Multifunctional self-healing polymeric nanocomposite coatings for corrosion inhibition of steel

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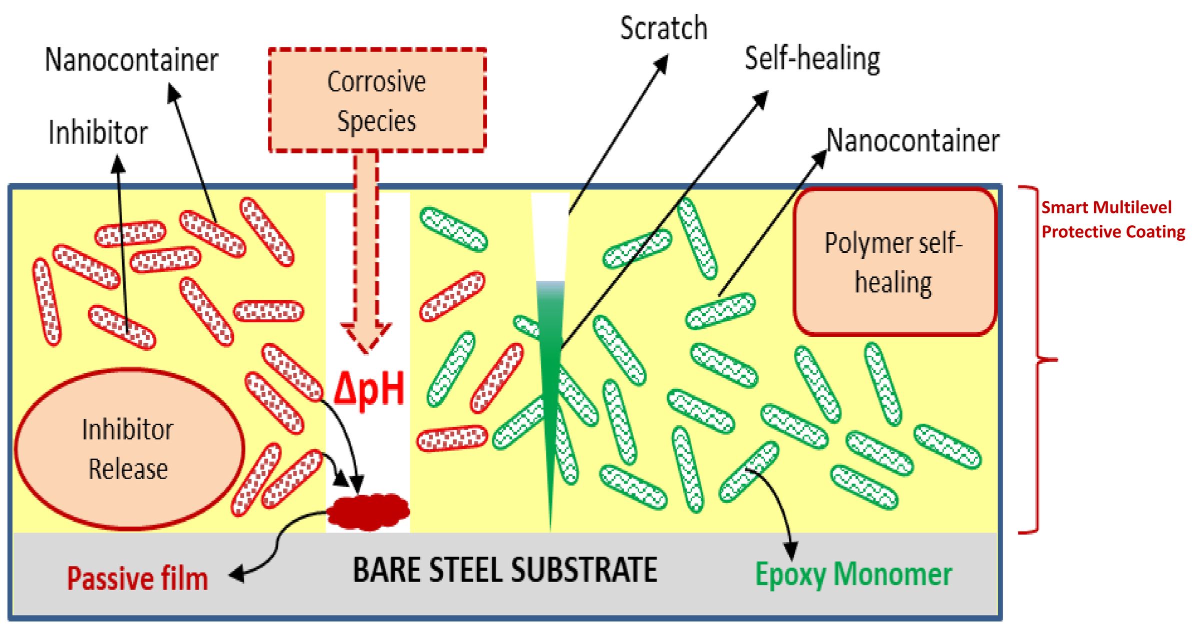
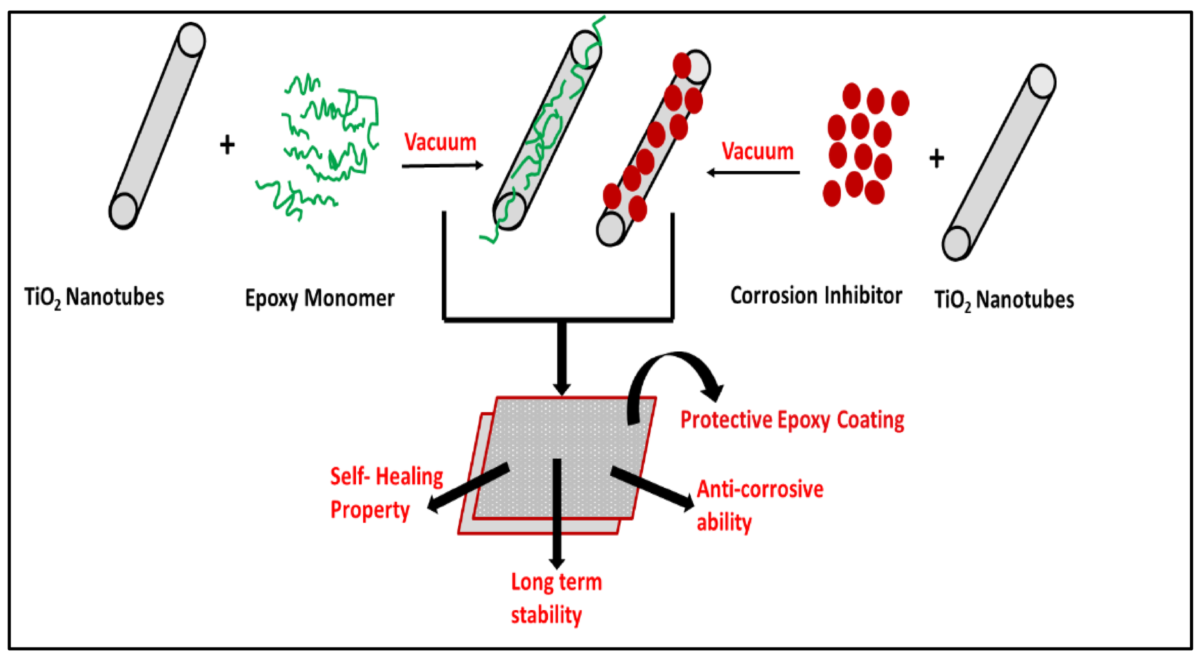
1- Abstract

