

Feature Project

Supercritical Fluid Assisted Polymer Blending

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Polymer blending is greatly influenced by the compatibility between individual polymers. Blending often involves components with vastly different melt viscosities and interfacial tensions. Thermal and mechanical behavior can be enhanced via polymer blending. The great majority of polymer blends are immiscible and controlling blend morphology can optimize mechanical properties. Mixing that occurs in polymer compounders like twin screw extruders can greatly affect the final product performance. Supercritical carbon dioxide can be added to melts as a processing aid to promote effective polymer blending. A blend system of a high viscosity polymethylmethacrylate (PMMA) and low viscosity polystyrene is analyzed in this work.

Adding supercritical carbon dioxide to polymer melts can lower the melt viscosities. This phenomenon primarily occurs by two mechanisms. First, the CO₂ adsorbs between the polymer chains, causing a decrease in chain entanglement and an increase in free volume. Second, the CO₂ acts as a 'molecular lubricant' that (along with the first effect) reduces the viscosity and perhaps the surface tension of the melt. Figure 1 shows a viscosity curve for PMMA at 200°C with different

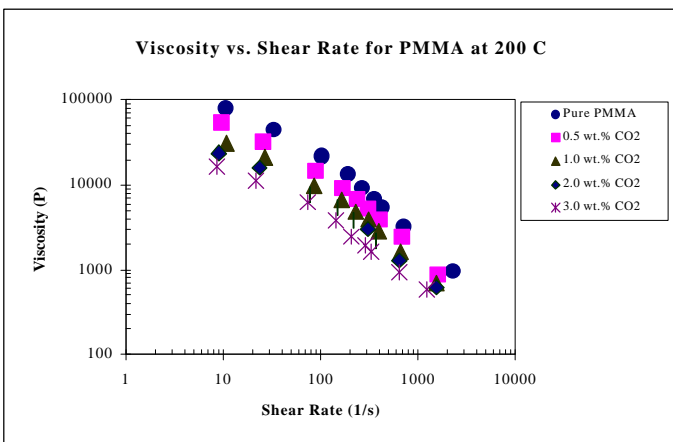


Figure 1. Viscosity curve for PMMA at 200°C with different CO₂ contents

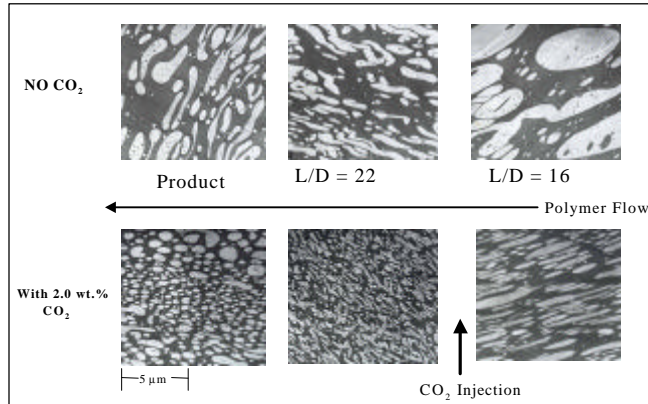


Figure 2. Morphology development of a 50/50 blend of PMMA (white) and polystyrene (dark) with and without CO₂.

amounts of CO₂. A reduction in melt viscosity of about 70% is observed. A similar phenomenon occurs with polystyrene, however a reduction of only about 40-50% is observed. By lowering the viscosity of the PMMA minor phase more than that of the polystyrene, more effective blending results.

A 50/50 blend of PMMA and polystyrene was prepared using a Leistritz ZSE-27 twin screw extruder with an L/D of 40. The extruder's gas injection port (L/D 16.8) was operated at a screw speed of 100 RPM in co-rotating mode. The influence of CO₂ on polymer blend morphology is shown in

Figures 2 and 3. The domain size of the PMMA minor phase is reduced with the addition of CO₂. The reduction in size occurs rapidly near the gas injection zone. Additional mixing along the length of the extruder does

not further reduce the domain size of

the PMMA. Evidence of coalescence is seen in the slight increase of size as the blend is further processed. Fig. 3 compares the morphology development of the 50/50 PMMA/polystyrene blend with and without CO₂. The blending mechanism is not affected, but the minimum size of the PMMA phase is substantially lowered by the addition of CO₂.

Other blend systems will be studied in the future, such as nylon 6/polypropylene, rubber compounds, and high and low molecular weight polyethylenes. The effect of surface tension will be examined under high temperature and pressure. A means of stabilizing blend morphology will be conducted by studying reactive blending, addition of block co-polymers, and the use of additives such as nano-clay materials. The arrangement of screw elements can be designed to optimize processes. Finally, thermally sensitive polymers can be processed at lower temperatures with the addition of CO₂.

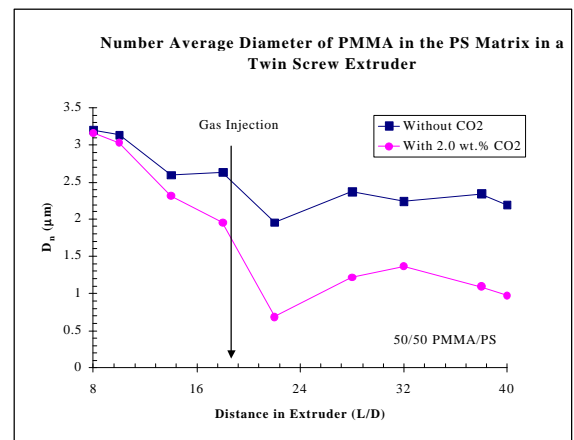


Figure 3. Domain size of PMMA along extruder length with and without CO₂