

Film Formation of Polymer-Silica Nanocomposites

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Polymer films may be formed by drying aqueous suspensions of colloidal polymer particles on a substrate. These find wide application in the coatings, adhesives, and cosmetic industries. Higher performance films may be obtained by using nanocomposite particles as the building blocks for the films. These are either polymer-polymer or polymer-inorganic nanocomposites. The latter type often includes a clay or silica particle within a latex particle and show good potential in producing tough, optically transparent, scratch-resistant coatings.

The final film must be continuous. i.e. crack-free. This work is a process model predicting the environmental conditions for which a given suspension will form a crack-free composite film. The model is an extension of a previous model for polymer colloids without inclusions [1,2]. This minimum film formation temperature (MFFT) depends on both the polymer and inclusion properties, with the most conveniently controlled process parameter during manufacturing being the volume fraction of silica within the polymer.

The model is mostly analytical with the final ODEs solved numerically. The inclusions are assumed to be rigid relative to a linear viscoelastic incompressible polymer. The particles and inclusions are assumed to be monodisperse and each particle incorporates one inclusion that remains centrally located within the particle. The inclusion-particle volume fractions studied is up to 10%. The major terms arising in the extended model are the interfacial normal stress and shear stress which are assumed to be functions of the average material (i) strain, and (ii) strain rate. Interestingly, the model predicts that surface tension between the polymer and inclusion has no effect on film formation time, and thus has no influence on the MFFT. The process is controlled by a dimensionless group that includes the interfacial shear stress, inclusion loading and inclusion aspect ratio.

References:

[1] A.F. Routh and W.B. Russel; *Langmuir*, **1999**. *15*, 7762-7773.

[2] A.F. Routh and W.B. Russel; *Langmuir*, **2001**. *17*, 7446-7447.