The present work focuses on the self-healing and corrosion behavior of novel epoxy based coatings containing epoxy monomer (EM) and dodecylamine (DDA) as self-healing and corrosion inhibitor, respectively. The coating self-healing ability and the corrosion inhibition effect have been combined, together, in one single coated layer providing autonomous corrosion protection. Towards this goal, the as-synthesized titania nanotubes (TNTs), with an average size of 20 nm were impregnated with DDA and EM and were thoroughly dispersed into the epoxy used as the matrix and applied on steel. Fourier-transform infrared spectroscopy (FTIR) analysis confirms the presence of DDA loaded nanotubes and the loading of inhibitor was estimated by thermogravimetric analysis. . Additionally, the amount of the released corrosion inhibitor was identified by gas chromatography–mass spectrometry (GC-MS). The scanning electron microscopy (SEM), analysis shows the polymer healing of the prepared coatings when damaged. The electrochemical studies indicate that the corrosion rate of the steel samples coated with the epoxy modified with the healing additives decreases after 5 days of immersion in saline water.



2- Experimental



Schematic diagram demonstrating the experimental procedure.

3- Results& Discussion

a-Surface morphology

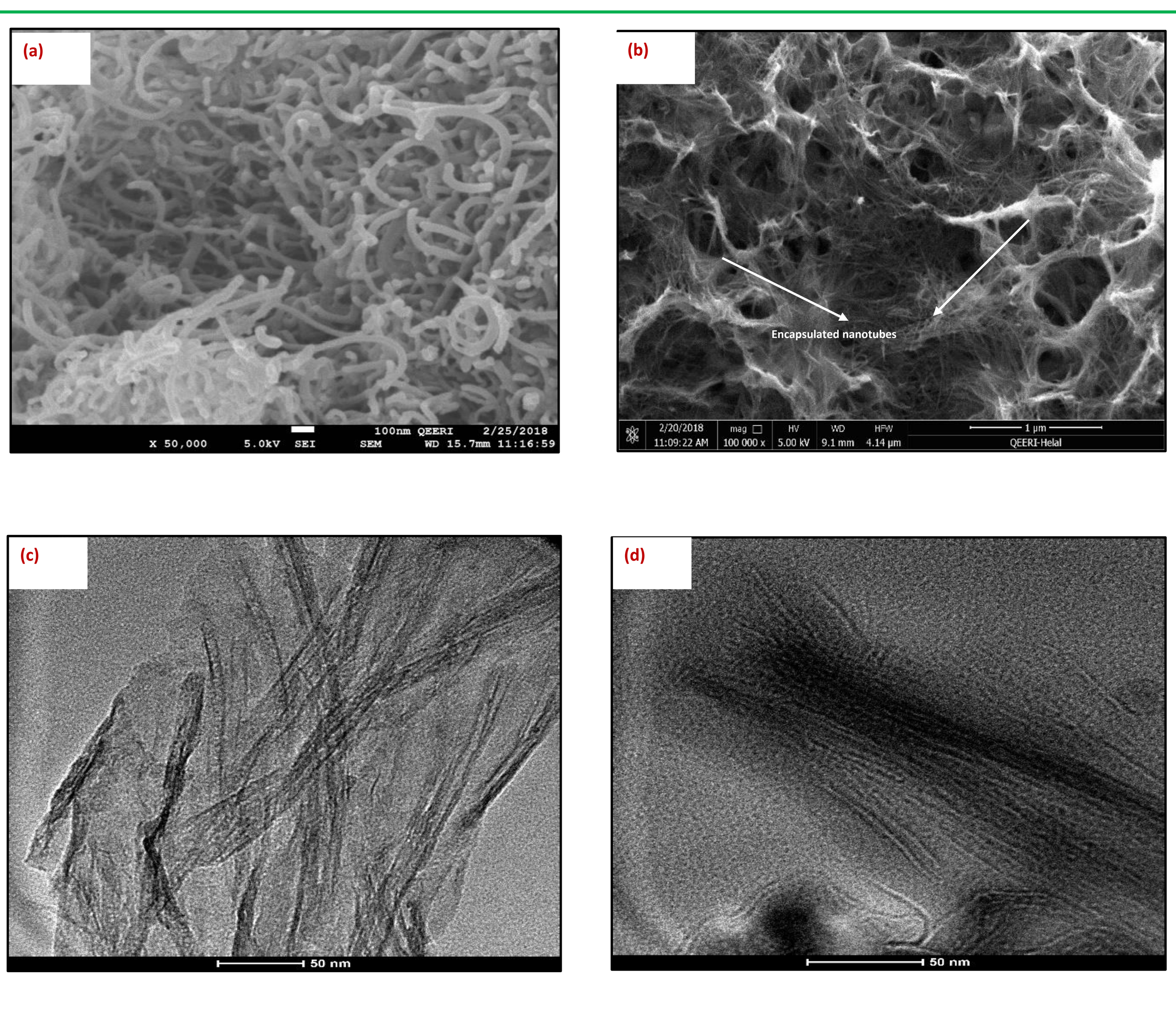


Fig. 2 (a, b) FE-SEM and (c, d) HRTEM analysis of as-synthesized TiO_2 nanotubes and TiO_2 nanotubes carrying corrosion inhibitor.

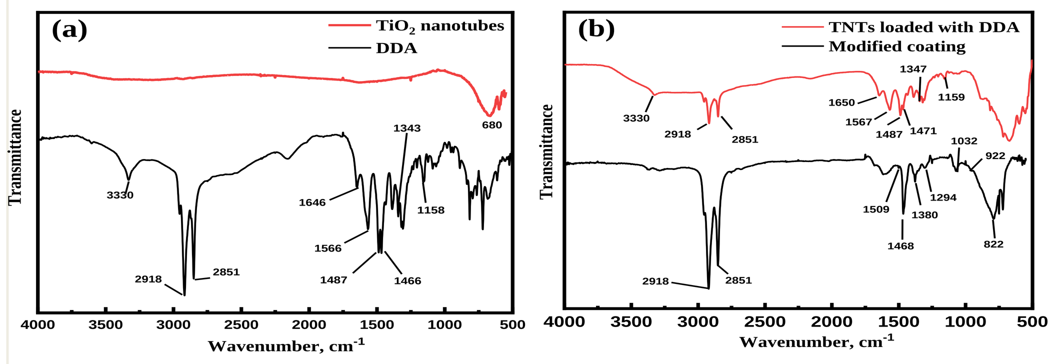


Fig. 3 FTIR spectra of (a) pristine TNT and DDA corrosion inhibitor and (b) TNTs loaded with DDA and modified epoxy coating with TNTs loaded with DDA and monomer.

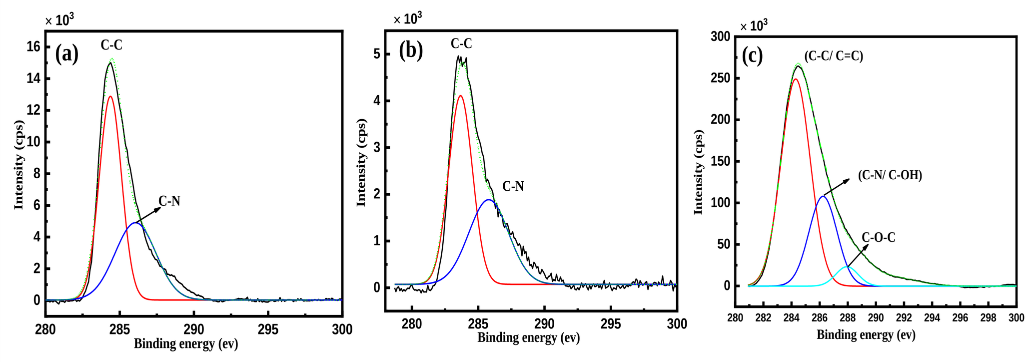


Fig. 4. C 1*s* XPS spectra of (a) dodecylamine, (b) TNT loaded with dodecylamine and (c) the smart coating

