pH-responsive self-healing composite coatings based on modified nanocontainer for corrosion protection of steel.

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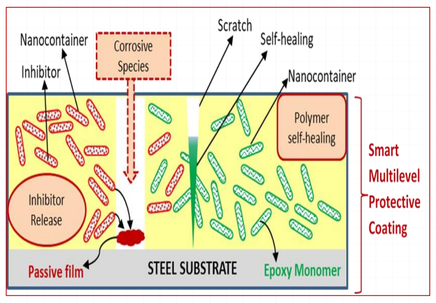
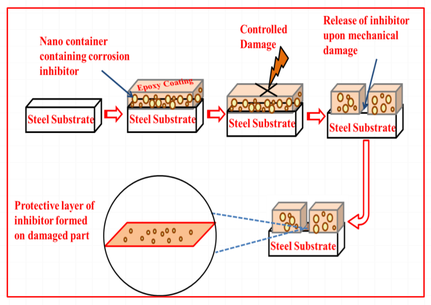
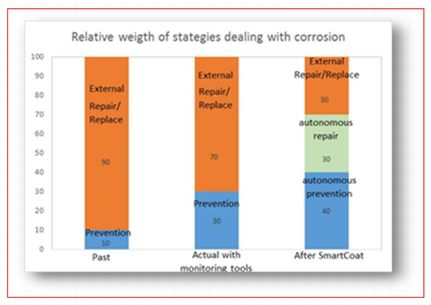
Background

