Manufacturing of biocomposite foams PLA / Natural fibres

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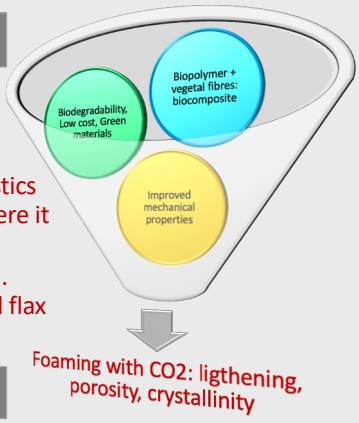
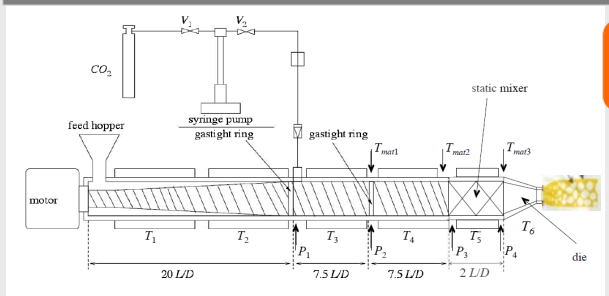
INTRODUCTION AND OBJECTIVE

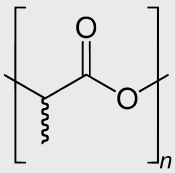
- Foaming is very common process used with polymers to lighten the materials while keeping acceptable mechanical properties.
- Bio-polymer foams are a viable alternative to petrochemical plastics.
- A polymer foaming process using supercritical CO_2 has been developed and applied to thermoplastics [1]. It is implemented via an extrusion process, CO_2 being injected in the barrel of an extruder where it acts as a removable plasticizer before giving its foaming effect through the die exit. It has been successfully applied to biopolymers like PLA (poly-lactic acid) [2] and some nanobiocomposites [3].
- Foaming of PLA reinforced with natural fibres: flour of spruce wood, cellulosic fibres (Arbocel) and flax fibres. The use of PLAs with different properties allows a better understanding of the process.



MATERIALS AND METHODS



Polymers used:
Poly-(lactic acid) : injection & extrusion grade



Extrusion assisted with supercritical CO_2:
Used as a plasticizer inside the extruder and as a physical blowing agent through the die to foam the PLA

Fibres used:
- Wood flour
- Cellulose fibres
- Flax fibres

PLA foam characterization:
- scanning electron microscopy (SEM)
- water pycnometry

RESULTS AND DISCUSSION

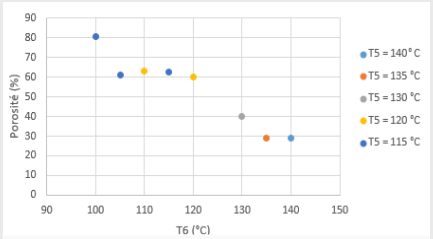


Figure 1. Porosity as a function of die temperature T_6 for different pre-expansion temperature T_5 for PLA mixture extrusion-foaming

With the injection-grade PLA, the process is difficult to control due to the recrystallization of the PLA before the die exit. At low temperature, a heterogeneous foamy structure (porosity >80 %) was obtained. The crystallisation behaviour seems to be the major factor influencing the structure of produced foams. High crystallinity favours the longitudinal expansion rather than the radial expansion of the foam. For the foaming of mixture of both PLA grades (Figure 1), similar morphology but higher porosity was achieved with however less pronounced layered structures at the surface of the extrudate.

When incorporating natural fibres, foams with a porosity up to 80 % could be obtained for the composites with 5 % of the fibres with the smallest dimensions (cellulose and wood flour). However, a skin effect was observed (figure 2). The outer layer of the extrudates exhibited almost no porosity, resulting in a smoother sample surface and a very stable process. In the core of the samples, the foaming remains irregular and several ruptures were observed due to limited interfacial adhesion between the fibres and the PLA matrix. The optimal foaming temperatures are decreased by the presence of the fibres. The foaming process is also impeded by too high fibre size and shape factor. Indeed, for the longer and bigger fibres (wood and flax), porosity below 30 % was obtained and the process stopped due to the extruder obstruction.

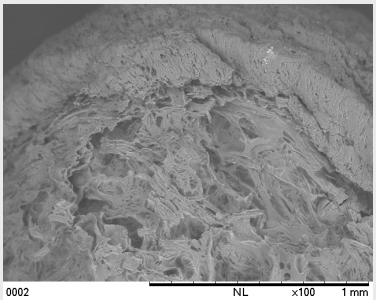


Figure 2. SEM of (PLA + Arbocel) foam cross section exhibiting outer skin and layered structure.

CONCLUSION AND PERSPECTIVES

While pure PLA foaming is a well-mastered process, incorporating natural fibres though promising to control foam structure and physical properties, appears much more difficult. To get polymer biocomposite foams with improved mechanical and end-user properties, process optimization is now required.

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