

Kinetic Study Of The Crystallization Of LLDPE And Wax In LLDPE/wax Phase-change Blends Used For Thermal Energy Storage

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Abstract

Phase-change materials are used to store and release energy through phase changes, be it melting and solidification processes or solid state phase transitions. Among a large number of phase-change materials are paraffin waxes that store and release large amounts of thermal energy through melting and solidification. Since molten wax has a low viscosity, it is important to contain the wax in some medium. A lot of research has gone into the preparation and characterization of immiscible polymer/wax blends in which the wax crystallizes separately in the amorphous phase of the polymer. These wax crystals can then melt and solidify without affecting the polymer, which should have a significantly higher melting temperature than the wax. It is, however, possible for some of the wax to co-crystallize with the polymer, in which case this wax fraction will not be available for thermal energy storage, making the system less effective as a phase-change blend.

The purpose of the presented research is to study self-nucleation (SN), SSA thermal fractionation, isothermal crystallization kinetics and the morphology of each of the constituents of LLDPE/wax blends as a function of composition. SN was performed in order to determine the ideal self-nucleation temperature ($T_s(\text{ideal})$) for thermal fractionation, which is the temperature that causes maximum SN without any annealing. It was performed on pure LLDPE, since this is the blend component that melts at a higher temperature ($T_m = 124\text{ }^\circ\text{C}$). For this particular LLDPE $T_s(\text{ideal})$ was $123\text{ }^\circ\text{C}$. Thermal fractionation was performed using successive self-nucleation and annealing (SSA) in order to observe whether there is possible co-crystallization or phase segregation between the components in the blend. SSA is very sensitive to branches or any other defect that interrupts the methylene linear sequence which crystallizes. The alpha olefin in LLDPE is a defect since it introduces a branch point, and we observed several melting peaks after thermal fractionation. Soft paraffin wax is made of a polydisperse collection of linear chains. It is not sensitive to fractionation, since the technique and especially the fractionation conditions are rather insensitive to molecular weight differences. This is an indication that soft paraffin wax is essentially linear and is not susceptible to thermal fractionation. The results obtained by SSA indicate that the wax acts as a solvent for LLDPE inducing a 'dilution effect' without co-crystallization. However, the amount of wax crystals in the blend is clearly less than what is expected from the amount of wax initially mixed into the LLDPE, which we explained as being the result of individual wax chains being trapped in the LLDPE matrix during LLDPE crystallization. This presentation reports on the results of crystallization kinetics and morphology studies on this system.