STAR-BRANCHED POLYAMIDE BY REACTIVE EXTRUSION: FLOW AND MECHANICAL PROPERTIES

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Introduction

Polyamides are engineering polymers applied in several industrial sectors due to their low cost, the high-temperature and chemical resistance, the good mechanical performance and the easy processing. Regarding the last feature, star-shape polyamides, which are formed by linear chains linked to a central core, be able to offer a significant reduction in melt viscosity. However the changes in rheological properties produce other changes in solid-state properties.

The aim of this work is to prepare a new star-shape polyamide (Figure 1) with low melt viscosity and improved mechanical properties to expand the field of application of polyamides. In particular, the effect of the amount of functional agent on solid-state properties was investigated.

Material preparation

Profile temperature, shear rate and feed flow were optimised by design of experiments in order to obtain a star-shape polyamide with 5% of trifunctional agent (5CoPA). Then, this polyamide was used as masterbach to prepare star-shape polyamides with different amounts of functional agent.

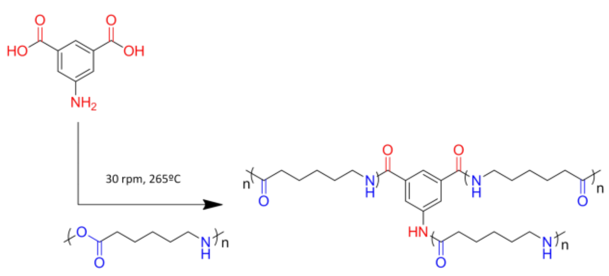

Figure 1. Molecular structure of star-shape polyamide

Rheological properties

The melt flow behaviour of the samples was measured by capillary rheometry and the curves are present in Figure 2. As can be expected, the rise of functional agent causes a significant viscosity drop. In particular, the sample with 5 wt.% of functional agent (5CoPA) presented a viscosity one order of magnitude lower than neat polyamide (PA).

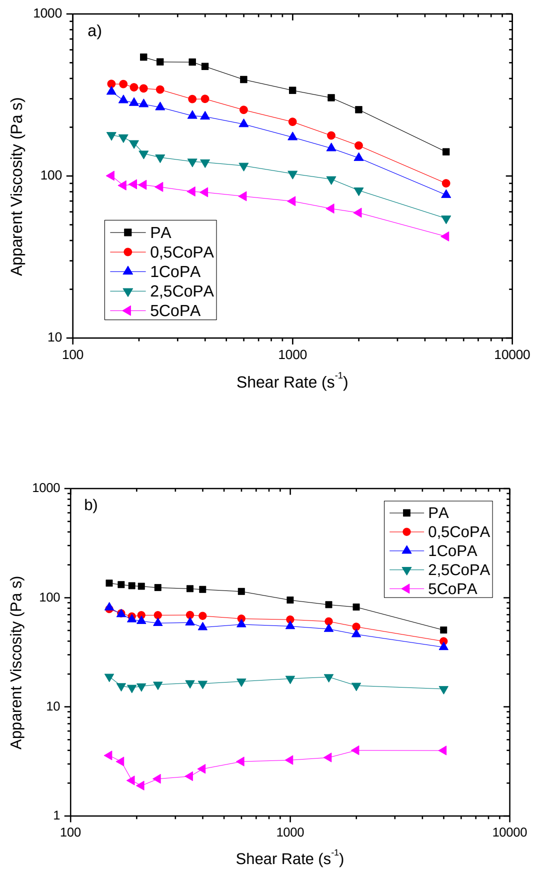

Figure 2. Apparent viscosity of star-shape polyamides by capillarity rheometry versus shear rate: a) 230°C and b) 260°C

