PHA-rich biomass direct extrusion

INTRODUCTION

Polyhydroxyalcanoates (PHA) are bioplastics that can be produced intracellularly by some bacteria as an energy resource (Figure 1). Activated sludge of wastewater treatment plants can be a good source of mixed microbial cultures with high PHA-accumulating potential. The bacteria has to be fed with volatile fatty acids and, through fermentation, they can produce PHA. The polymer has, then, to be extracted from the cells with an organic solvent, so it can be used in practice (REIS et al., 2020). One of the main techniques for making products out of plastic is called extrusion. For this, pellets of polymer are fed into an extruder (Figure 2), which soften the polymer and transform it into a constant cross-section shape. Extruding the PHA-rich biomass directly and skipping the extraction step would be a good way to avoid the environmental impact caused by the solvent, besides making the material more biodegradable and the process faster and cheaper.

Figure 1: PHA granules inside bacterial cells.

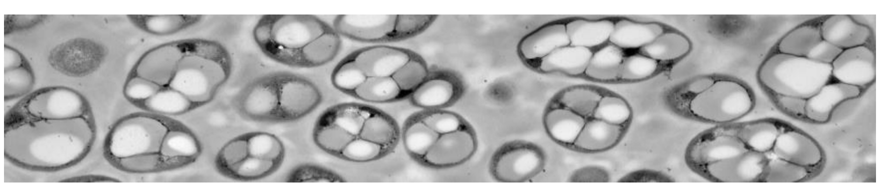
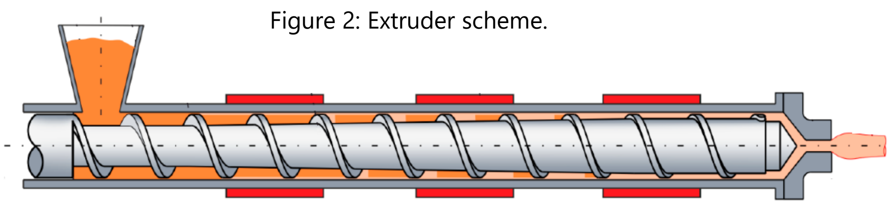


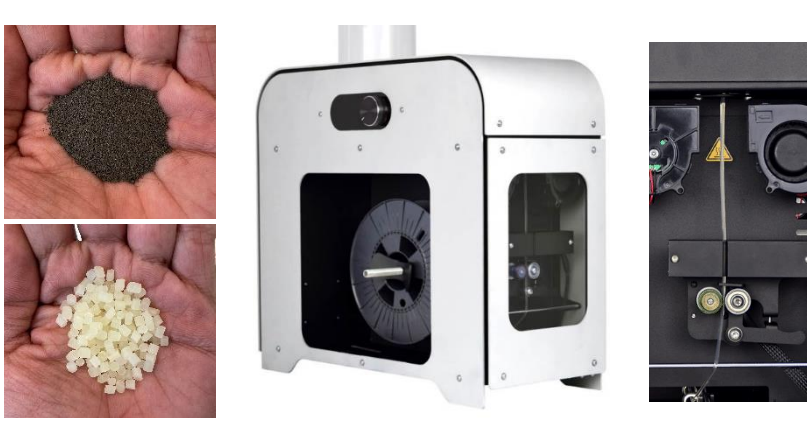
Figure 2: Extruder scheme.



GOALS AND METHODS

This project has the goal of analyzing the possibility of extruding PHA-rich biomass directly. The parameters in the process, such as temperature, extrusion speed and the ratio between the biomass and a commercial polymer (Figure 3) was varied in order to find the best conditions to obtain a homogeneous material that has good chemical and mechanical properties.

Figure 3: Extrusion setup.



RESULTS

The extrusion of pure biomass was not possible. It was necessary to use a commercial PHA (PHBH) as a blend. The best parameters for the extrusion were 130 °C in all the heating areas, 2 rpm extrusion speed, 100% speed of the fans and filament diameter of 2,85 mm. It was possible to reach up to 67% of biomass in the filament, as it can be seen in the filament in Figure 4. More than this, the biomass get stuck inside the extruder.

Figure 4: 67% biomass filament. Extremely heterogeneous and brittle.

Figure 5: 60% biomass filament. Stiff.

Figure 6: 51% biomass filament. Stiff but a little elastic.

Figure 7: 23% biomass filament. Re-extruded. Stiff, more homogeneous and elastic.

It was observed that the higher the amount of biomass in the filament, the more brittle it is. One of the biggest issues in the process was the homogeneity of the filament and predicting the percentage of biomass on it, so it had to be calculated using TGA graphs (Figure 8). After testing all the conditions, it was noticed that the biomass was working as a solid filler for the material, but not really blending to the PHBH. Pelletizing the obtained filament and extruding again made the filament more homogeneous (Figure 7). A stiff plate could be obtained after pressing the pure biomass at high temperatures (Figure 9). This leads to believe that the biomass could be used in other techniques such as compression moulding.

Figure 8: TGA graph. 67% biomass filament.

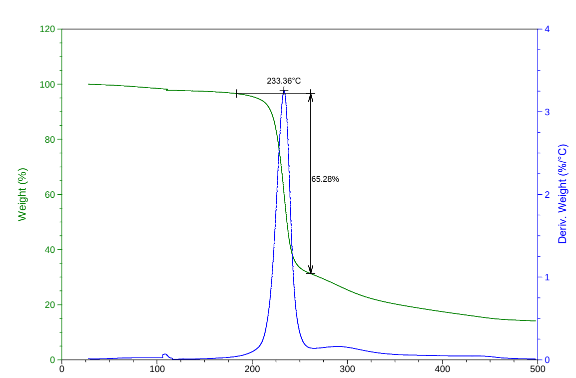


Figure 9: Biomass plate.

REFERENCES

REIS, G. A. DE S. et al. Optimization of green extraction and purification of PHA produced by mixed microbial cultures from sludge. **Water (Switzerland)**, v. 12, n. 4, 1 abr. 2020.

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