DESIGN AND OPTIMIZATION OF 3D PRINTABLE POLYPROPYLENEBASED MATERIALS

DESIGN AND OPTIMIZATION OF 3D PRINTABLE POLYPROPYLENE-BASED MATERIALS

Arrigo R[1,2], Battegazzore D[1], Bernagozzi G[1], Frache A[1,2]

[1]*Department of Applied Science and Technology, Polytechnic of Turin, Alessandria, Italy*
[2]*National Interuniversity Consortium of Materials Science and Technology (INSTM), Florence, Italy*

Introduction

Material extrusion (MatEx) 3D printing techniques are the most exploited additive manufacturing processes for thermoplastics, being simple and economic in terms of both materials and tools. Nevertheless, the catalog of available thermoplastics is still severely limited, mainly due to the lack of reliable information on the processability of the materials. In this work, we aim developing a deep knowledge about polypropylene, one of the most relevant thermoplastic commodities, focusing on designing and optimizing PP-based formulations fulfilling the requirements to be suitable for MatEx 3D printing.

Material and Methods

Composites based on a PP heterophasic copolymer and different loadings of talc, calcium carbonate, silica and an organo-modified nanoclay were produced using a co-rotating twin screw and characterized through rheological, thermal and mechanical analyses.

Results and Discussion

Firstly, the composition and the processing conditions of the PP-based compounds have been optimized, aiming at achieving the proper thermal and rheological properties for MatEx printability. DSC characterization demonstrated that the introduction of the different types of fillers allowed reducing the melting entalphy of the PP-based systems, hence minimizing the typical high volumetric shrinkage of PP. Besides, the results of the rheological measurements pointed out that the introduction of all the exploited fillers caused the appearance of a yield-stress behavior which is progressively more pronounced as the loading of fillers increases. Furthermore, all investigated composites showed a significant shear thinning behavior at high frequencies. In a previous work we demonstrated that the strictest criterium to classify a polymer as MatEx-printable from a rheological point of view is the occurrence of a yield stress behavior in quasi zero-shear conditions, which guarantees low propensity of the filament to drip after the extrusion and a good shape stability of the extrudate at the exit of the nozzle and during the deposition step. Furthermore, the shear thinning behavior ensures a low viscosity during the extrusion step, hence enhancing the flowability of the material. Therefore, the introduction of the different fillers allowed properly modifying the rheological behavior of PP, helping in ensuring an effective printability of the materials. In the second part of the work, a step-by-step optimisation of the process parameters has been conducted, and the mechanical properties of the printed samples were evaluated.