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Graphene–MXene Heterostructure for Combating Bacterial Infections: A Step Toward Safer Health and Environment

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INTRODUCTION & AIM

Pollution of pathogenic bacteria on consistently handled surfaces, medical equipment, and clothing that is protected provides an essential danger to patients as well as healthcare providers. Hospital-acquired infections (HAIs) represent a significant worldwide healthcare burden, with millions of cases reported each year, resulting in greater sickness, longer stays in the hospital, and more expensive medical care. Microbial colonization on inanimate surfaces such as surgical instruments, wound dressings, bed rails, and catheter tubes might enhance transmission and biofilm development, rendering routine cleaning measures ineffective. The doctors and nurses have regular exposure to infectious pathogens. Incorporating antimicrobial nanocomposites into personal protective equipment, or PPE, such as gowns, gloves, shoe coverings, and face masks might drastically minimize contamination by bacteria.

The application of antimicrobial properties of Graphene/MXene has studied by the few researchers but still there are many challenges around this field. Needs to improve its optimization, functionalization and characterization. In this study the antimicrobial properties of Graphene–MXene Heterostructure studied at various concentrations in colloidal solution for various applications in the fields of science and daily life. Graphene–MXene Heterostructure has improved adsorption capabilities, catalytically active sites, and electron transfer ability.

METHOD

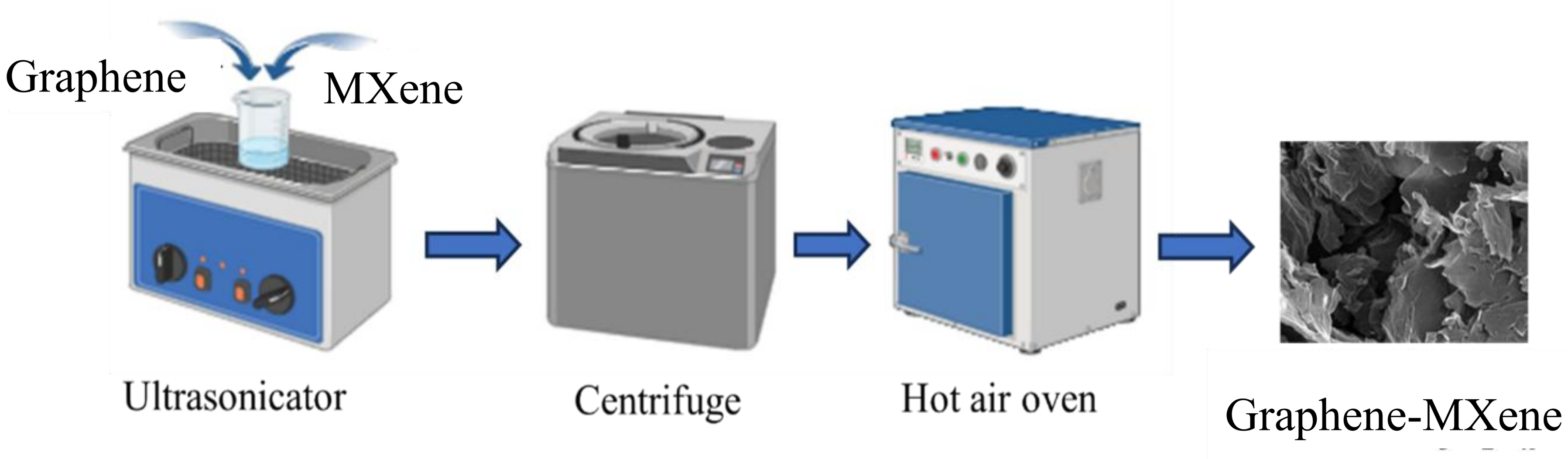

Figure 1

To prepare the Graphene–MXene Heterostructure 0.050 g of Graphene dispersed in 200 ml DI and ultrasonicated for 2 h. After 2 h the 0.005 g of MXene was added slowly and the resultant solution was ultrasonicated for 2 h. Then 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–MXene heterostructure is shown in Figure 1.

