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Surface-Engineered Graphene Oxide–MXene–SLG Composite with Enhanced Bactericidal Properties

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INTRODUCTION & AIM

- Rising cases of multidrug-resistant bacteria highlight the urgent need for novel antimicrobial materials utilizing physical and chemical surface mechanisms instead of conventional biochemical ones.
- A ternary nanocomposite comprising Graphene Oxide (GO), Single Layer Graphene (SLG), and delaminated MXene was synthesized via an ultrasonication-assisted method to ensure homogeneous mixing and strong interfacial bonding.
- PXRD, FE-SEM, and EDX analyses confirmed the successful integration of the layered structures while retaining their surface functionalities.
- The antibacterial performance was evaluated through colony-forming unit (CFU).
- The GO–SLG–delaminated MXene composite exhibited superior antibacterial activity compared to individual and binary composites.
- Enhanced antibacterial action results from a synergistic mechanism combining: GO, SLG, and delaminated MXene.
- Findings indicate that such 2D heterostructures hold strong potential as next-generation antimicrobial materials.
- The study provides a foundation for designing surface-tailored nanomaterials for healthcare, sanitation, and environmental protection applications.

METHOD

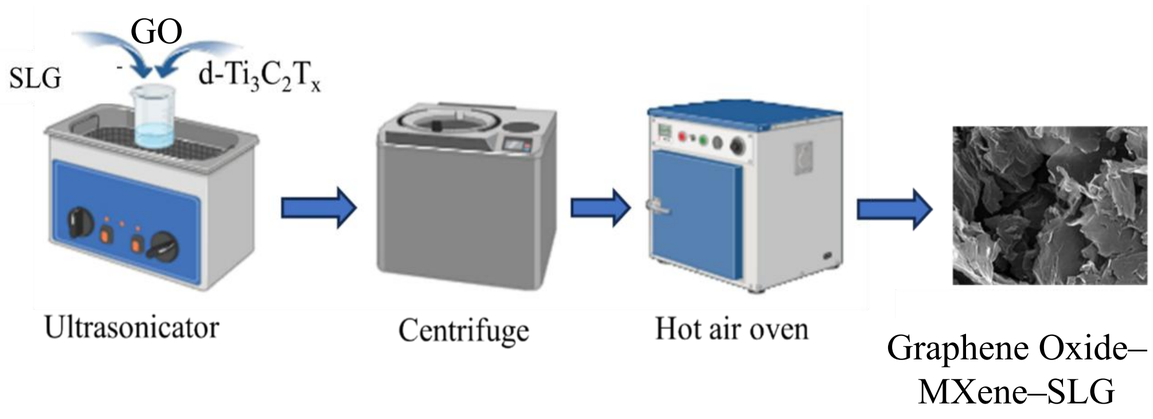

Figure 1

To prepare the Graphene Oxide–MXene–SLG Composite 0.050 g of SLG dispersed in 200 ml DI and ultrasonicated for 2 h. After 2 h the 0.005 g of MXene was added slowly and sonicated for 2h then 0.005 g of Graphene Oxide added and the resultant solution was ultrasonicated for 2 h. After sonication the solution was centrifuged two times for 30 min at 10000 rpm. Assemble the precipitate and dried for 24 h at 60 °C. The synthesis scheme of Graphene Oxide–MXene–SLG Composite is shown in Figure 1.

