Aggregation of Carbon Nanotubes in a Semi-Dilute Suspension

Moreira Ludovic, Fulchiron René, Seytre Gerard, Marceau Sandrine, Dubois Philippe, Cassagnau Philippe

Multiwall carbon nanotubes (MWNT) aggregation and de-aggregation mechanisms for semi-dilute suspensions (Phi<0.5 %) in low viscosity PDMS matrix were investigated. Both dynamic shear modulus and electrical conductivity measurements were performed. Especially, the effect of the total applied strain was scrutinized. First, from low strain measurements in the linear viscoelasticity domain, the complex shear modulus gives evidence for a second terminal relaxation zone at low frequencies which can be related to the Brownian motions of the dispersed nanotubes embedded by the surrounding ones. However, an additional slowing of the rotary diffusion for concentrations higher than 0.3% was obtained. This critical concentration is much lower than this deduced from the Doi-Edwards theory of rigid rod dynamics which predicts the transition between semi-dilute and the concentrated isotropic regimes near 2%. This deviation was explained by a clustering phenomenon of MWNTs. Therefore, the MWNTs aggregation mechanism was more deeply studied from simultaneous time resolved measurements of electrical conductivity and dynamic shear modulus for a concentration of nanotubes (phi=0.2 %). The material was subjected to different strain magnitudes. Hence, after a non-linear compressive deformation, it was shown that the kinetics of MWNT aggregation strongly depends on the amplitude of the dynamic shear deformation. Actually, the kinetics of aggregation increases with increasing the deformation. However, above a critical deformation (60%), the equilibrium value of the storage modulus and electrical conductivity decreases with increasing the deformation. It was then concluded that low shear deformations enhance an aggregation mechanism, but these aggregates break down at high shear, forming small aggregates with less entanglements. Furthermore, this phenomenon of MWNT cluster aggregation was also highlighted by optical microscopy.