Motivation

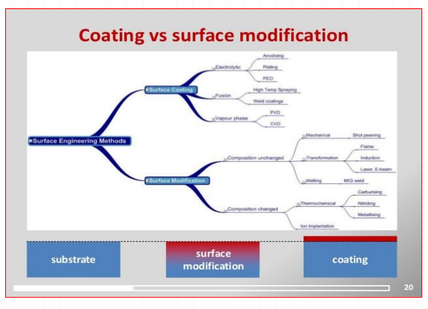


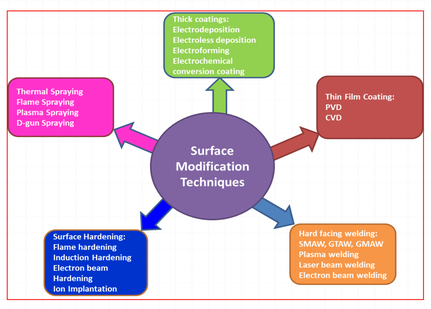


Problem Statement

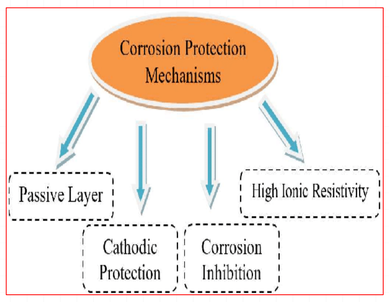


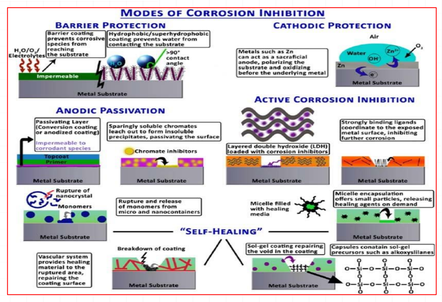
Surface Modification Techniques



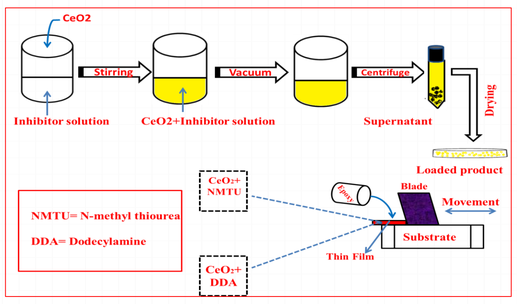


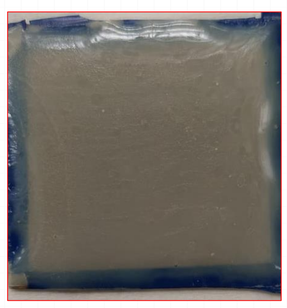
Corrosion Protection Mechanism





Nanocomposite coating system





Results and Discussion

Morphological and structural analysis

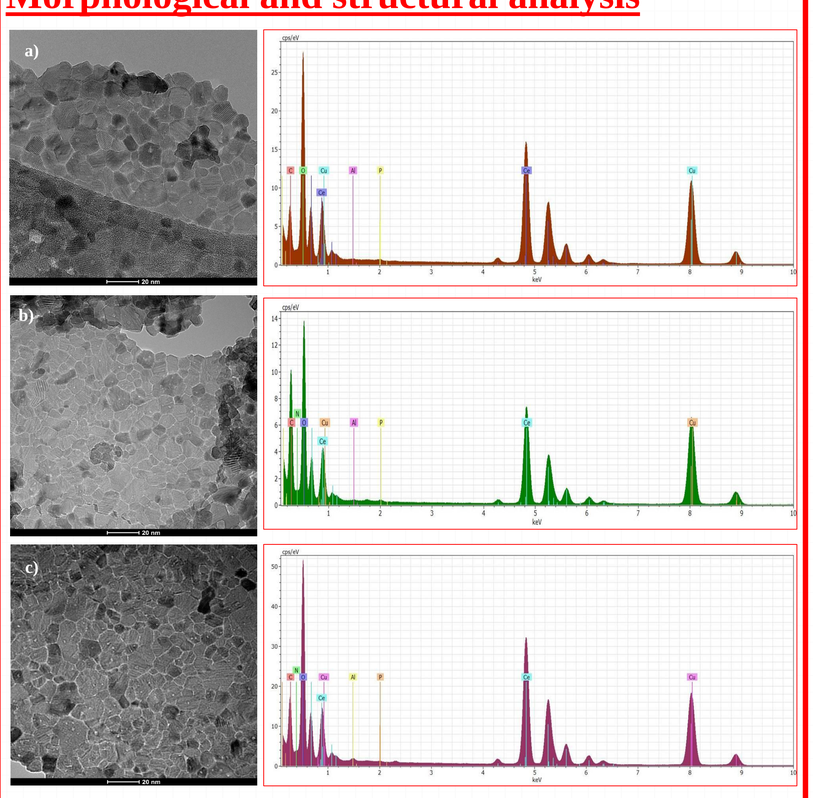


Figure 1: a), b) and c) TEM images of unmodified CeO_2 nanoconatiners and modified CeO_2/DDA as well as CeO_2/NMTU, and their respective EDS analysis.

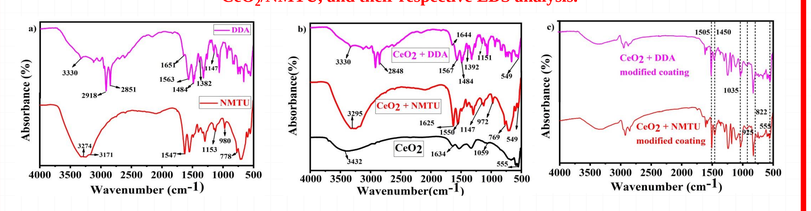


Figure 2: FTIR spectra of (a) as-received inhibitors (NMTU and DDA), (b) unmodified and modified CeO_2, and (c) nanocomposite smart coatings.

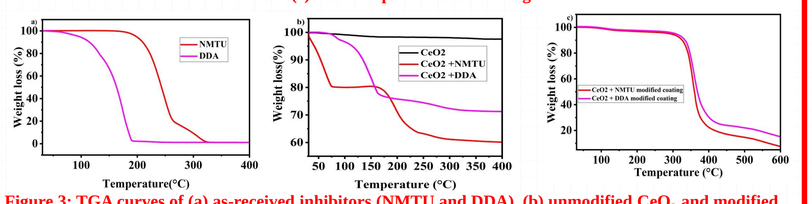


Figure 3: TGA curves of (a) as-received inhibitors (NMTU and DDA), (b) unmodified CeO_2 and modified CeO_2, and (c) Nanocomposite smart coating.