RESULTS & DISCUSSION

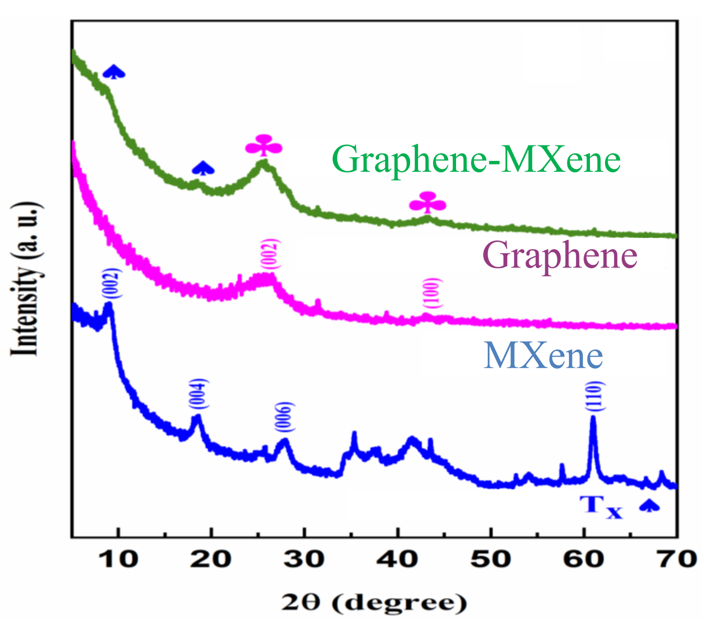

Figure 2. PXRD patterns

- The characteristic diffraction peaks of MXene and Graphene at 8.7° and 26.2° respectively corresponding to the (002) plane in Graphene–MXene Heterostructure confirms the successful synthesis of Target material.