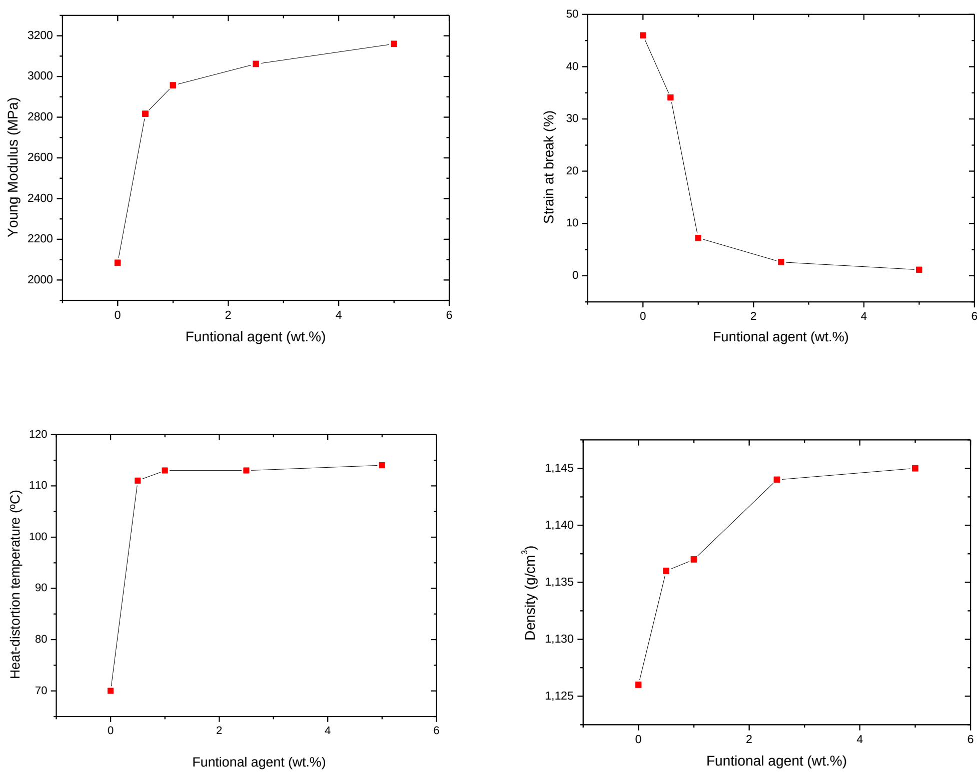

Figure 3. a) Young modulus, b) strain at break c) heat-distortion temperature and d) density versus functional agent content

Mechanical properties

An overview of the mechanical properties of CoPA samples are shown in Figure 3a-c. The first observation is the surprisingly high rise of modulus with low amount of functional agent (Figure 3a). This phenomenon is produced by the increase of rigidity because of the aromatic character of the central core. It is noteworthy that these values are better than the reported using aramid fibre as reinforcement, and similar to composites reinforced with 10 wt.% of glass fibre. However, this increase is associated with a significant loss of toughness (Figure 3b). In this sense, only the samples with amounts <1 wt.% of functional agent were able to keep some deformation during tensile test.

The changes in the macromolecular stiffness also showed important improvements in the service temperatures of the polyamides. Figure 4c evidence the increase of heat-distortion temperature with the percentage of functional agent.

Other important observation to keep in mind is that the increase in density was lower than 2%. This means two important advantages with traditional short glass fibre composites: the first one is the weight reduction and the second one is the decrease in the loss of specific mechanical properties.

Conclusion and scope

Due to the improved rheological and mechanical properties, the studied star-shape polyamides are able to improve processing in two different applications: injection moulding (Figure 4a) and fabrics impregnation (Figure 4b).

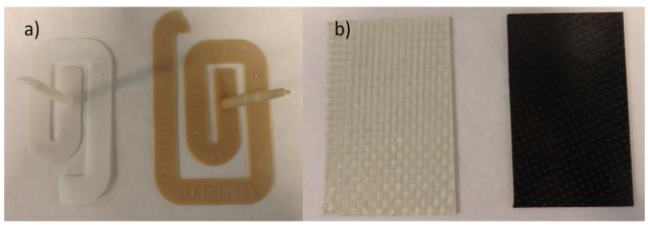

Figure 4. a) Injection moulding tests of PA and 5CoPa using pressure-limit control. b) Structural thermoplastic composites based on glass-fibre and carbon fibre by film-stacking process.

Acknowledgements

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