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Hot melt centrifugal spinning apparatus for thermoplastic micro- and nano-fibre production

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ABSTRACT

Non-woven textiles are used to fabricate high filtration products such has medical masks. Electrospinning is a common method to produce nonwoven micro- or nanofibres but its low production rate makes it unsuitable for commercial needs. Meltblown, on the other hand, has a high production rate, but also a high energy consumption rate because high heat flow is a requirement to extrude polymer melt. A new method that could answer these issues is centrifugal spinning. Like a cotton candy machine, this method uses high-speed rotation to generate centrifugal force to extrude either polymer solution or melt from small orifices to form the fibres. Using a polymer melt offers the best production potential while bypassing issues with solvent elimination and toxicity at the cost of a more challenging process. The main issue with hot melt centrifugal spinning is to ensure sufficiently high temperatures along the whole pathway of the polymer, from the fusion of the feedstock to the formation of the fibre jets.

In this work, we design a versatile hot melt spinneret with continuous feeding. The rotating (3450 rpm), temperature controls (up to 350ºC), reservoir melts and extrudes the polymer through interchangeable nozzles (Ø1.0 to 0.2 mm) while a suspending funnel above the head inlet is continuously feeding pellets. We have investigated the performance of the system with different feedstocks (PP, PLA or PHB) that are added at approximately 0.463 g/min as a feeding rate with pellet diameter ranging between 1.7 and 6 mm. The fibres are captured by a 66 cm diameter collector and examined with optical and electron microscopy to characterize their morphology and diameter distribution.

The results show that we can obtain fibres with average diameters varying between 700 nm and 10 µm, and reduce defects using continuous feeding to avoid transient extrusion. The results also show that it is easy to produce fibres with multiple polymers, even very viscous melts (melt flow index as low as 2.8 g/10 min).

With these results, we demonstrate a lab-scale prototype that can enable researchers to easily produce micro-nanofibres from various polymers without interference from solvents. This modular design can help to further understand the hot melt centrifugal spinning method and allow exploring unconventional nozzle-free geometries for the formation of fibres.

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