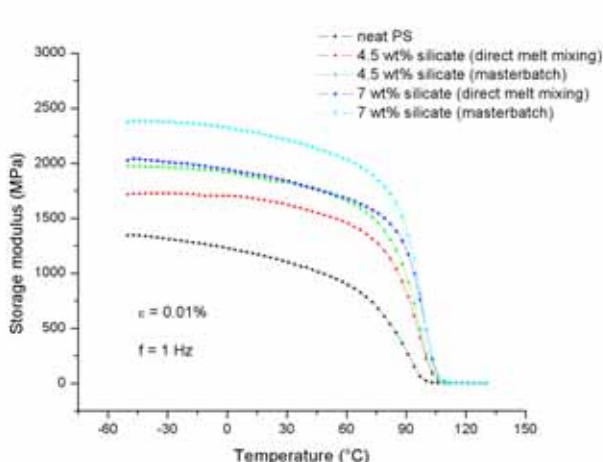


Figure 3: PS and its silicate nanocomposites prepared by different methods: Storage moduli as function of temperature.

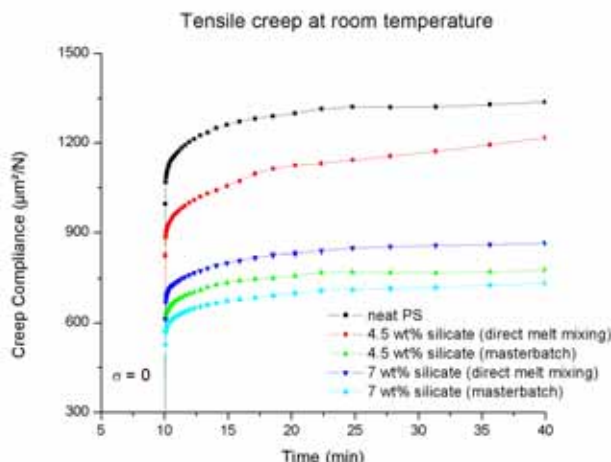


Figure 4: Creep of the neat PS and its silicate nanocomposites prepared by different methods (Notes: Stress applied at t = 10 min).