MICRO- AND NANOCELLULAR FOAMS

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Polymer foams can have various morphologies: open-, closed- and the combination of open- and closed-cell structures. This variety enables a wide range of applications. Mastering the control of the foaming process and thus, the preparation of desired foam morphologies, is the key to the production of materials with improved properties and furthermore, it opens the possibility to use foams in various innovative ways. In this work, we focused on micro- and nano-cellular foams, which should have improved heat insulation properties. Their cell sizes are more than 10 times smaller than of the commercial “macro-cellular” foams, while the porosity is maintained.

We experimentally studied i) CO_2 high-pressure (PIF) and ii) laser induced foaming (LIF), and iii) thermally induced phase separation (TIPS). We placed emphasis on morphology analysis by using various methods and in-house developed advanced image analysis tools [1]. For the morphology analysis, we employed SEM, AFM, X-ray micro-tomography, He pycnometer and Hg porosimeter. For PIF of polystyrene (PS), we identified the process limitation which causes poor porosities [2] and offered a possible solution by using of co-blowing agents [3]. Preliminarily experiments showed that LIF may help to better understand early stages of foaming. For TIPS, we validated a model describing the morphogenesis of microstructured PS [4, 5]. The morphologies were predicted by the Cahn-Hilliard approach with the only input being the Flory-Huggins lattice model. The model predicts qualitatively and quantitively correct length scales of close-cell morphologies for a variety of system compositions and temperatures in 2D and 3D using only one fitting parameter. By careful optimizations, we prepared PS foams with various morphologies and with the cell sizes below 10 μm and porosities higher than 90 %. In future, we want to extend our studies to other polymer-solvent systems and thus, to prepare unique foamy materials.

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