Thermophysical Properties of Polymer Melts with Dissolved Blowing Agents by Optical Techniques

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Thermoplastic foams are used in a broad variety of technical applications and are produced by injection molding or extrusion of polymer melts with physical or chemical blowing agents. In such processes, the resulting macroscopic structure of the foam and, thus, its properties, are governed by the nucleation and bubble growth kinetics, which are both strongly influenced by the thermophysical properties of the blowing-agent-loaded polymer melt. In particular, the Fick diffusion coefficient D_{11} and the interfacial tension σ in corresponding mixtures are properties which strongly influence the mass transfer from the bulk of the polymer melt into the gas nuclei or bubble. For a comprehensive characterization of corresponding mixtures, also knowledge about their composition at phase equilibrium is necessary. To date, reliable thermophysical property data at process-relevant conditions are scarce, which hinders the development of sound modeling approaches for the whole production process up to the resulting foam properties.

In the present work, mixtures of polystyrene or polypropylene melts with the dissolved blowing agents nitrogen or carbon dioxide at mass fractions up to about 0.003 or 0.05 are characterized at temperatures up to 533 K by optical techniques. In contrast to conventional techniques that require macroscopic gradients, dynamic light scattering is applied for the determination of D_{11} at macroscopic thermodynamic equilibrium. For the investigation of the gas solubility w_i, the isochoric-saturation method is employed. The required information on volume swelling of the melt upon saturation is determined from polymer droplets by axisymmetric drop shape analysis and further used to calculate the saturated-melt density. From the contour of the droplet, also information about σ is deduced. In parallel, Raman spectroscopy is applied to identify thermal degradation of the polymer melts. Furthermore, its calibration with help of w_i data enables the contactless determination of blowing-agent concentration in corresponding polymer melts with unknown composition.