THE EVALUATION OF MICROSTRUCTURE EVOLUTION IN POLYETHYLENE/ORGANOCLAY NANOCOMPOSITE FILMS VIA RHEOLOGICAL MEASUREMENTS

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The aim of this work was to study the relationship between the microstructure obtained in polyethylene (LLDPE)/organoclay nanocomposite cast films and linear/nonlinear viscoelastic behavior. The nanocomosite samples with the same organoclay (Cloisite 15A) content (5%) but varying in elongation rate with compatibilizer (Polyethylene-g-Maleated Anhydride) were considered. All the mixed samples were prepared by melt compounding using a twin screw extruder and the films were produced by single screw extruder equipped with a slit die and a drawing device. XRD patterns and the melt linear viscoelastic results were evident to a highly intercalated morphology for the compatibilized nanocomposite samples. To evaluate the contribution of nanoclay flow-induced orientation to the total stress overshoot due to microstructure evolved through flow fields, we utilized multi-step stress growth tests. In order to prevent the 3-D network reformation and measure only the stress contribution of clay platelets rotation, right after imposing rotational shears (with different rates), we applied the same shear rate but in opposite direction. To gain the shear-flow induced clay orientation overshoot extent and steady state onset time, we divided these values, obtained in the second step, to 2 because they were nearly due to a 2-time rotation of clay platelets. By comparing the resulted values to the first step shear growth tests, it was found that in the shear flow, nearly 70% of the stress overshoot shown by the nanocomposite samples is due to the 3-D network breaking contribution and the rest is related to tactoid and/or platelet orientation. It was also found that the time to reach the steady state (steady state onset time) can mostly be related to nanoclay platelets alignment. By considering the shear flow results, we were able to evaluate the nanoclay orientation in different elongation rates. We evidenced a decrease in steady state onset time for drawn films in comparison to mixed samples that was a proof of nanoclay orientation through extensional flow. We also adopted annealing periods on drawn films to make aligned samples with reformed 3-D network. To do this, we implemented 3000-second annealing periods in melt state for making networks reformed without considerably changing the state of clay orientation since we knew that it takes more than 10000 s for a large number of clay platelets to get disoriented. After annealing, we evidenced a 50% restructuring showing the same contribution for 3-D network breaking via elongational flows to the overall stress overshoot. By using the proposed method and quantitatively comparing the microstructures resulted via shear and elongation flows, we found that even though we evidenced nanoclay orientation in only big enough shear rates (more than 0.5 1/s), the clay alignment always took place through extensional flows in all elongation rates.