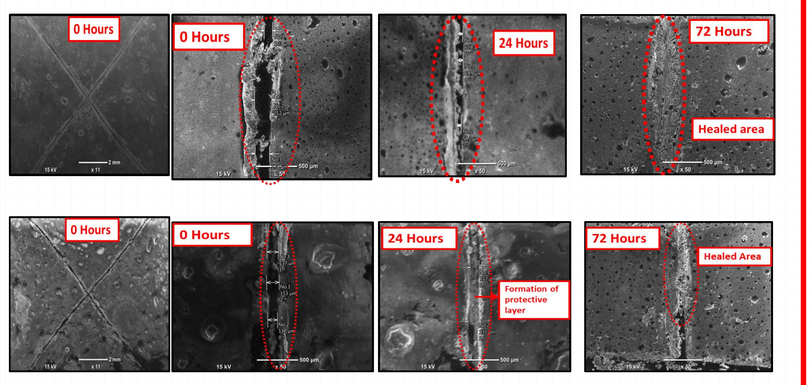
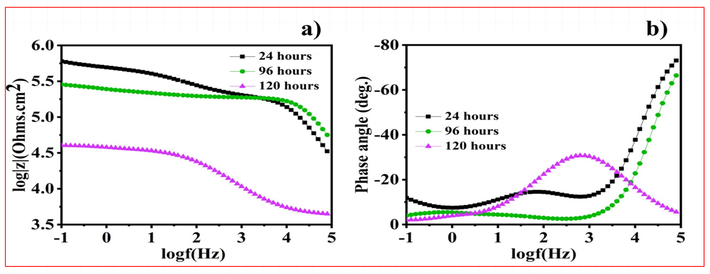


Figure 4: SEM images of the scratched reinforced CeO_2/DDA (left) and CeO/NMTU (right) epoxy coating at different time intervals (0, 24 and 72 h).

Corrosion inhibition behavior



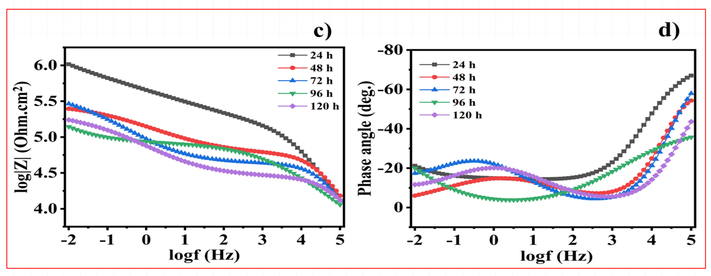
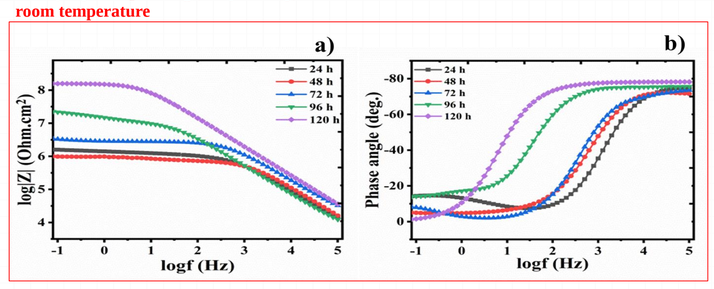


Figure 5: a, b) Bode and c, d) the corresponding phase angle plots for the scratched blank and epoxy/CeO_2 coatings, respectively, after different immersion times in 3.5 wt% NaCl at room temperature



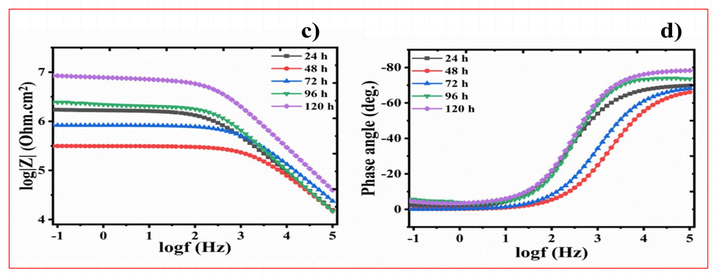


Figure 6: a and b) Bode and c and d) the corresponding phase angle plots for the scratched reinforced epoxy/CeO_2/DDA and epoxy/CeO_2/NMTU coatings, respectively, after different immersion times in 3.5 wt% NaCl at room temperature.

