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3D Printing of Photocuring Resin Reinforced by Functionalised Graphene Nanoplatelets

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Research Objectives

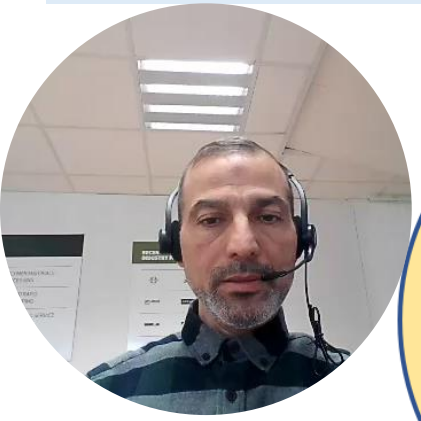
Challenges:

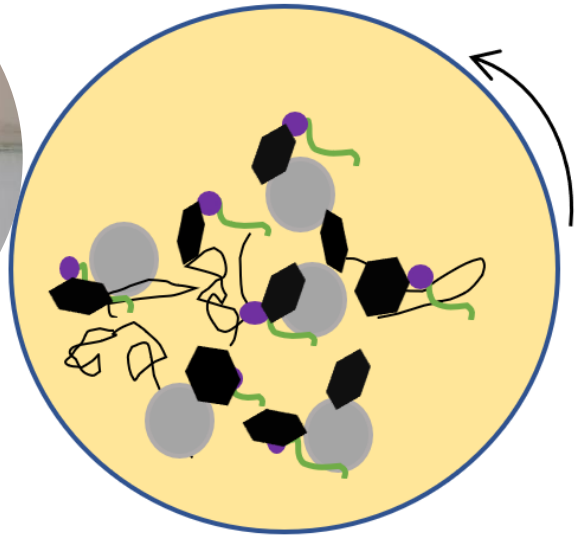
- The poor mechanical and thermal properties resulted from the 3D printing of resins;
- Nanoparticle agglomeration drawbacks of liquid-based 3D printed nanocomposites.

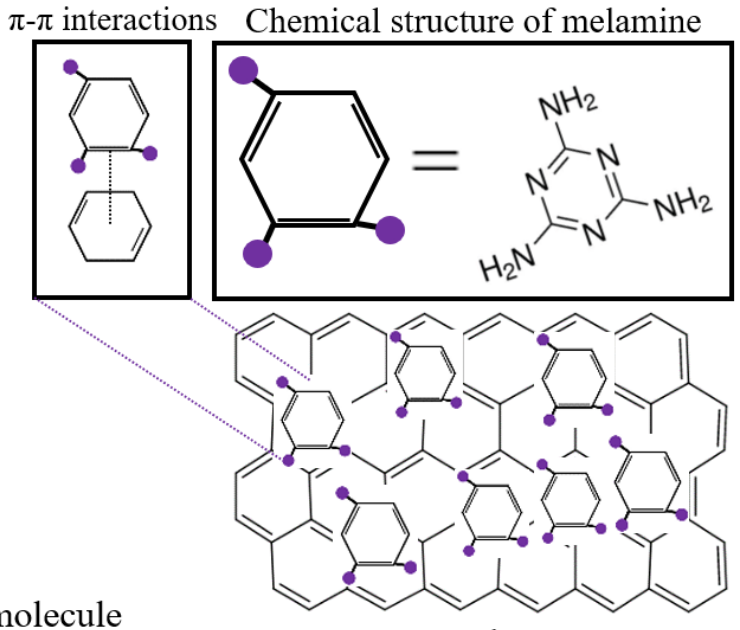
Solution:

- Chemical surface modification of GNP with melamine can prevent aggregation, enhance printability and improve mechanical and thermal properties.

- Noncovalent functionalisation is interactions between π-bond on GNP's surface and the hexagonal ring of melamine.