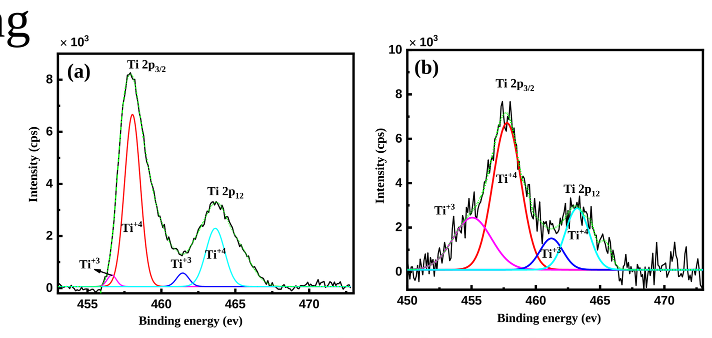


Fig. 5. N 1*s* XPS spectra of (a) dodecylamine, (b) TNT loaded with dodecylamine and (c) the smart coating

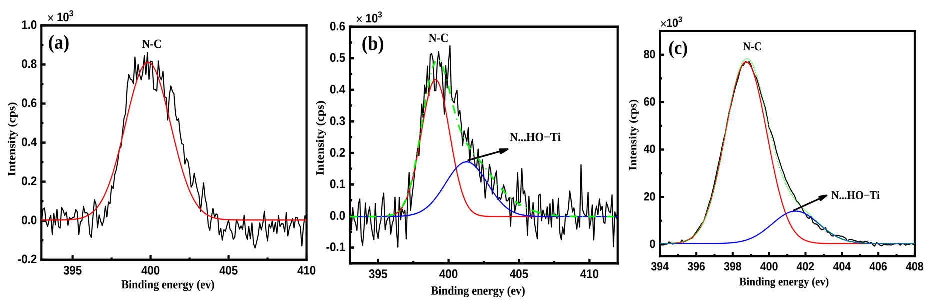


Fig. 6. O 1*s* XPS spectra of (a) TNT loaded with dodecylamine and (b) the smart coating

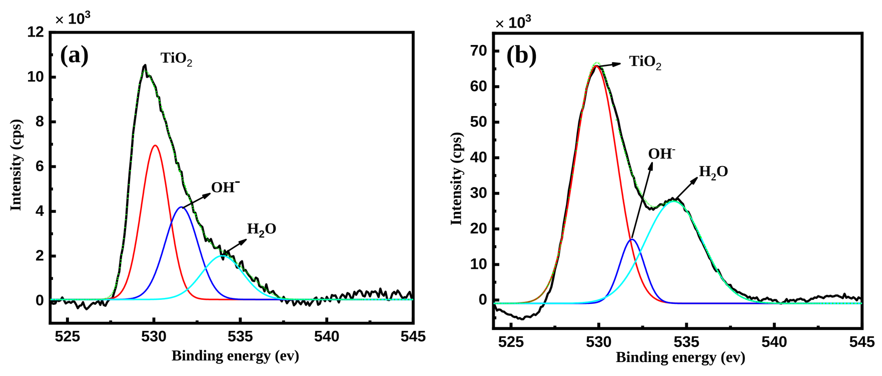


Fig. 7. Ti 2*p* XPS spectra of (a) TNT loaded with dodecylamine and (b) the smart coating