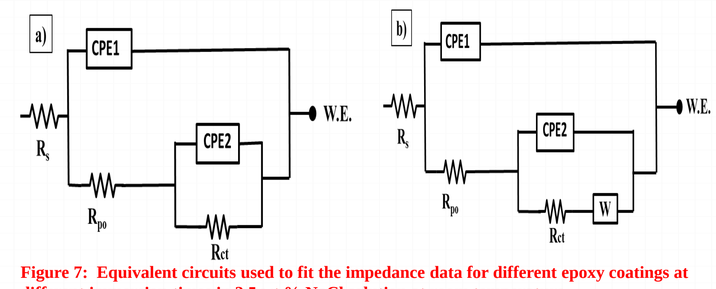


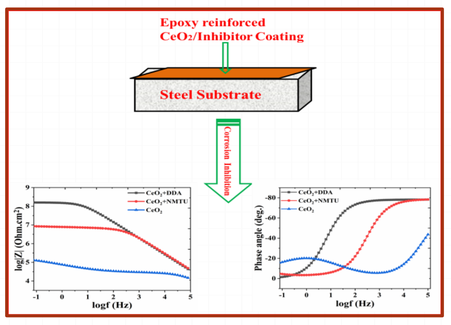
Figure 7: Equivalent circuits used to fit the impedance data for different epoxy coatings at different immersion times in 3.5 wt.% NaCl solution at room temperature.

Table 2. The obtained fitted electrochemical values of the EIS data for the different coated specimens immersed in 3.5 wt.% NaCl for different immersion times at room temperature.

Coatings	Time (days)	R_{po} (MΩ.cm²)	CPE_1 (F.cm⁻².S^n⁻¹)	R_{ct} (MΩ.cm²)	CPE_2 (F.cm⁻².S^n⁻¹)	W (MΩ.cm⁻².S^-1/2)
blank epoxy	1	0.185	1.608×10^{-7}	0.294	1.522×10^{-10}	-
	4	0.038	2.908×10^{-6}	0.068	1.206×10^{-9}	-
	5	0.033	7.701×10^{-5}	0.002	4.259×10^{-9}	-
Epoxy/CeO_2	1	0.075	1.459×10^{-6}	1.947	9.518×10^{-10}	-
	2	0.043	6.613×10^{-6}	0.266	1.048×10^{-9}	-
	3	0.055	3.710×10^{-6}	0.235	1.280×10^{-9}	-
	4	0.022	3.532×10^{-6}	0.166	1.408×10^{-9}	-
	5	0.028	6.562×10^{-6}	0.155	1.994×10^{-9}	-
Epoxy/CeO_2/DDA	1	0.705	4.794×10^{-8}	1.708	1.014×10^{-9}	-
	2	0.313	8.047×10^{-7}	1.408	2.175×10^{-9}	-
	3	0.966	1.628×10^{-9}	2.238	5.937×10^{-10}	2.83
	4	10.54	6.077×10^{-10}	9.123	2.289×10^{-10}	11.0
	5	42.77	8.101×10^{-11}	167.3	1.081×10^{-10}	47.5
Epoxy/CeO_2/NMTU	1	0.205	2.907×10^{-7}	1.125	1.885×10^{-9}	-
	2	0.013	3.969×10^{-7}	0.132	2.461×10^{-9}	-
	3	0.839	1.625×10^{-8}	0.695	6.962×10^{-10}	1.70
	4	1.076	3.627×10^{-9}	1.831	4.471×10^{-10}	10.5
	5	1.614	1.233×10^{-9}	6.892	1.145×10^{-10}	13.5

Summary

- FTIR analysis confirmed the successfully loading of the inhibitors in CeO_2 nanoparticles.
- TGA measurements clarified the loading amount of inhibitors by weight loss measurements.
- SEM analysis investigated the release of the inhibitors and formation of the protective layer at the scratched area.
- Exceptional protection efficiency reaching 99.8 and 95.7% for the modified epoxy coating with DDA and NMTU, respectively.



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Refernces:

1. A.A. Nazeer, M. Madkour, Potential use of smart coatings for corrosion protection of metals and alloys: A review, J. Mol. Liq. 253 (2018) 11–22. doi:10.1016/j.molliq.2018.01.027.
2. TomaszLiskiewicz/functional-surfaces-for-corrosion-protection-current-challenges-and-future-trends