Porosity and Cell Size of CO2 Blown Polystyrene Foams: Experiments and Modelling.

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Porosity and cell size of CO_2 blown polystyrene foams: experiments and modelling

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Polymer foaming with CO_2 is a promising area of research with applications already commercialized and more on the horizon. In batch experiments, polymer absorbs supercritical CO_2 at the temperature adjusted above its glass transition temperature, Tg, until saturation is reached. Rapid depressurization is then applied, causing gas supersaturation and allowing cell formation. In our experiments, polystyrene films of the thickness of hundreds of micrometers up to a few milimeters were exposed to supercritical CO_2 at saturation conditions in the range of 40-100 °C and 18-28 MPa. Additional experiments were conducted with polystyrene modified with light hydrocarbons. The cell size distribution and porosity of foams were measured and related to the saturation conditions and depressurization time.

The polymer foaming is an interdisciplinary field reaching to polymer rheology, mass transport, thermodynamics, and nucleation. Computational approaches enable insight into foaming phenomena, while experimental techniques are coming that can provide reliable data. Most of theoretical effort is focused on phenomena of cell nucleation and cell growth.[1-3] Less attention has been paid to foam vitrification.[4] As the temperature of CO_2 decreases by its expansion, the polymer in tight contact with growing cells is cooled down until Tg is reached and polymer vitrification occurs. The cell size and foam porosity are fixed at this moment and can be measured after the depressurization is finished. CO_2 solubility in the polymer and Tg depression under the effect of CO_2 play an important role in the process.

While the cell size is related to the solvent solubility in the polymer, in respect to the foam porosity we propose a novel approach considering the changes in the temperature of the mixture in the course of CO_2 expansion due to the Joule-Thomson effect. Heat balance equations including heat transfer over the film surface were integrated to the time when the decreases to Tg. (The necessary properties of CO_2 were available on the NIST web pages and the properties of polystyrene mixtures with CO_2 necessary for the calculations were published in recent research papers.) The estimates were compared with experimental results.

References

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