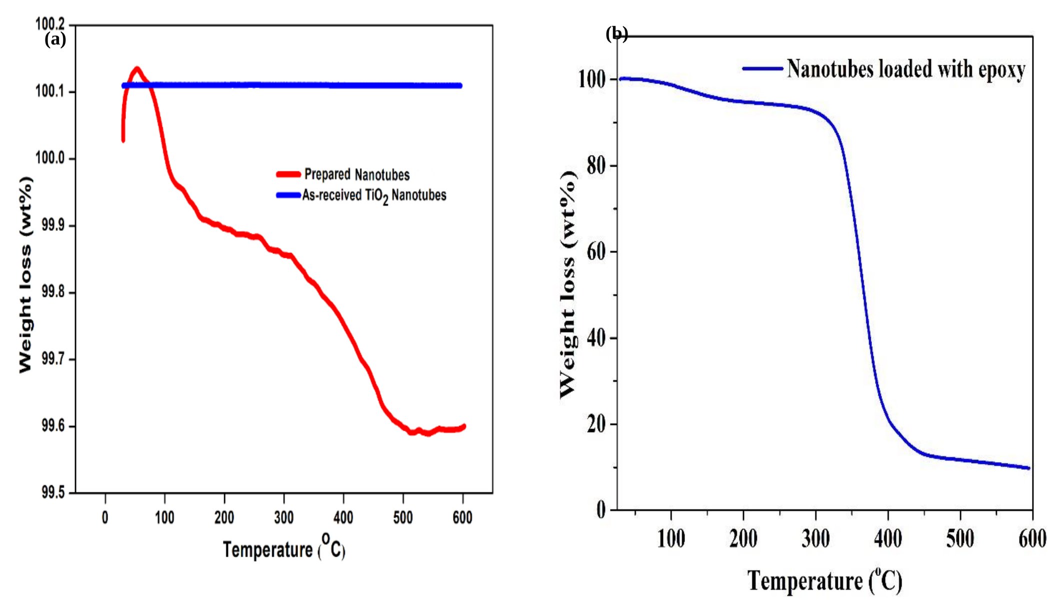


Fig. 8 (a) TGA curves of as-received TiO_2 nanotubes and the prepared DOC loaded nanotubes (b) TiO_2 nanotubes loaded with epoxy.

