Short and Aligned Fiber filaments for 3D Printed High-Performance Composites

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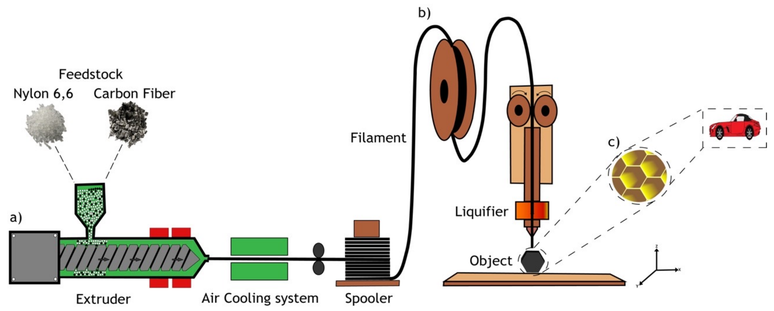
Abstract

Oriented-fibre composites offer favourable properties, such as a high strength-to-weight ratio and controlled anisotropy. However, there are challenges in adopting a feasible method for uniformly distributed, preferentially oriented fibers in polymer reinforcement, especially for highly-loaded composites. This research will focus on extrusion and additive manufacturing with parametric studies (e.g., speed and precision) to produce composite prepregs with enhanced mechanical and thermal behaviour. Fiber alignment will be induced via shear forces during the extrusion and 3D printing processes.

Methodology

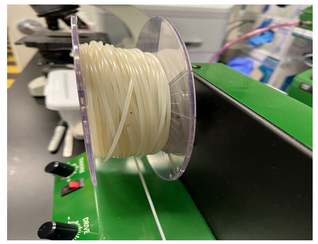
Phase 1 : Extrusion of PA66 and PA66/CF(30%) was done using Filabot EX6 Extruder. Extrusion parameters such as nozzle size, melting temperature, extrusion speed will be considered to develop an optimum combination. Characterization of the produced filaments will be carried out based on their mechanical, thermal using DSC, TGA, DMA and so on.

Phase 2 : The customized filaments is subjected FDM to additively manufacture flexible composites parts after which they will be characterized under the same characterization methods as the filaments. Characterization goals will be used to investigate how the different short fiber alignment affects the final printed part.

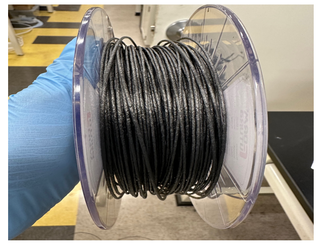


Results

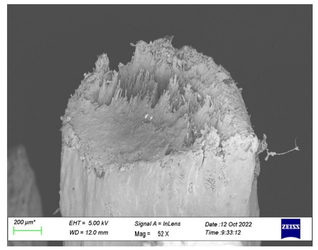
Nylon 6,6

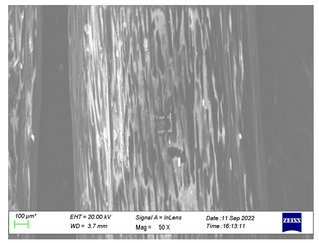


Nylon 6,6 30%CF

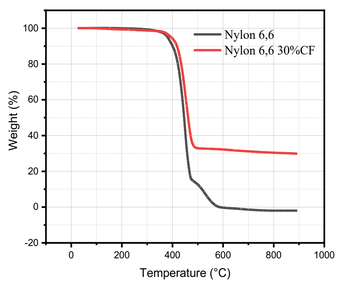


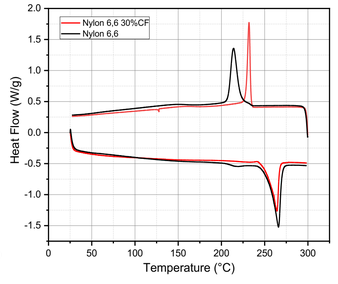
Morphology (Nylon 66/CF)





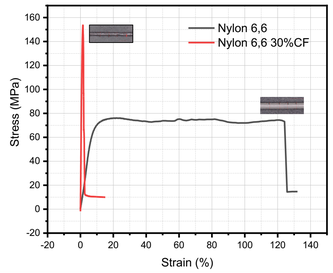
Thermal analysis





Sample	Tm	Enthalpy(Tm)	Tc	Enthalpy(Tc)	Xc(%)
Nylon 6,6	265.9℃	65.215 J/g	214℃	50.79 J/g	34.68
Nylon 6,6 (30%CF)	264.1℃	46.37 J/g	231℃	30.83 J/g	24.66

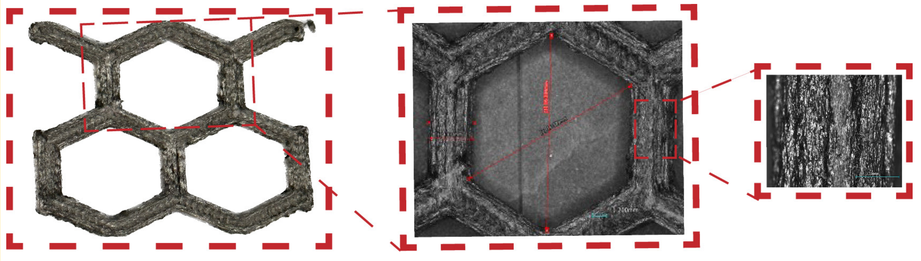
Mechanical analysis



Sample	Youngs Modulus (GPa)	Tensile Strength (MPa)	Toughness (MPa)	Strain (%)
Nylon 6,6 30%CF	11.4 ±2.6	157.63 ± 39.92	2.53 ±1.03	2.28 ± 0.20
Nylon 6,6	1.1 ± 0.20	76.01 ± 14.39	70.3±10.5	120.68 ±15.6

Tensile Strength was done at a gauge length of 10mm with a constant linear strain rate of **30$\mu m/sec$** for nylon 6,6 30%CF and **150$\mu m/sec$** for nylon 6,6.

Honeycomb structure



Future work.

- 3D printing honeycomb with different printing parameters.
- Testing the mechanical properties of the printed part.

Acknowledgements

I would like to thank Dr. Kenan Song and Varun Kumar for their support and guidance during the project. Special thanks to Timothy D. Rooney for this opportunity.

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