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Rheology Studies of the Solutions of Polyethylene with Chemical and Physical Blowing Agents in an Injection Molding Machine

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An in-line capillary rheometer nozzle equipped to a conventional reciprocating 55- tonne injection molding machine was used to study the viscosity of single phase low density polyethylene (LDPE)/chemical blowing agent (CBA) and physical blowing agent (PBA) solutions. Masterbatch pellets of chemical blowing agents (endothermic and exothermic type) were dry mixed with the polymer, in the range of 0 to 5 wt%. Physical blowing agent (nitrogen) was directly injected into a specially designed injection nozzle composed of static mixing elements (SMX type) using a syringe pump. The steady shear viscosity of LDPE with chemical blowing agents was measured for shear rates ranging from 170 to 200,000 s^{-1} and under pressure conditions up to 36 MPa. The shear viscosity of LDPE with nitrogen was measured for shear rates ranging from 800 to 16,000 s^{-1} and under pressure conditions up to 10 MPa. In order to determine the pressure effect and the changesof the free volume during the experimental conditions, pvT measurements had been done. Experimental results indicate that the viscosity of these LDPE/BA solutions was sensitive to shear rate, melt temperature, melt pressure and blowing agent (BA) concentration. The viscosity of each solution revealed a reduction dependent on concentration of the blowing agent and melt pressure. Based on the pvT behavior of the pure LDPE, a model based on a simplified Cross-Carreau model and the free volume concept was proposed to estimate the viscosity reduction results with the addition of blowing agent. The viscoelastic scaling method in this paper, employing a concentration-dependent and pressure-dependent shift factors to scale both viscosity and shear rate, was successfully applied to collapse the viscosity data to a master curve at each temperature.