Integrated Corrosion Protection and Electrochemical self-warning and Self-healing Behavior in Hydrodynamically Exfoliated Graphene-Based Polymer Composite Coatings

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Abstract Graphene-based polymer nano-composite coatings with multifunctional capability are gaining increasing attention for smart surface engineering applications. In this work, a coating system based on hydrodynamically exfoliated graphene-reinforced bisphenol-based polymer incorporating zinc oxide-based hybrid filler particles has been successfully synthesized and structurally characterized. The incorporation of multilayer exfoliated graphene within the polymer matrix creates a tortuous diffusion pathway, resulting in enhanced barrier properties against the ingress of corrosive species, while the ZnO-based hybrid filler improves interfacial compatibility and electrochemical activity. Comprehensive physicochemical and micro-structural characterization confirms the uniform dispersion and strong interfacial interaction among exfoliated graphene, polymer matrix, and inorganic filler. Electrochemical impedance spectroscopy and potentiodynamic polarization studies demonstrate a significant improvement in corrosion resistance compared to the neat polymer coating. Additionally, the composite coating exhibits distinct and reproducible electrochemical responses under varying pH and corrosive environments, confirming its functionality as an electrochemical sensing layer. The pH-responsive behaviour and dynamic interactions within the composite architecture indicate its potential to facilitate self-healing-assisted restoration of protective performance. Overall, the developed composite coating presents a promising platform for advanced industrial and marine applications.

References

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Figures

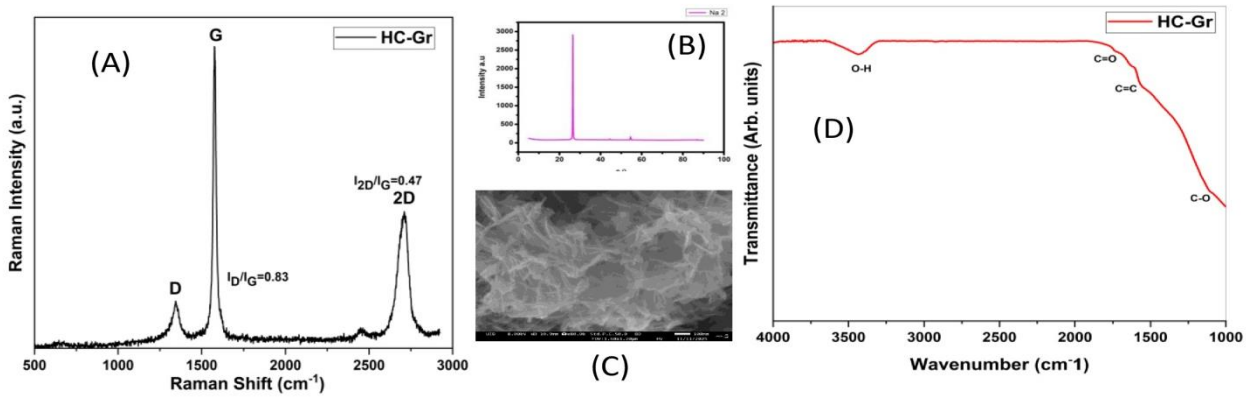

Figure1: (A) Raman analysis for Exfoliated Graphene/Na, (B) XRD analysis for Gr/Na 2h, (C)SEM analysis for Gr/Na 2h and (D) FT-IR analysis for Gr/Na 2h