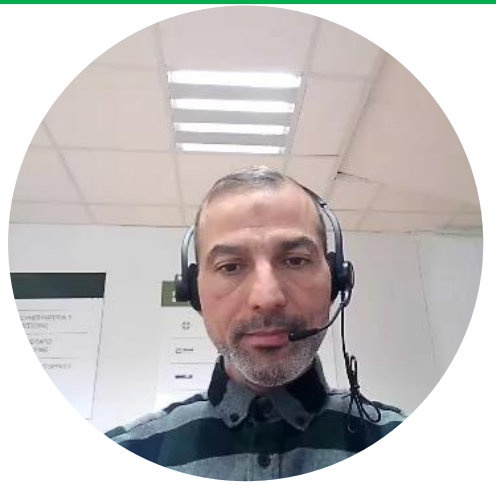


Methodology

Materials selection & Preparation | 3D-printing & | Characterisation & Testing

❖ **Materials**:

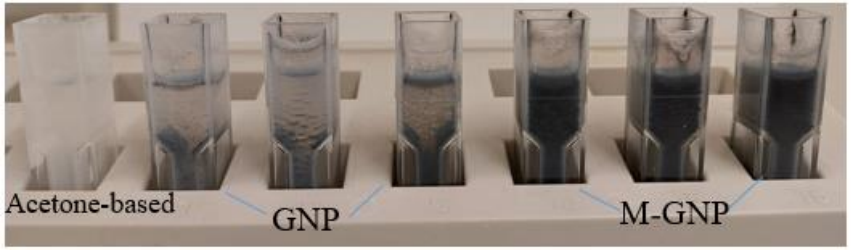
- Clear resin (Refer as neat) (Dimethacrylate-based) of Formlab 2 SLA printer;
- Graphene nanoplatelets (GNP), Melamine and DMF.



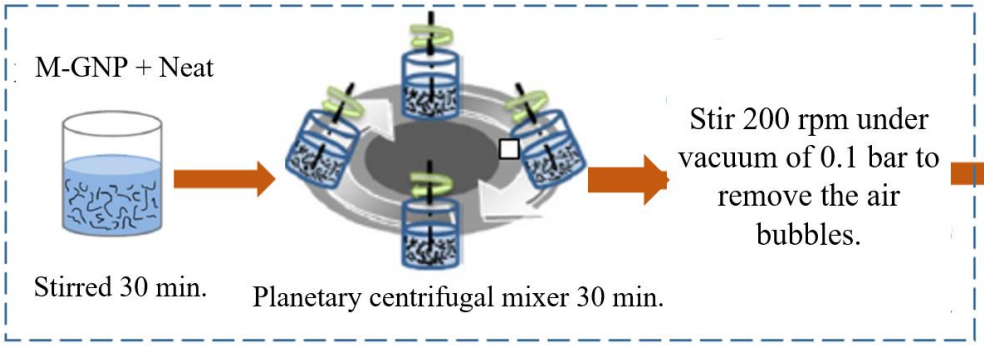
❖Fabrication of 3D-Printed Nanocomposites:

1- Preparation of functionalised GNP:

Characterise M-GNP
FTIR & TGA



2- Preparation of M-GNP/neat resin:

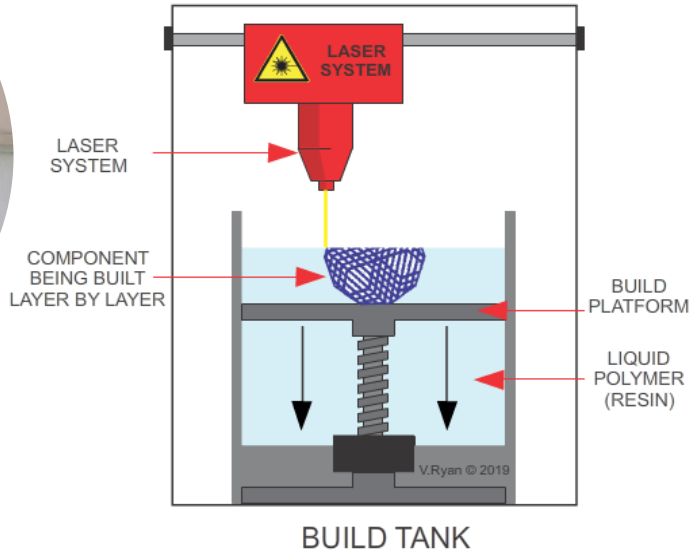


Methodology

Materials selection & Preparation | 3D-printing & | Characterization & Testing

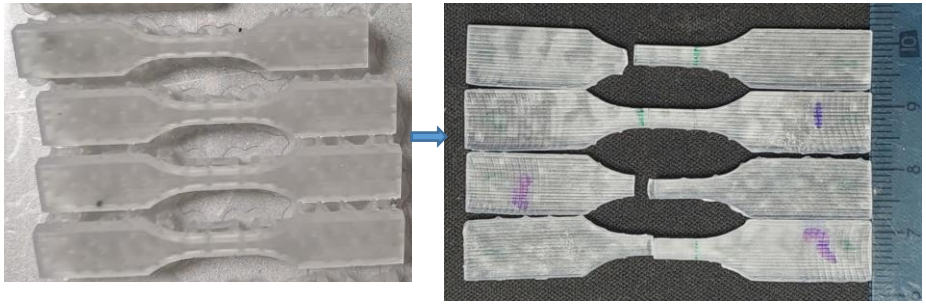
3- SLA 3D-Printing:

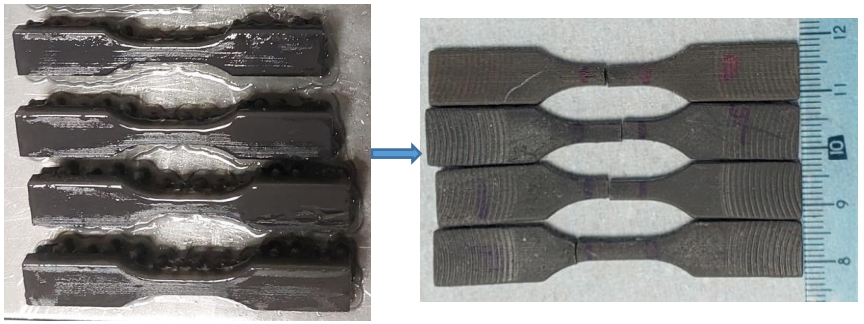
- 3D-drawing (CAD) export to SLA;
- SLA slices 3D-drawing into layers.

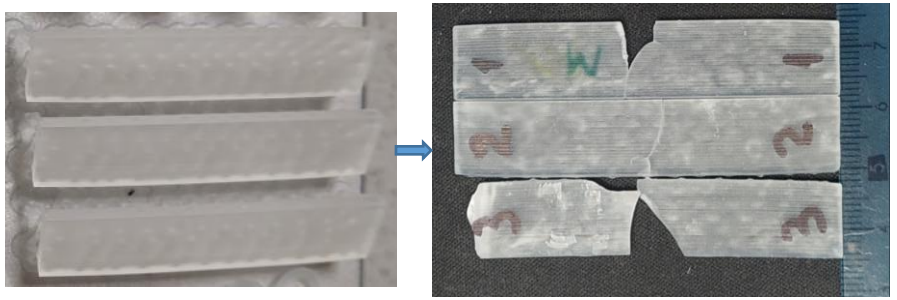


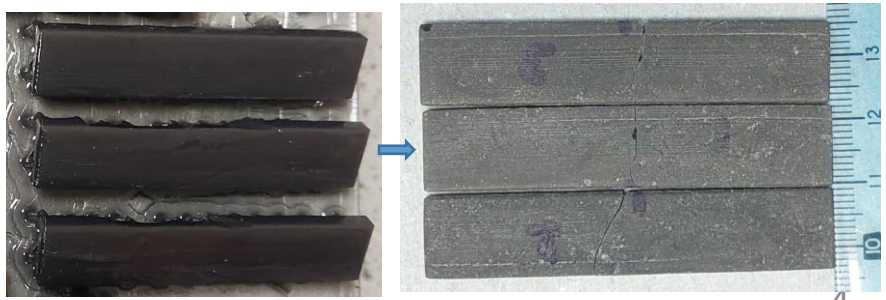
❖ **Characterisation & Testing:**

- TGA, Tensile (Type V), Izod impact and SEM.





