Image processing procedures for quantification of bubble germ growth/collapse in synthesized highly-porous polymer matrices

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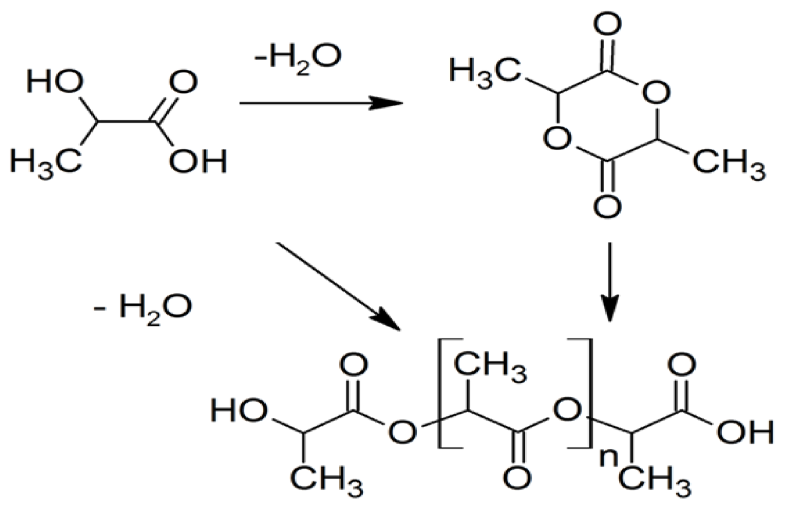
Materials

Polylactic acid (PLA) is biodegradable, biocompatible, and renewable thermoplastic polyester which is mainly derived from corn starch. The monomer lactic acid (LA) of PLA is derived from natural sources. PLA is a very useful material to be used as a replacement for petroleum-based polymers because of its good mechanical properties and good processability. PLA, however, is a hydrophobic polymer and has poor toughness, slow degradation rate, less reactive side chain groups, and low thermal stability. It can be readily fabricated with good biocompatibility and thermal plasticity. Compared to other biodegradable polyesters, PLA is the highest potential biopolymer due to its abundant availability and low cost. Highly porous polymeric matrices can be obtained by carbon dioxide supercritical fluid saturation of PLA.

