Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

Freeform DIW 3D printing of mechanically tunable 2D material-based nanocomposites

Zixin Zhang[1], Changhong Cao[1*]
[1]Department of Mechanical Engineering, McGill University, Montreal, QC, Canada
*changhong.cao@mcgill.ca

ABSTRACT

2D materials, such as graphene, graphene oxide, hexagonal boron nitride (hBN), and MXene, provide unique possibilities for creating advanced nanocomposites due to their exceptional lightweight nature and remarkable electrical, thermal, and mechanical properties. To fully exploit these attributes, precision engineering of intricate structures becomes imperative. A promising avenue to achieve structurally optimized systems is through 3D printing or additive manufacturing. This process involves creating 3D objects layer by layer based on a digital design, providing greater production versatility compared to traditional methods. It grants engineers the freedom to design intricate geometries not feasible by other means, enabling the production of functional parts without assembly and allowing customization of weight, shape, and strength.

While DIW 3D printing is effective for fabricating 2D material-based nanocomposites, challenges arise in the fabrication of complex configurations, such as unsupported structures, to achieve both reliable in-situ curing and structural stability. Traditional methods primarily rely on the UV-assisted DIW 3D printing. Nevertheless, UV-DIW printing structures encounter a trade-off between the amount of nanofiller added and the effective curing depth. Highly loaded systems are inherently constrained by the absorbance and scattering of UV irradiation caused by the nano particles, limiting both the curing depth and the degree of conversion of the photopolymer.

Our research addresses these limitations by introducing interfacial polymerization (IP) as a new, versatile pathway for DIW 3D printing of unsupported GO and other 2D material-based nanocomposites. IP enables direct solidification of 2D material-laden inks through a chemical reaction at the interface between two immiscible solutions. This method can be applied to any 2D material, such as graphene oxide, MXene, or carbon nanotubes, providing a robust backbone for nanocomposite structures. Furthermore, the choice of monomers allows flexibility in selecting a wide range of polymers synthesized through IP, including polyamides and other mechanically tunable options. This approach enables the rapid production of freeform nanocomposites with high concentrations of 2D materials, offering a scalable, customizable method for fabricating strong, lightweight structures suitable for diverse applications.