DEVELOPMENT OF PP-BASED MATERIALS WITH FLAME RETARDANCE AND THERMAL CONDUCTIVITY PROPERTIES FOR 3D PRINTING

ELEONORA LORENZI[1]

[1]*Department of Applied Science and Technology, Politecnico di Torino, viale Teresa Michel 5, Alessandria, Italy*

Email: eleonora.lorenzi@polito.it

Role: research fellow

Abstract

The aim of this thesis was to determine the 3D printability of polypropylene (PP) formulations functionalized with different fillers, and then study and compare the thermal conductivity and fire-retardant properties of the material processed both with a 3D printer and a conventional compression molding machine. Two different additives were used to obtain the aim, in particular boron nitride (BN) and Cloisite-20A (C-20A). A polypropylene-polyethylene random copolymer (PP COPO) was used as the polymer matrix. At the same time two commercial filaments from Filoalfa®, a thermally conductive PLA-based filament addicted with graphene (Grafylon®3D) and a self-extinguishing filament based on ABS (ABS V0) were used as references.
The work can be divided into four parts. In the first one, samples produced with commercial filaments were studied, from which it easily emerged that 3D printing, compared to compression molding, does not generally bring to a deterioration of material properties and, in some cases, even leads to an improvement.
In the second part, the two PP COPO-based formulations were produced with a twin-screw extruder. To investigate the processability of the materials, and in particular their 3D printability, rheological tests were performed and from the viscosity curves it was observed that the addition of both fillers led to an increase in the non-Newtonian behavior of the material. Consequently, the composites have better 3D printability than the starting PP COPO. It was therefore possible to extrude the two compounds with a single-screw extruder and obtain smooth filaments with a constant diameter and circular section. Characterization by SEM also showed that both fillers were well dispersed and distributed in the polymer matrix.
The third part of the study focused on the combustion behavior of PP COPO/C-20A samples. Results from cone calorimeter tests showed that the addition of Cloisite-20A greatly improved the combustion behavior of PP COPO. However, a more interesting comparison was observed between pressed and 3D printed samples. The latter exhibited slower combustion and significantly lower HRR peak. This indicates that 3D printing improves alignment and arrangement of fillers, resulting in a more compact layer with better barrier properties. The superior properties of 3D printed samples were also observed in UL94 horizontal burning tests, where all ±45 patterned 3D printed samples passed, while none of the pressed samples did.
In the last part, the thermal conductivity properties of PP COPO/BN samples were studied. Hot disk tests showed that the addition of 12% BN increased the thermal conductivity of the polymer matrix. Comparing the results of BN-additivated samples, the 0-90 filling pattern in 3D printed samples resulted in a significant decrease in thermal conductivity values, while ±45 patterned samples had values similar to those of pressed samples. Moreover, light flash tests revealed that the in-plane thermal diffusivity of the material was much higher than the cross-plane diffusivity.
In conclusion, this study demonstrated that it is possible to develop and use functionalized polypropylene filaments for 3D printing, and that 3D printing can yield comparable or even superior properties to traditional compression molding process.