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SHEAR-INDUCED STRUCTURE BUILDUP IN POLYMER-CLAY NANOCOMPOSITES

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Clay is frequently added to polymers to improve their flame retardancy, barrier properties, strength and stiffness. Due to the large aspect ratio of exfoliated clay, material performance can be enhanced at much lower filler volume fractions as compared to conventional fillers. However, the rheology and properties of these nanocomposites are very sensitive to the particulate microstructure. The generated microstructure not only depends on the size, shape and volume fraction of the particles and the interparticle forces, but the shear history can also have a tremendous effect. In the present work, structure buildup in polymer-clay nanocomposites is studied and compared under quiescent conditions, during weak shear flow and for more complex flow protocols. Nanocomposites with different clay concentrations have been prepared by dispersing organically modified bentonite clay in a polydimethylsiloxane matrix by means of solution mixing. The buildup kinetics of the clay network, after breakdown in a strong shear flow, have been probed by means of rheology. Applying a weak shear flow for a limited time after structural breakdown can significantly increase the final modulus of the clay network and decrease its critical strain as compared to clay samples for which the flow was arrested directly after structural breakdown. Shear steps generating a strain on the order of 1 are already effective, suggesting effects of reorientation of the clay platelets. In addition, the shear clearly affects the generated network structure, as evidenced by a lowering of the percolation threshold. If the low shear rate is continued for a longer time, a drastic acceleration of the recovery of the moduli is observed, followed by a structural reorganization or breakdown at longer time scales, that causes the moduli to drop again. Finally, structure buildup during large amplitude oscillatory shear flow and in flow protocols with alternating rotation directions has also been investigated.