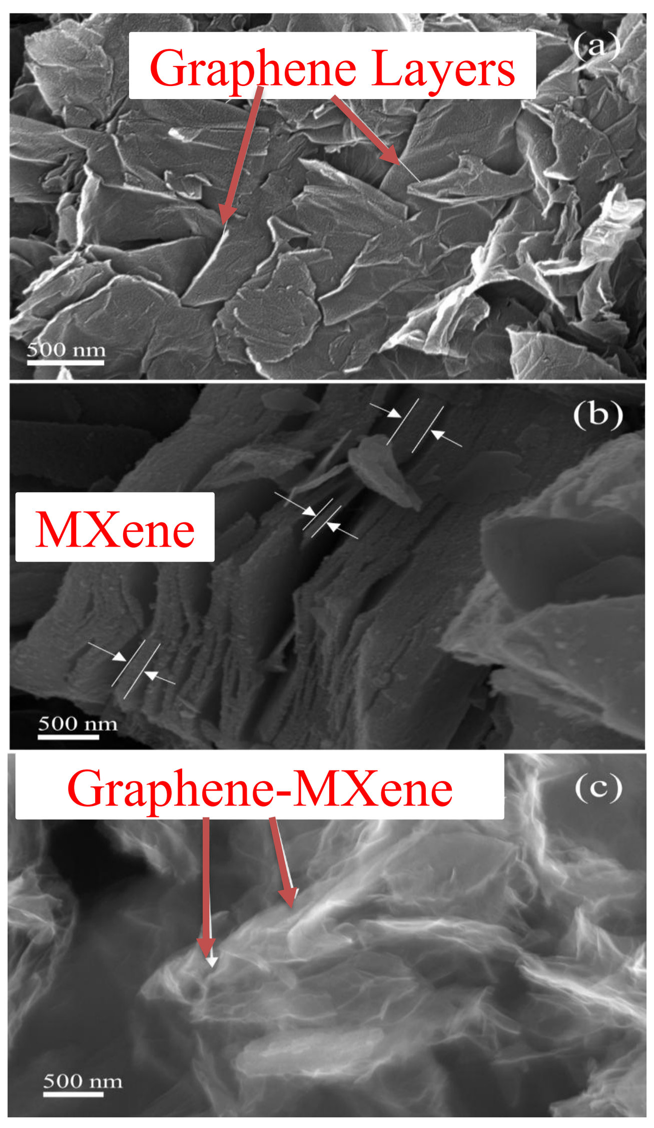

Figure 3. FE-SEM images

- The crumpled sheet-like shapes typical of SLG covered the whole interlayer spacing and sheets of MXene which can be clearly seen that there is an intimate integration of SLG and MXene.
- FE-SEM images of Graphene-MXene heterostructure provides the sharper edges in 2D structure and ROS active sites which are relevant to the antimicrobial activity.

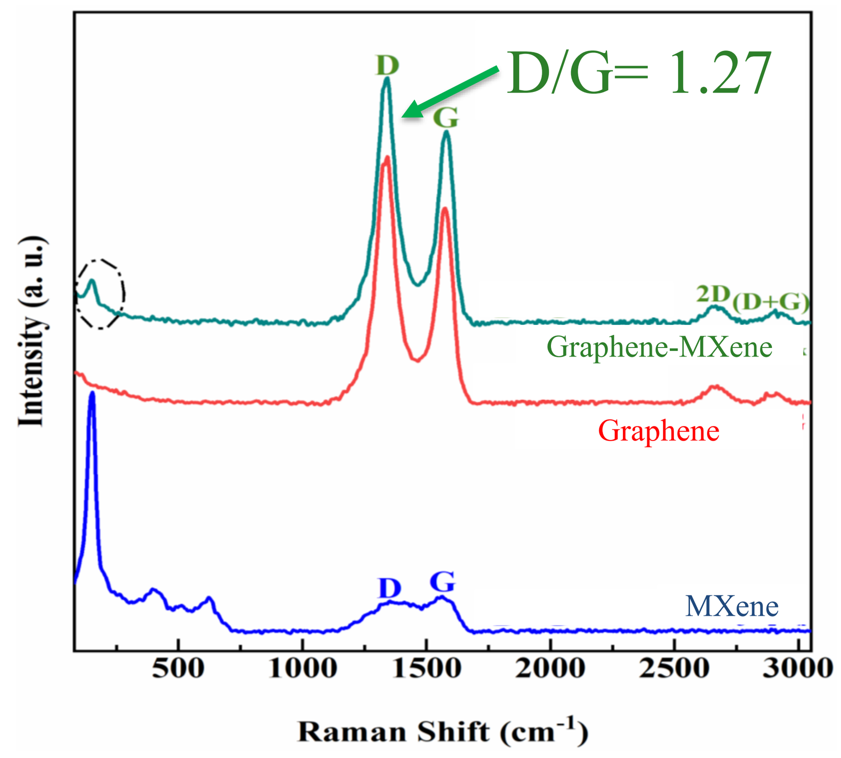

Figure 4. Raman Spectra

- The Raman spectra show the prominent **D** and **G** bands, confirming 2D carbon structures.
- The presence of Ti with abundant sp²-hybridized carbon (C–C) and oxygenated groups (O–C=O, C=O) in XPS confirms the successful synthesis of Graphene-MXene.