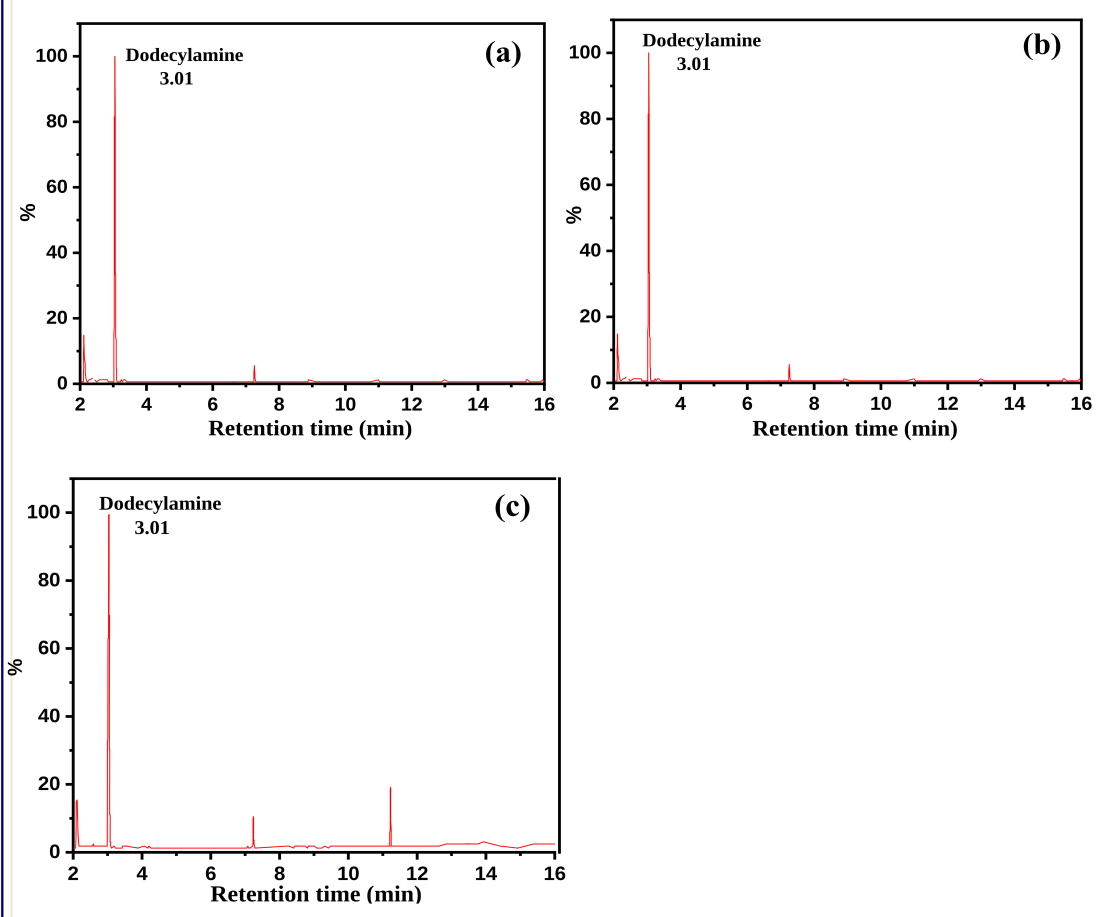


Fig 9. GC-MS of the DDA standard with different concentration of (a) 250 and (b) 500 ppp and (c) is the released DDA corrosion inhibitor from TiO_2 nanotubes.

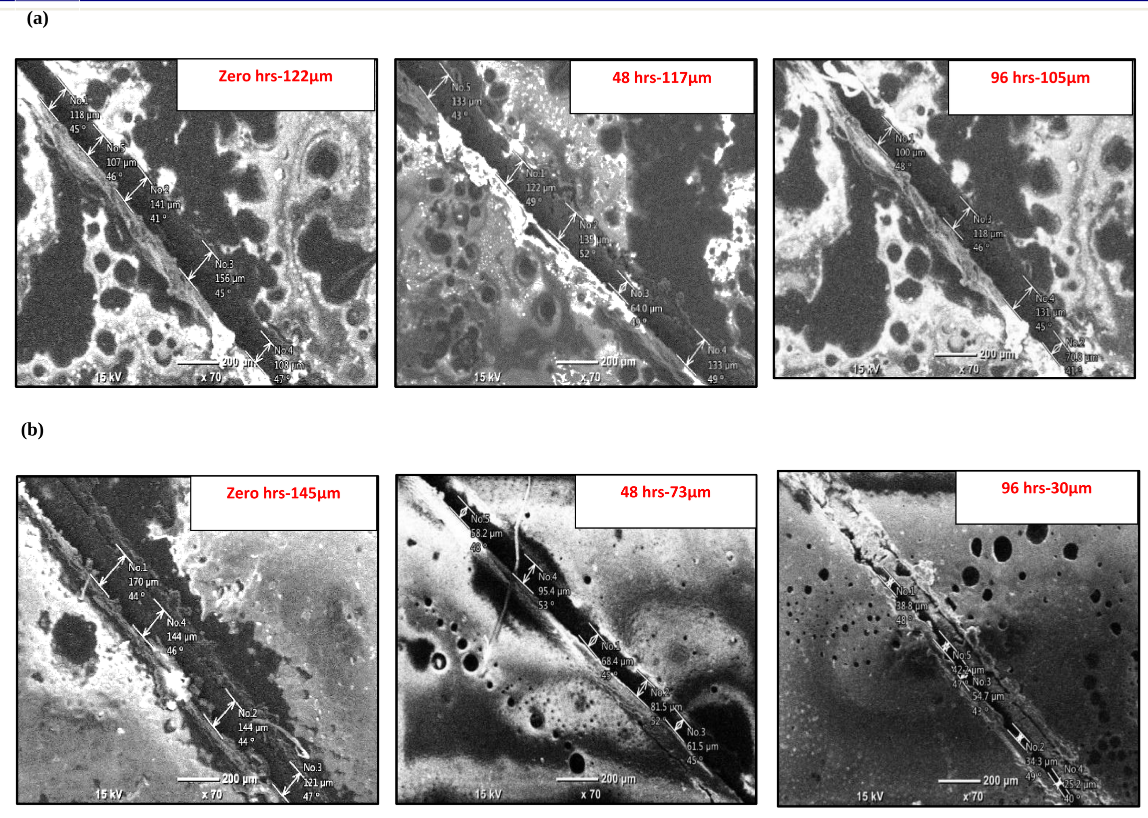


Fig. 10. SEM images of the scratched samples (a) Pure epoxy (b) Coating modified with TiO_2 nanotubes loaded with epoxy monomer.

