Graphene-Based Nanocoatings for Improving the Corrosion Protection of Stainless Steel in Seawater Conditions

Inass El Hajj[1]
Kassiogé Dembelé[1,2], Barbara Laïk[3], Fatima Buoanis[1,4]
[1]*Ecole Polytechnique, PICM laboratory, Saclay road, 91120 Palaiseau, France*
[2]*Centre interdisciplinaire de microscopie électronique, Ecole Polytechnique, 91120 Palaiseau, France*
[3]*Paris-Est University, ICMPE laboratory, Henri Dunant Street, 94320 Thiais, France*
[4]*Gustave Eiffel University, IMSE laboratory, boulevard Newton, 77420 Champs-sur-Marne, France*
inass.el-hajj@polytechnique.edu

Since its isolation in 2004, graphene has attracted significant attention as an ultrathin barrier material for corrosion protection due to its exceptional impermeability and chemical stability. Its densely packed structure effectively limits the diffusion of aggressive species such as chloride ions (Cl^-), making it particularly promising for marine applications [1,2].
In this work, we studied the corrosion protection of stainless steel 316L (SS) using graphene nanosheets (GNSs) coatings prepared and deposed by scalable and versatile method. Few-layer graphene (3–5 layers) was synthesized in water via liquid-phase shear exfoliation and deposited onto steel substrates through interfacial self-assembly, forming uniform ultrathin films (~100 nm). Structural analyses confirmed high crystallinity and good film continuity.
Electrochemical measurements in 0.5M NaCl elctrolyte demonstrated a significant improvement in corrosion resistance compared to uncoated stainless steel, including a reduction in corrosion current density, an increased polarization resistance (253 kΩ) along with a decrease in corrosion rate compared to bare steel. Post-immersion characterization confirmed coating stability in a marine environment.
This eco-friendly combination of aqueous exfoliation and self-assembly offers a cost-effective route to durable graphene-based protective coatings for chloride-rich environments.

References

[1] El Hajj, I., Laïk, B., Gassama, A., Bensifia, M., Dembélé, K., Jama, C., Monnier, J., Léonard, C., Yassar, A., Bouanis, F., *Surf. Coat. Technol* 494 (2024), 1314112.
[2] Xu, H., Zang, J., Yuan, Y., Tian, P., Wang, Y., *Appl. Surf. Sci.* 492 (2019), 199-208

Figures

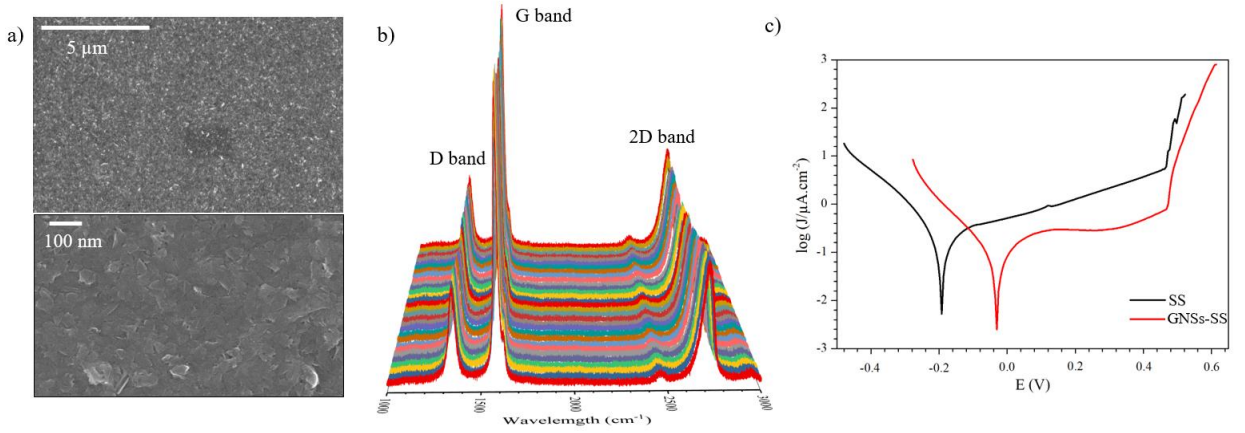

Figure 1: a) SEM micrographs of GNSs filtrated on a nitrocellulose membrane, b) Series of Raman spectra of an exfoliated GNSs solution assembled on SS substrate & c) Tafel plots of bare and GNSs coated SS after immersion for 96 h in chloride electrolyte