

# Modifying Silicates for Better Dispersion in Nanocomposites

Processability and final material properties are improved.

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An improved chemical modification has been developed to enhance the dispersion of layered silicate particles in the formulation of a polymer/silicate nanocomposite material. The modification involves, among other things, the co-exchange of an alkyl ammonium ion and a monoprotinated diamine with interlayer cations of the silicate. The net overall effects of the improved chemical modification are to improve processability of the nanocomposite and maximize the benefits of dispersing the silicate particles into the polymer.

Some background discussion is necessary to give meaning to a description of this development. Polymer/silicate nanocomposites are also denoted polymer/clay composites because the silicate particles in them are typically derived from clay particles. Particles of clay comprise layers of silicate platelets separated by gaps called "galleries." The platelet thickness is 1 nm. The length varies from 30 nm to 1  $\mu\text{m}$ , depending on the silicate. In order to fully realize the benefits of polymer/silicate nanocomposites, it is necessary to ensure that the

platelets become dispersed in the polymer matrices. Proper dispersion can impart physical and chemical properties that make nanocomposites attractive for a variety of applications.

In order to achieve nanometer-level dispersion of a layered silicate into a polymer matrix, it is typically necessary to modify the interlayer silicate surfaces by attaching organic functional groups. This modification can be achieved easily by ion exchange between the interlayer metal cations found naturally in the silicate and protonated organic cations — typically protonated amines. Long-chain alkyl ammonium ions are commonly chosen as the ion-exchange materials because they effectively lower the surface energies of the silicates and ease the incorporation of organic monomers or polymers into the silicate galleries. This completes the background discussion.

In the present improved modification of the interlayer silicate surfaces, the cation exchange strengthens the polymer/silicate interface and ensures irreversible separation of the silicate layers. One way in which it does this is to essen-

tially tether one amine of each diamine molecule to a silicate surface, leaving the second amine free for reaction with monomers during the synthesis of a polymer. In addition, the incorporation of alkyl ammonium ions into the galleries at low concentration helps to keep low the melt viscosity of the oligomer formed during synthesis of the polymer and associated processing — a consideration that is particularly important in the case of a highly cross-linked, thermosetting polymer. Because of the chemical bonding between the surface-modifying amines and the monomers, even when the alkyl ammonium ions become degraded at high processing temperature, the silicate layers do not aggregate and, hence, nanometer-level dispersion is maintained.

*This work was done by Sandi Campbell of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17339.*