Influence of thermo-rheological history on carbon nanotube composite melts: Combined rheo-electrical experiments

Ingo Alig, Dirk Lellinger, Tetyana Skipa*

Deutsches Kunststoff-Institut - Darmstadt - Germany

Although, carbon nanotube (CNT)-polymer composites are commercially available a major restraint in broad market acceptance is the wide variations in electrical conductivity as function of processing conditions. The tremendous influence of processing conditions on the electrical conductivity has been demonstrated by in-line measurements during extrusion [1,2] and mould injection [3]. In order to achieve a deeper understanding of the influence of thermo-rheological prehistory on electrical and mechanical properties systematic rheo-electrical experiments have been performed in the CNT-composite melts [4-6]. Electrical conductivity and complex shear modulus (G', G'') were measured simultaneously after transient shear, during quasi-steady shear and in the quiescent melt. The time-evolution of shear modulus, viscosity and conductivity under shear were found to depend strongly on the initial state of CNT agglomeration. Both, shear induced destruction and formation of the filler network was detected. Under steady flow the electrical and mechanical properties approach stationary values, representing a "dynamic equilibrium" of the filler network. Furthermore, is has been shown that the mechanisms for charge carrier transport and viscoelasticity are different. The findings were described by a model combining the interplay of destruction and reformation of the filler network under shear. The model has been applied for FEM simulation of mould injection. [1] Alig I., Lellinger D., Dudkin, S., Pötschke, P., Polymer 48 (2007) 1020. [2] Alig I., Lellinger D., Engel M., Skipa T., Pötschke, P., Polymer 49 (2008) 1902. [3] Lellinger, L., Xu D., T. Skipa, Alig I., Phys. Stat. Sol. (b) 245 (2008) 2268. [4] Alig I., T. Skipa, Lellinger, M. Engel, S., Pötschke, P., Phys. Stat. Sol. (b) 244 (2007) 4223. [5] Alig I., Skipa T., Lellinger D., Pötschke P. Polymer 49, (2008), 3524. [6] Skipa T., Lellinger D., Saphiannikova M., Alig I., Polymer 50 (2009), DOI: 0.1016/j.polymer.2009