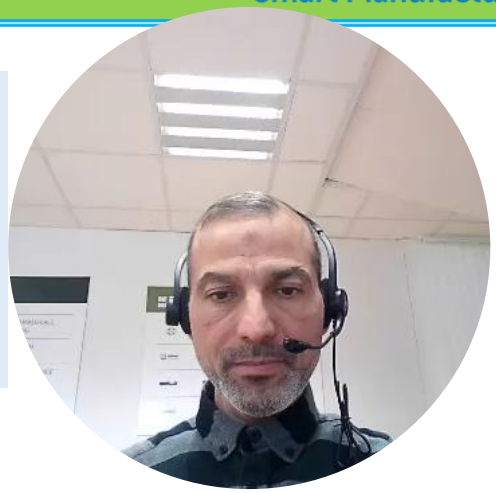




Results & Discussion

1. Characterisation of the M-GNP:

- The peaks (**FTIR** spectra) confirm the functionalisation of the GNP surface due to the low-energy ball-milling process.
- The decomposition of M-GNP (**TGA**) indicates the functionalisation of GNP by melamine.



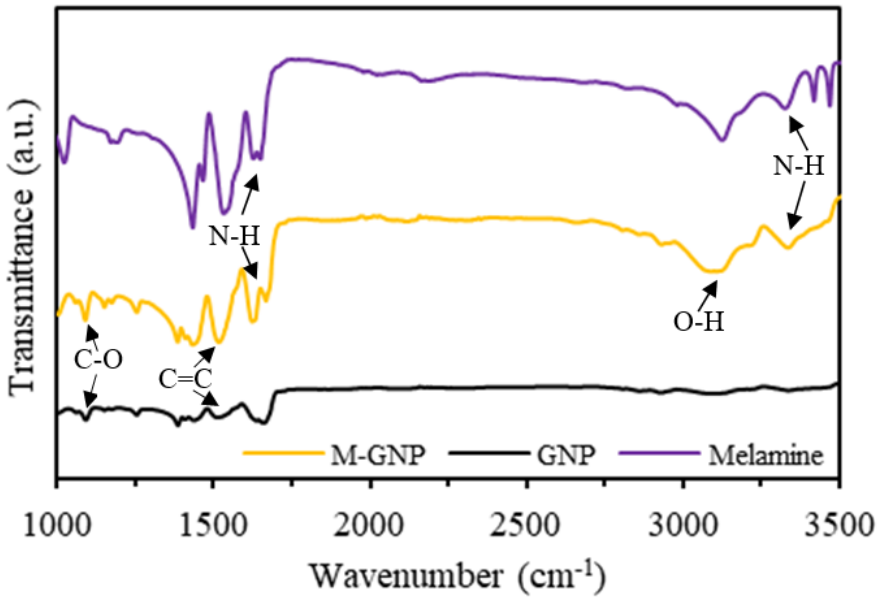


Figure 1. FTIR spectra of melamine, GNP, and M-GNP.

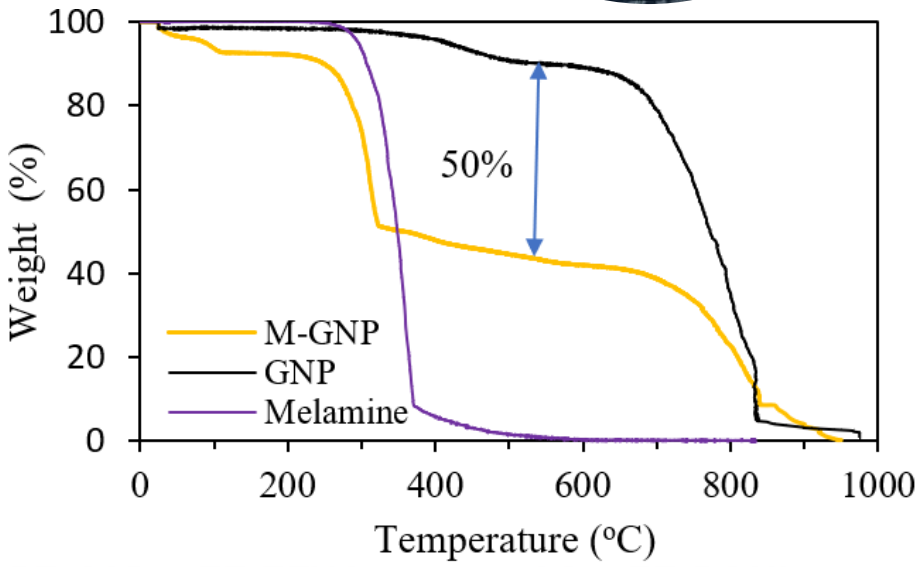
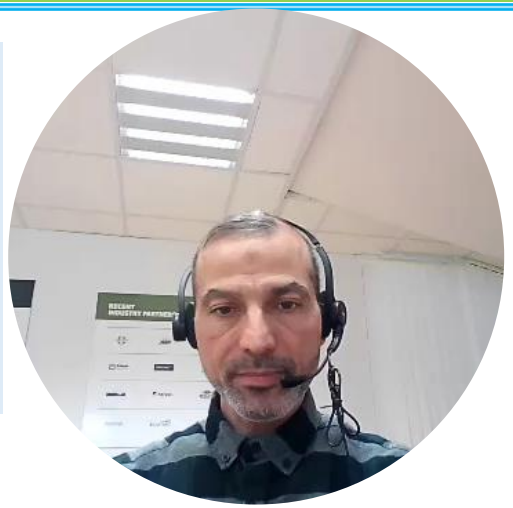