RESULTS & DISCUSSION

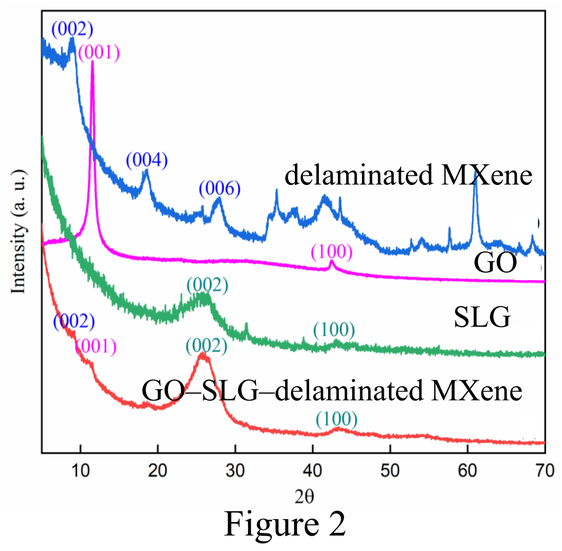

Figure 2

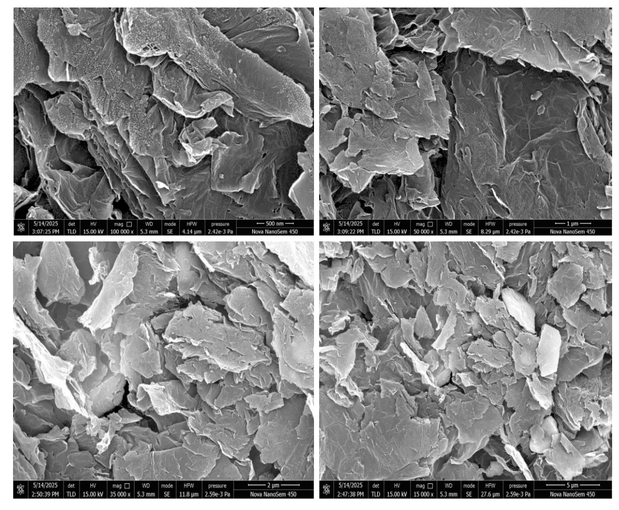

Figure 3

- The XRD analysis confirms the successful synthesis of GO–SLG–delaminated MXene composite.
- The FE-SEM image shows synergistic integration among the Graphene Oxide, Single Layer Graphene, and delaminated MXene to increase the improved surface area and surface roughness in GO–SLG–delaminated MXene composite.

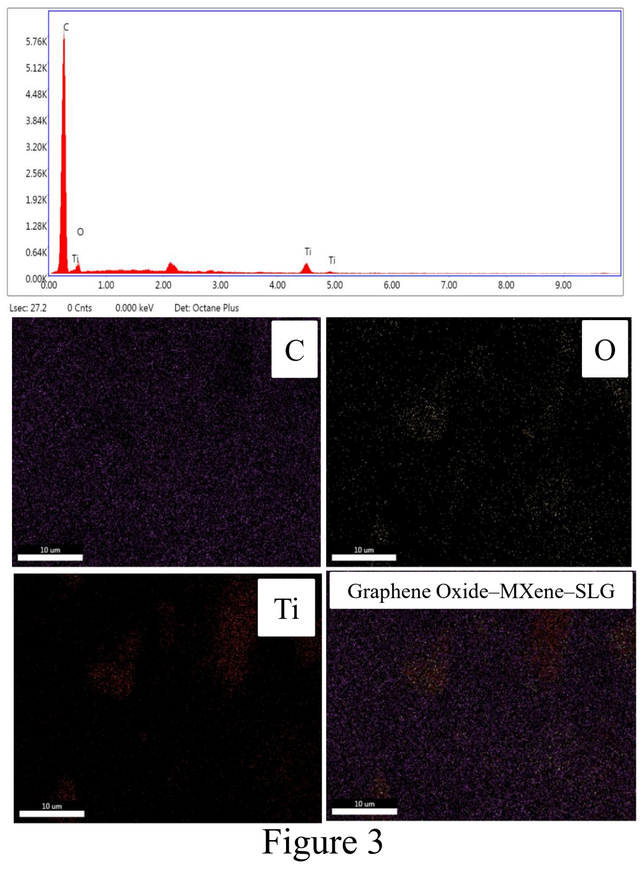

Figure 3

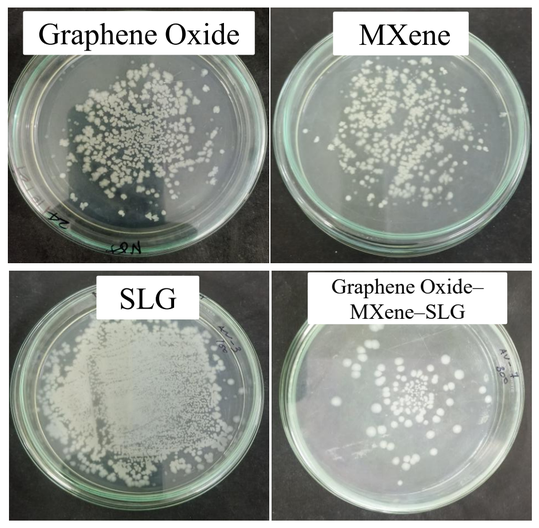

Figure 3

- The minimum number of bacterial colonies (1.8×10^4 C. F. U./ml) in the Graphene Oxide–MXene–SLG confirms its superior antimicrobial activity.
- The order of antimicrobial activity of nanomaterials is SLG < Graphene Oxide < MXene < Graphene Oxide–MXene–SLG.
- The elemental composition of the synthesized Graphene Oxide–MXene–SLG Composite confirms the presence of C, O, and Ti.
- The percentage molecular contribution of C, O, and Ti in Graphene Oxide–MXene–SLG Composite observed by the EDX spectra and elemental mapping are C (90.9%), O (1.8%), and Ti(7.27%).

CONCLUSION

The synthesized GO–SLG–delaminated MXene composite showed remarkable antibacterial activity compared to individual nanomaterials due to the synergistic effects of large surface area, and sharp-edged reactive surfaces. The integration of GO, SLG, and delaminated MXene enhanced bacterial membrane disruption and oxidative damage. Structural and morphological analyses confirmed successful heterostructure formation. However, the 2D ternary composites as a highly promising candidate for antimicrobial applications.