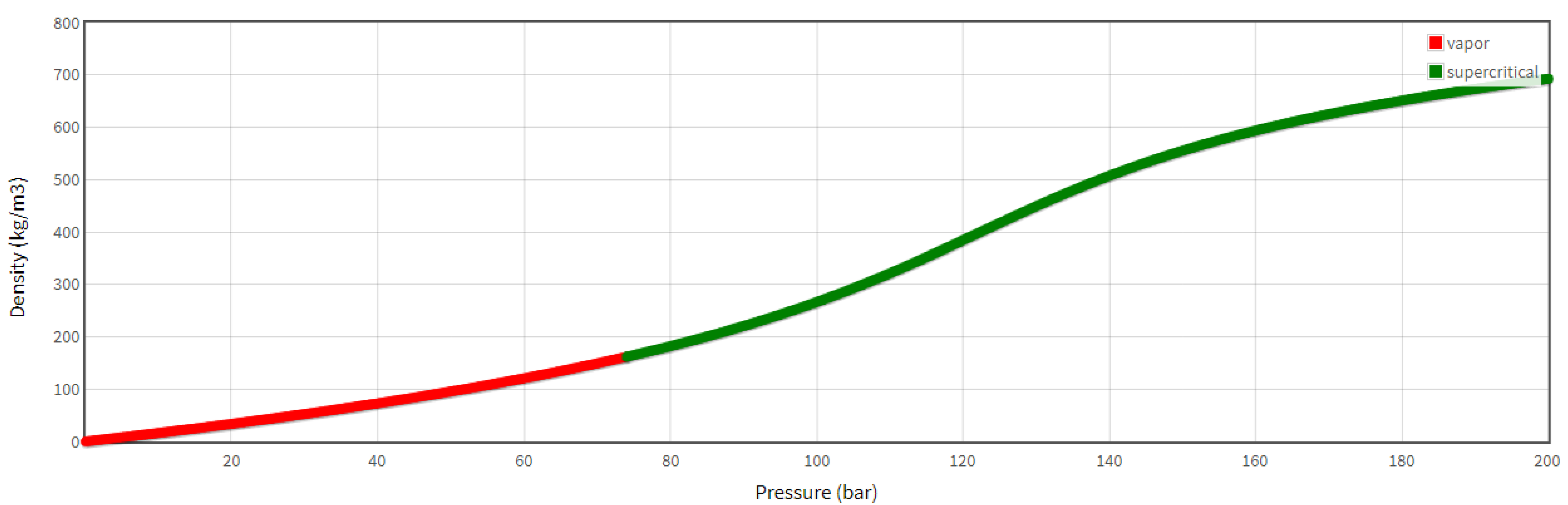


The monomer lactic acid and polymer polylactic acid

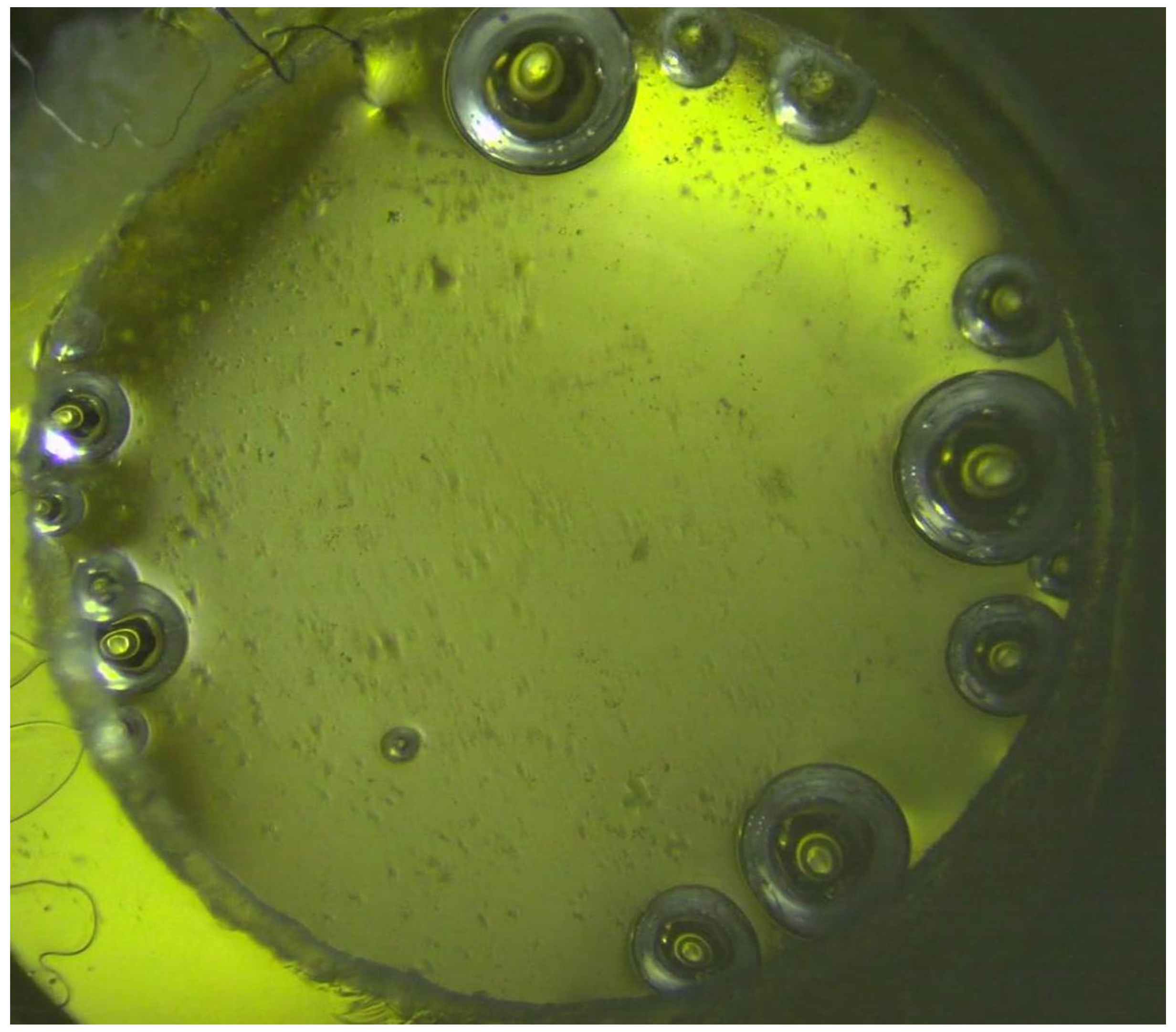
Supercritical carbon dioxide

The gas-like viscosity and the liquid-like density, the very low surface tension and high wettability of CO_2 are the key characteristics that allow the process to be tuned to the application. There is a huge interest in the design and development of advanced polymeric materials using clean and foaming technologies. During this process, the carbon dioxide is pumped to a tank (extractor) containing the raw materials that are to be prepared. The carbon dioxide in a gaseous state extracts the desired particles from the raw material and is further directed to a separation vessel. The useful particles remain on the bottom of the vessel for extraction while the carbon dioxide and the solvent are recycled. Foaming process control allows to set parameters of highly porous polymeric matrices depending on the external conditions.