Figure 2. TGA curves of the melamine, GNP and M-GNP.

Results and Discussion

2. TGA of the M-GNP Composites:

- Neat sample begin to lose weight before M-GNP composites;
- The improvement in thermal stability was due to the good interfacial adhesion between M-GNP and the 3D-printed polymer matrix.



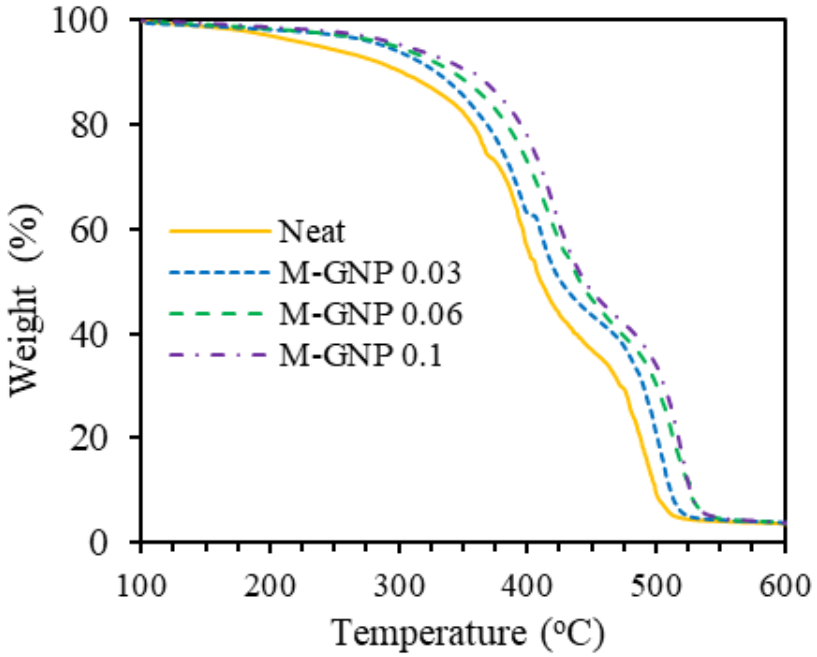


Figure 3. Weight loss versus temperature M-GNP composites

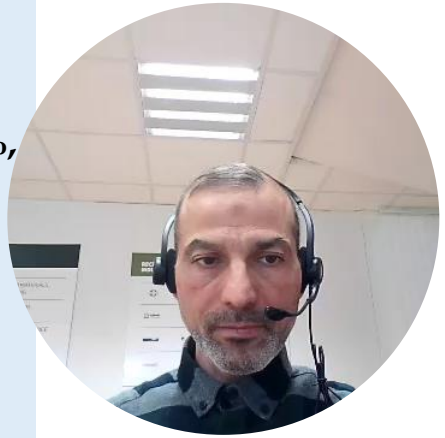
Table 1. TGA values of the M-GNP nanocomposites.

Material	T_5 (°C)	W_{400} (%)
Neat	236	56
M-GNP 0.03	288	63
M-GNP 0.06	296	72
M-GNP 0.1	304	77

Results and Discussion

3. Mechanical Properties of the M-GNP composites:

- The tensile strength and impact resistance are improved by **35% and 78%,** respectively;
- SEM images show M-GNP were embedded and homogeneously dispersed;
- M-GNP agglomerations are not observed in the resin matrix;
- The melamine prevents the GNP from aggregating through π-π interactions;
- These interactions improved the load transfer across the interface between matrix and M-GNP.