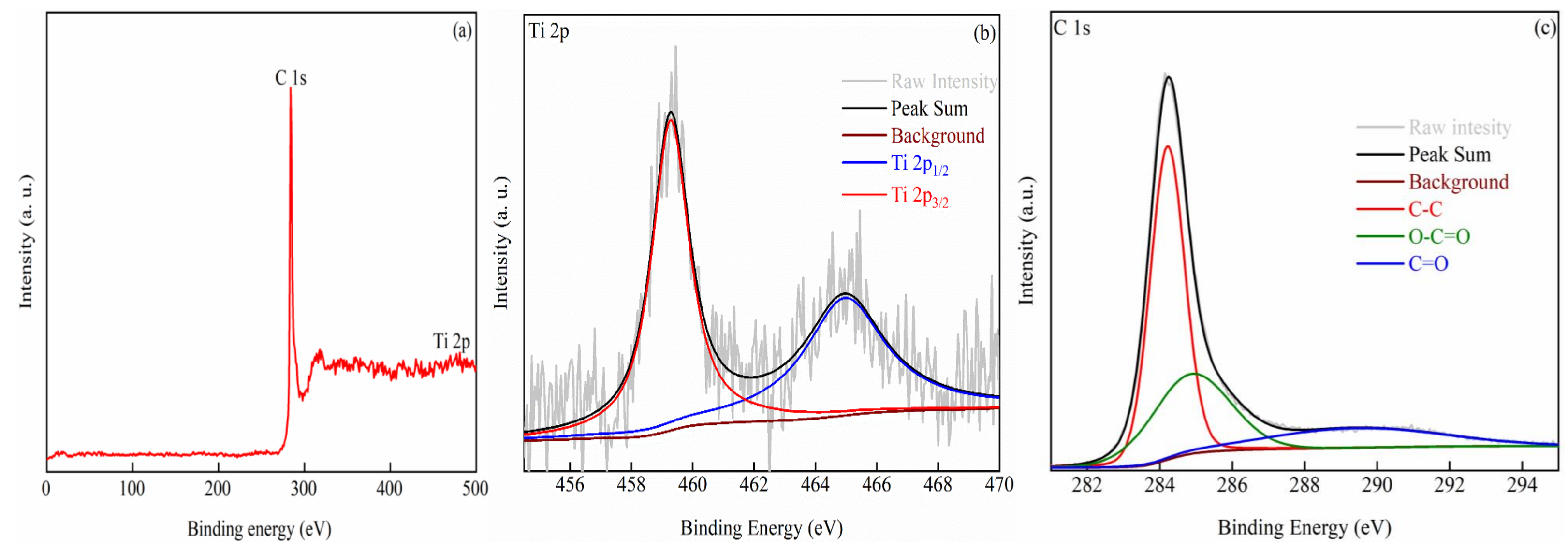

Figure 5. XPS Spectra

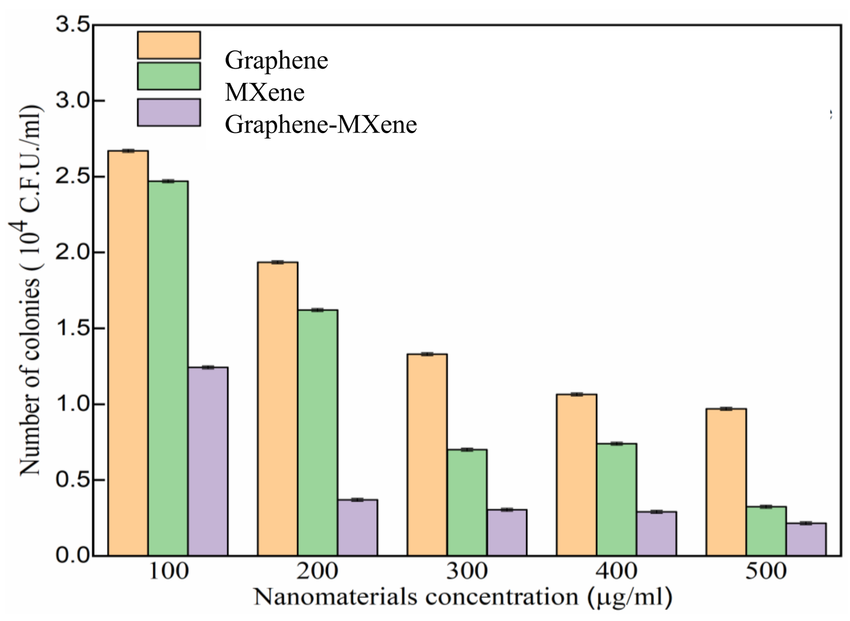

Figure 5. Colony-Forming Unit (CFU) method

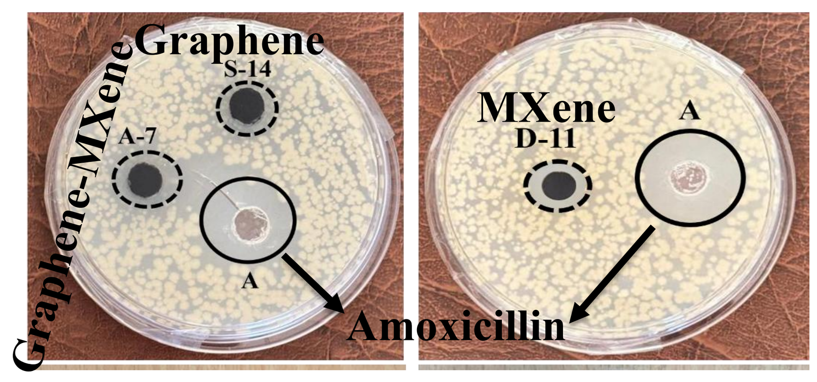

Figure 6. Disc Diffusion Method

The Zone of Inhibition : Amoxicillin (2.2 cm) > Graphene-MXene (1.5 cm) > MXene (1.1 cm) > Graphene (0.9 cm)

- The no of colonies are decreases with the increasement in concentration of nanomaterials $n_{100} > n_{200} > n_{300} > n_{400} > n_{500}$ and $n_{Graphene} > n_{MXene} > n_{Graphene-MXene}$

