Melt-spinning of in-situ polymerised composites of ε-caprolactam and graphene monolayers

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In the last years, several reports about functionalised graphene-polymer composites and the fabrication of nano-composite fibres have been reported [1]. However, during the fabrication process of polymeric fibres, the graphene monolayers build micrometre-sized agglomerations acting as defects with the consequence that the mechanical properties of the fibres decrease. In order to solve this problem, a study of melt-spinning of functionalised graphene-fibres by using a self-made piston spinning machine was published recently [2]. We now report the transferability of this approach towards a lab-scale twin-screw micro-compounder with winding velocities up to 100 m/min. Tensile tests are performed showing a significantly enhanced tensile strength of the melt-spun functionalised filaments in comparison to neat polyamide 6 fibres and graphene-modified fibres without functionalisation. Optical microscopy measurements show significantly lower agglomerations of graphene in the functionalised filaments in comparison to melt-spun filaments without any functionalisation of graphene.

Graphene monolayers (AvanGraphene) were purchased from Avanzare Innovacion Tecnologica S.L., La Rioja, Spain, and dispersed into tetrahydrofuran for 1 h at 80 °C, whereby ε-caprolactam was given to the dispersion. After one hour, 6-aminohexanoic acid was added and the temperature was raised to 180 °C for 60 minutes again. After that, the system was heated to 220 °C for 16 h in order to start the ring-opening polymerisation reaction and the functionalisation of the graphene with polyamide 6. The obtained samples were processed to monofilaments by using a twin-screw micro compounder of DSM Xplore N.V., Geleen, Netherlands. Tensile tests showed a tensile strength of 710 MPa for functionalised graphene-PA6 fibres melt-spun with 25 m/min and 183 MPa for the same filaments melt-spun with 100 m/min. These values were about a factor 12.80 and 1.25 higher than the measured tensile strengths for neat PA6 showing that this approach is promising for the fabrication of mechanically strong man-made fibres via functionalisation of graphene.

References

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