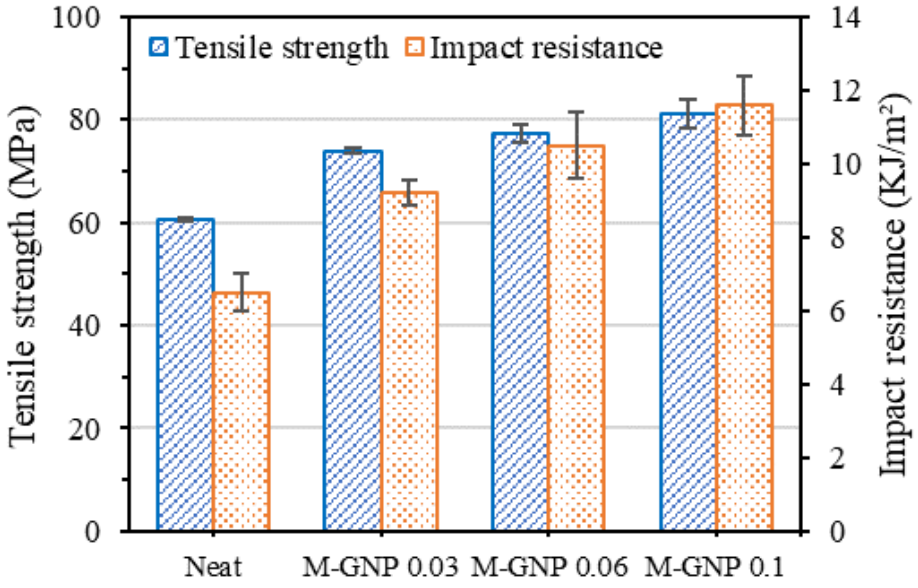


Figure 4. Tensile strength and impact resistance.

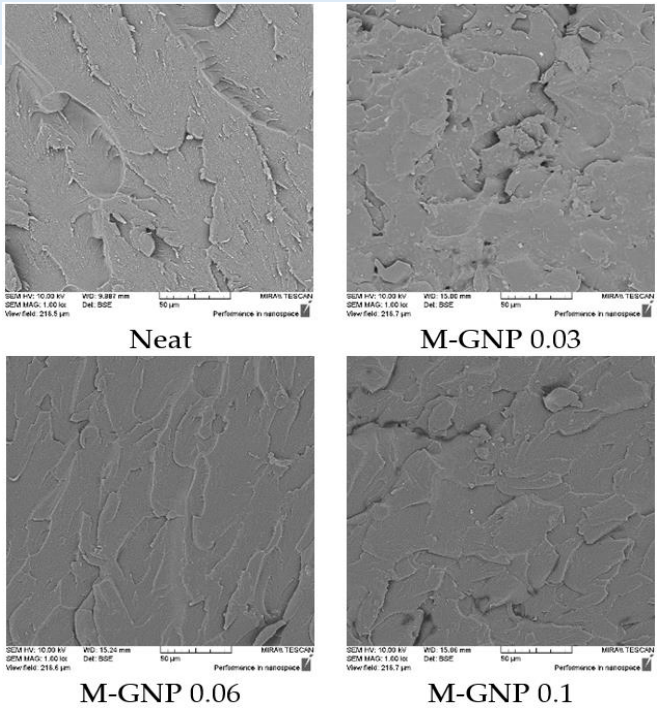


Figure 5. SEM micrographs of the tensile fracture surface.

Conclusions & Findings

- This study investigates the effect of melamine-functionalised GNP on the tensile, impact and decomposition properties of the 3DP polymer composites;
- The functionalisation of the GNP is proved via FTIR and TGA;
- The noncovalent functionalisation of melamine via π-π interactions improved the dispersion of the GNP and inhibited surface defect formation, which led to **strong interfacial adhesion** between **M-GNP** and **polymer matrix**;
- Enhancing the UV curing reaction in 3DP;
- Improvement **up to 35% in tensile strength, 78% in impact strength and 38% in residual weight.**

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