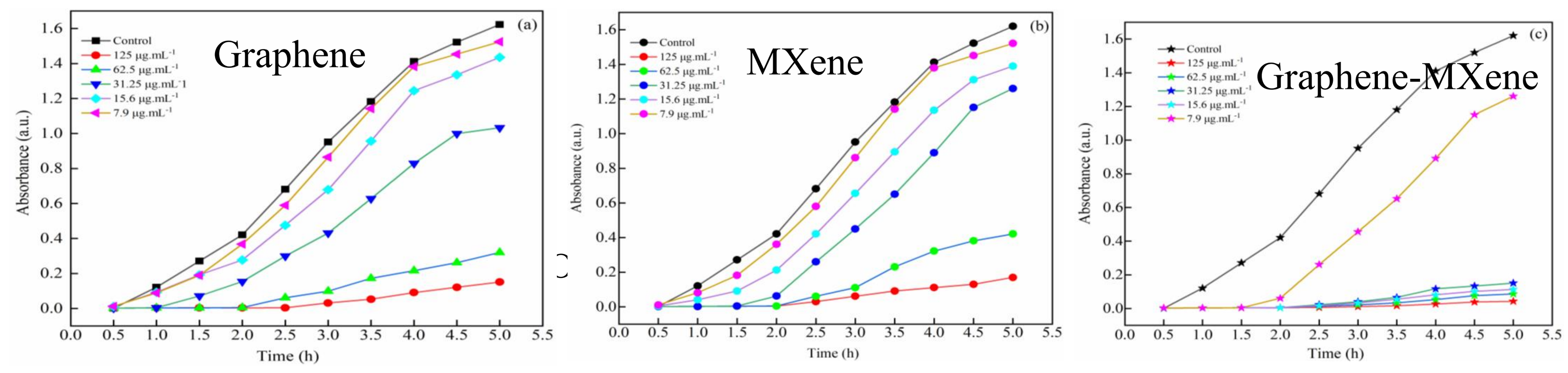

Figure 7. Optical Density method

- The Graphene-MXene heterostructure shows the lower absorbance then Graphene and MXene.

CONCLUSION

- The designing of the Graphene-MXene heterostructure is a promising strategy to achieve the antimicrobial activity for various healthcare and hygiene applications.

FUTURE WORK / REFERENCES

- The optimization, functionalization, and characterization of 2D/2D-based heterostructures need further improvement.