

Supercritical carbon dioxide aided extrusion foaming of biodegradable polymers

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In my work, polylactic acid (PLA) foams, as potential green replacements for polymeric foams of petrolchemical origin (e g. expanded polystyrene), were investigated.

High porosity microcellular PLA foams were produced by continuous, supercritical carbon dioxide (sc-CO₂) assisted extrusion process. To obtain dense and uniform cell structures, epoxy-functionalized chain extender (CE) and talc were applied. The effect of these additives was investigated on the morphology and mechanical properties of PLA foams.

Four types of PLA mixtures were manufactured containing 2 and 3 wt% of CE and 2 and 4 wt% of talc, respectively. The materials were compounded using a twin-screw extruder (Labtech LTE 26-44) and then pelletized prior to foam extrusion. Supercritical-CO₂-aided melt extrusion was performed on a modular twin-screw extruder (Collin Teach-Line ZK 25T). As physical foaming agent, sc-CO₂ was injected into the extruder using a double syringe pump. When CO₂ is supercritical (over 74 bar and 31 °C), its solubility and diffusivity in PLA increases significantly. CO₂ dissolves in the polymer melt and acts as a plasticizer, that is why lower processing temperatures are applicable.

In my experimental work, the produced PLA foams were comprehensively characterized by morphological (SEM, porosity measurement), thermoanalytical (DSC) and mechanical (compression strength) test methods.

In my experiments, highly porous ($\epsilon > 95\%$) PLA foam structures were obtained (Figure 1). The DSC measurements revealed that the degree of crystallinity increased with porosity. It is likely due to the lower applicable temperature profile and the strain-induced crystallization of the highly expanded PLA material. The addition of CE and talc promoted the formation of uniform cell-structure and this resulted in outstanding compression strength.

It is believed that further chemical or physical modifications, such as reinforcement and flame retardancy, could promote the market penetration of PLA foams in technical application fields as well.

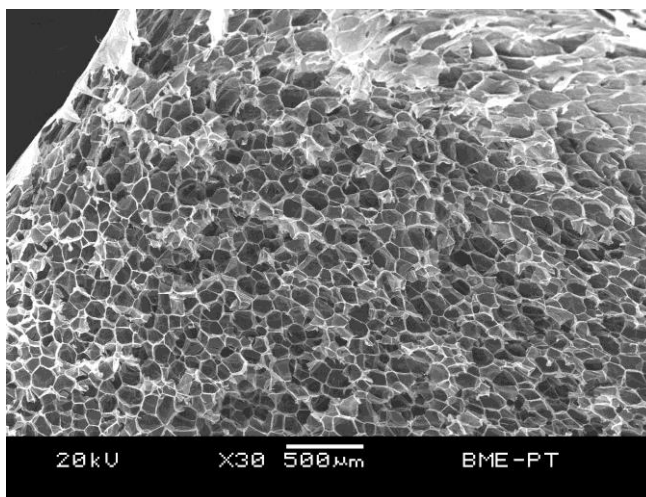


Figure 1: SEM image of chain extender and talc containing PLA foam