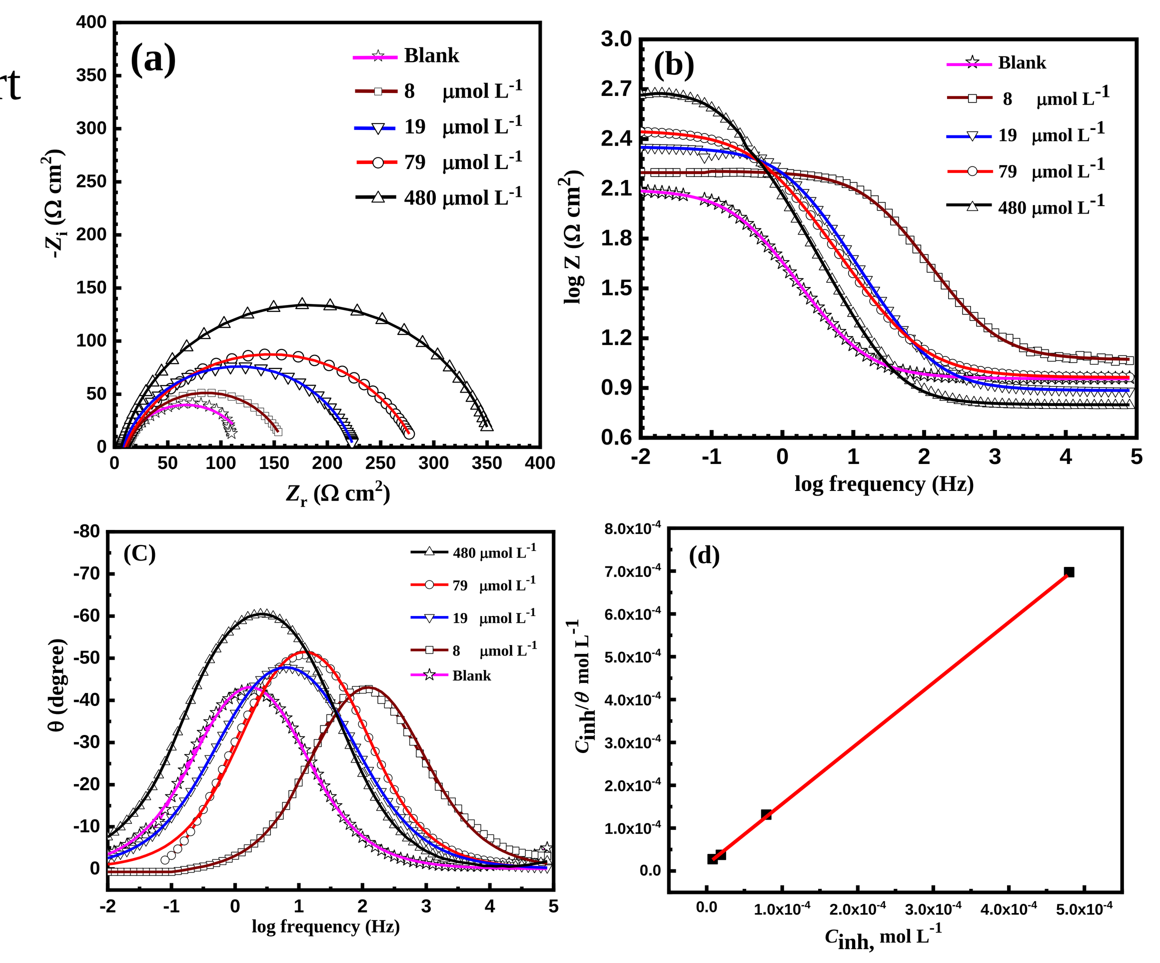


Fig. 11. EIS Nyquist plots of different concentration of DDA inhibitor and its related (b) bode, (c) phase angel and (d) the Langmuir adsorption plot.

