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Delicate Polymer Nanocomposite Structures

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Delicate polymer structures such as films, fibres, and foams containing nanoparticles are of enormous scientific and economic interest due to the potential of improving the resulting physical and mechanical properties of components which cannot be modified using conventional reinforcements. However, the successful development and industrial implementation of such novel materials pose unique challenges. The nanoscale fillers not only impact the resulting properties of the polymer structure but can also have significant influences on the processing behaviour and resulting matrix morphology.

The manufacturing of polymer nanocomposites usually consists of two steps: the compounding of a nanocomposite and the subsequent melt-forming process such as injection-moulding. A primary concern is the achievement of a polymer nanocomposite containing homogeneously distributed and well-dispersed nanoparticles. The dispersion of nanoparticles especially depends on a magnitude of processing parameters, e.g. shear rate and processing temperature, as well as on the selection of appropriate materials. The subsequent forming behaviour is also influenced by the dispersion of the nanoparticles as well as their specific geometry and surface properties.

The present article highlights the potential of using nanoscale reinforcements to improve both the processing behaviour of polymers as well as the solid-state properties of delicate structures where conventional reinforcements cannot physically be accommodated. For example, the interactions between a given polymer melt and the nanoscale filler during processing exhibiting significant elongational flow can lead to drastic changes in the resulting matrix microstructure, an effect that needs to be considered in order to correctly interpret the nanocomposite performance. In addition, the nanoscale constituents offer a unique opportunity to tailor the melt rheological properties of polymer melts for applications such as fibre-spinning and foaming.