Isothermal Properties for Carbon dioxide for T = 338 K

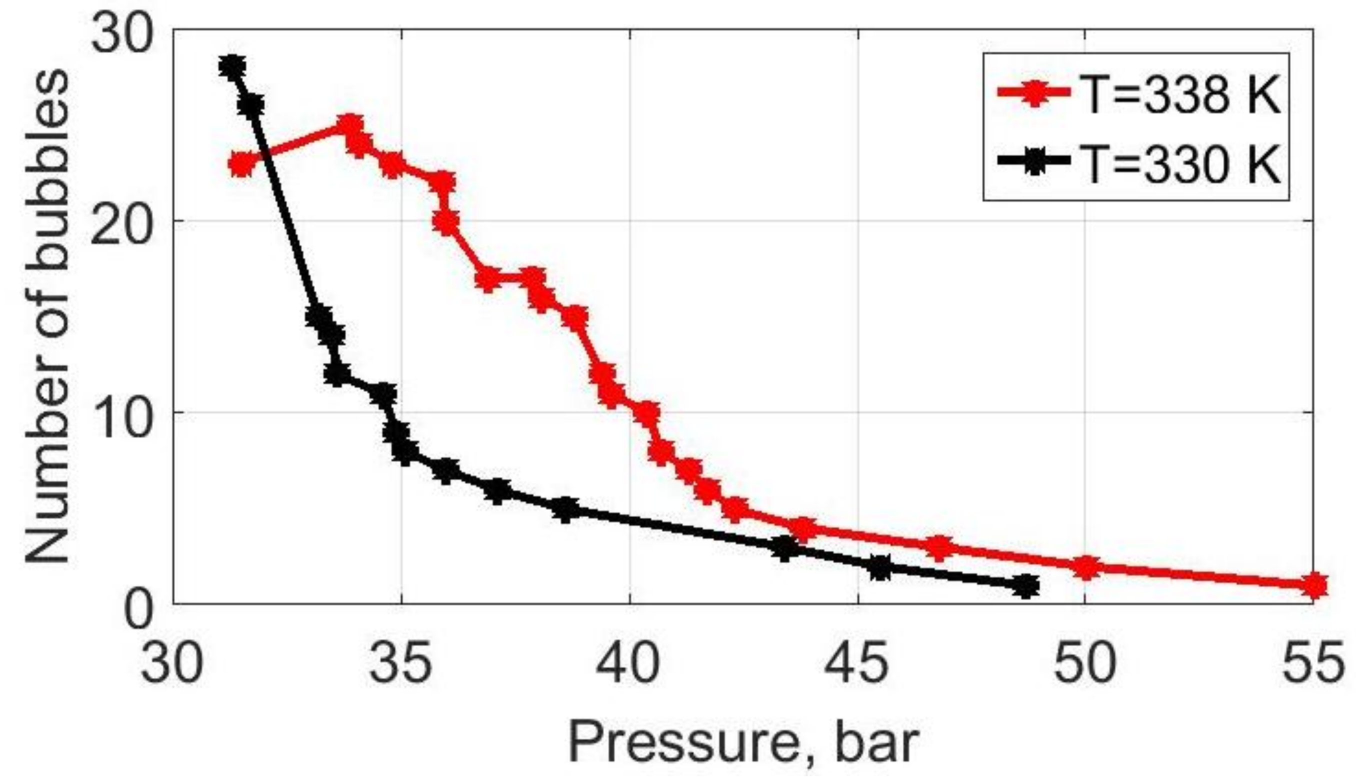


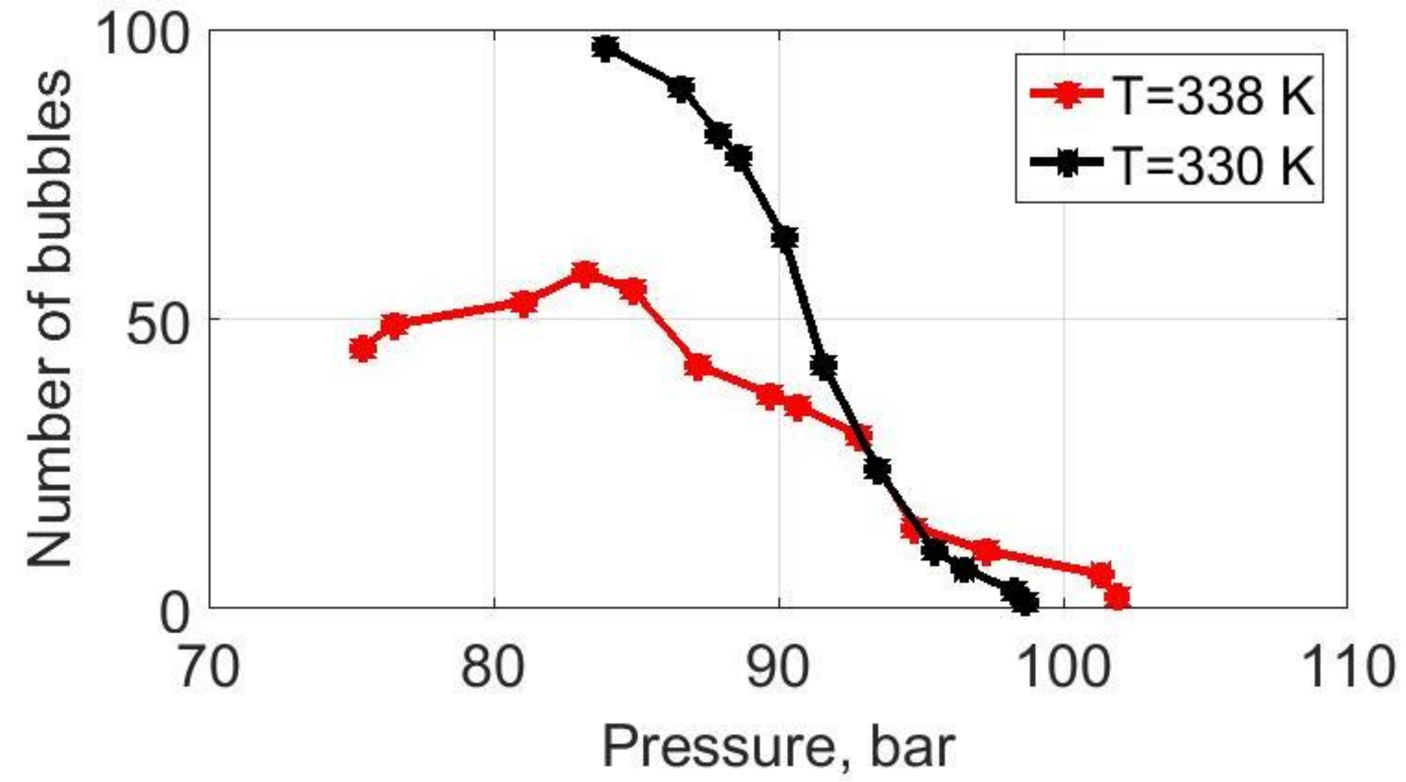
The process of nucleation of single pore germs in plasticized polymers.



Nucleation in plasticized polymers as the first stage of temperature- or pressure-mediated synthesis of highly porous polymeric matrices is the key factor affecting the structural properties of synthesized matrices. Accordingly, quantification of growth/collapse processes in the ensembles of pore germs during their evolution is of importance for the characterization and control of the morphological and functional properties of matrices. Additionally, analysis of the growth/collapse kinetics for single pore germs allows for evaluation of the physical-chemical properties (the surface tension, the mass fraction of plasticizing agent in the polymer) depending on the external conditions.

The analysis of the growth/collapse kinetics for single pore germs in polylactide saturated by supercritical carbon dioxide





Conclusions

There is estimation of kinetics of the nucleation, growth and collapse processes for single pore germs in polylactide saturated by supercritical carbon dioxide by pressure decrease by different external conditions. These data maintain information about thermophysical properties of polylactides what can be used to control of parameters of highly porous polymeric matrices.

The robust image analysis procedures for quantitative description of the pore evolution on the base of video-reflectometry data are discussed. Experimental results obtained in the case of supercritical/subcritical foaming of polylactides are presented.

Acknowledgement

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