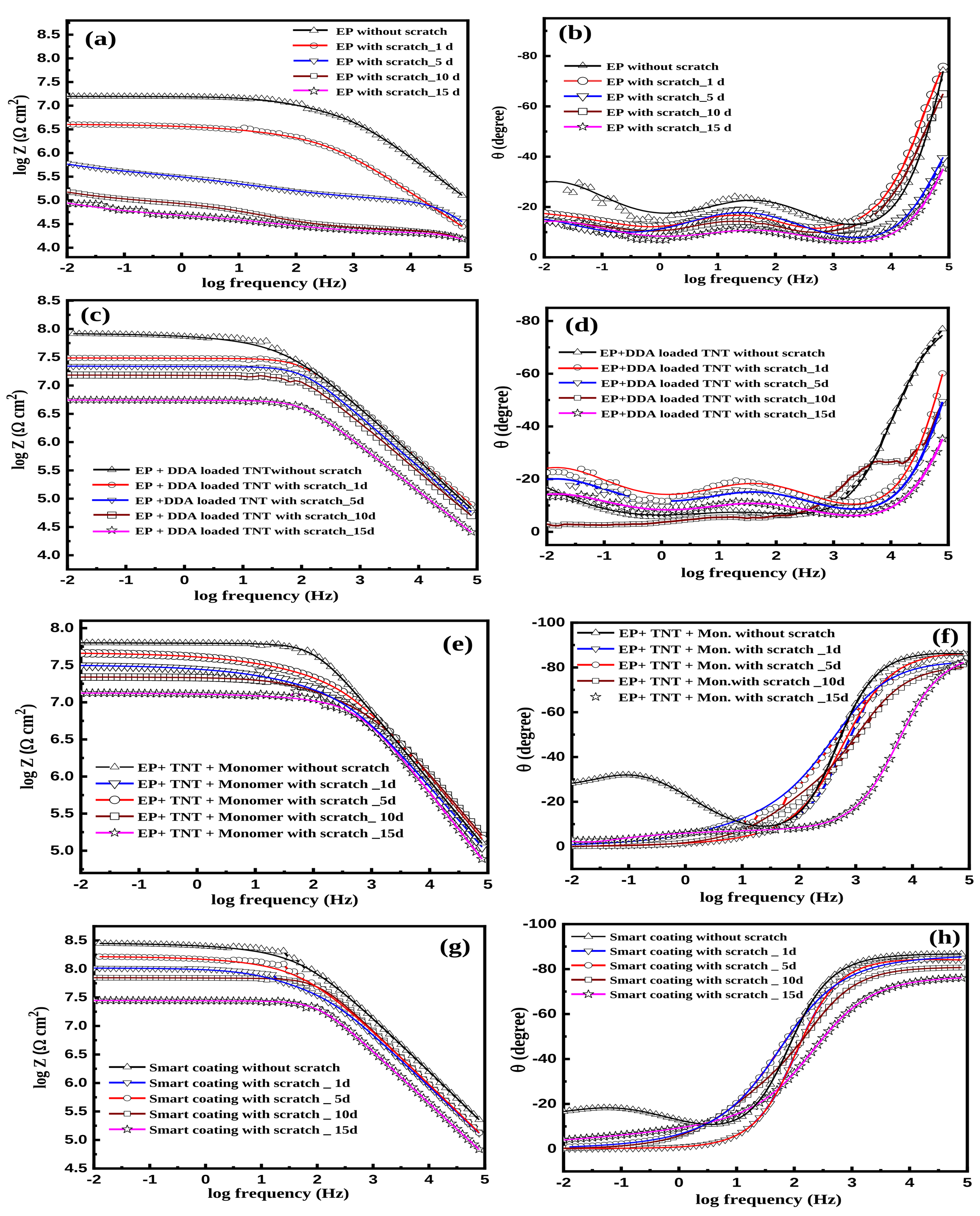


Fig. 12. EIS Bode plots of (a) plain epoxy coatings (c) epoxy modified with DDA loaded TNT, (e) epoxy + TNT+ monomer and (g) the smart coating before and after scratch tested at different time intervals in 3.5 wt% NaCl solution and their corresponding phase angle (b, d, f and h), respectively.

Conclusion

Novel single layer nanocomposite coatings have been successfully synthesized by reinforcing epoxy matrix with TiO_2 nanotubes loaded with inhibitor (DDA) and self-healing agent (epoxy). The improved properties of the modified coatings may be attributed to the efficient release of inhibitor and self-healing agent from the loaded TiO_2 nanotubes, making it potentially attractive for protection of steel components used in oil and gas industry.

Acknowledgment

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References

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