Graduate Students, Energy and Environment

Self-Healing Performance of Smart Polymeric Coatings Modified with Tung Oil and Linalyl Acetate

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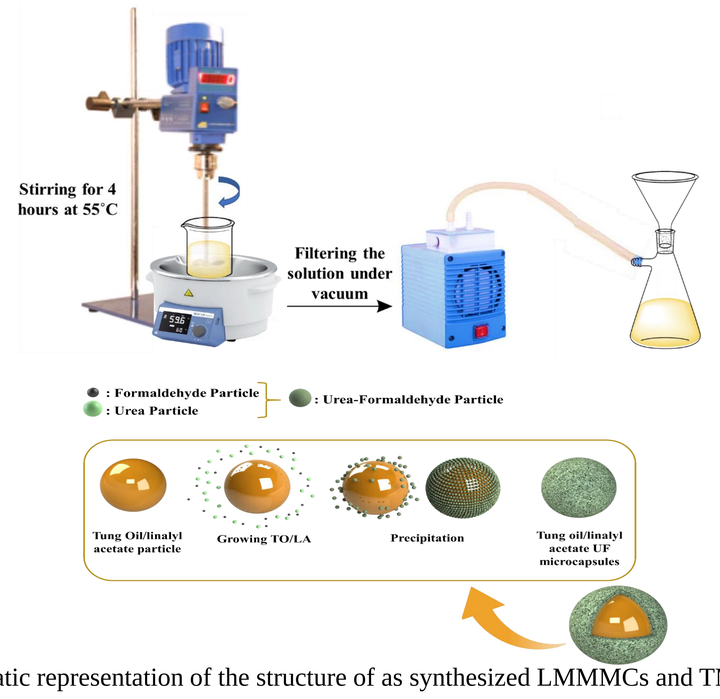
Abstract

This work focuses on the synthesis and characterization of polymeric smart self-healing coatings. A comparison of structural, thermal, and self-healing properties of two different polymeric coatings comprising distinct self-healing agents (tung oil and linalyl acetate) is studied to elucidate the role of self-healing agents in corrosion protection. Towards this direction, urea-formaldehyde microcapsules (UFMCs) loaded with tung oil (TMMCs) and linalyl acetate (LMMCs) were synthesized using the in-situ polymerization method. The synthesis of both LMMCs and TMMCs under identical experimental conditions (900 rpm, 55 ◦C) has resulted in a similar average particle size range (63–125 μm). The polymeric smart self-healing coatings were developed by reinforcing a polymeric matrix separately with a fixed amount of LMMCs (3 wt.% and 5 wt.%), and TMMCs (3 wt.% and 5 wt.%) referred to as LMCOATs and TMCOATs, respectively. The development of smart coatings (LMCOATs and TMCOATs) contributes to achieving decent thermal stability up to 450 ◦C. Electrochemical impedance spectroscopy (EIS) analysis indicates that the corrosion resistance of smart coatings increases with increasing concentration of the microcapsules (TMMCs, LMMCs) in the epoxy matrix reaching ~1 GΩ. As a comparison, LMCOATs containing 5 wt.% LMMCs demonstrate the best stability in the barrier properties than other developed coatings and can be considered for many potential applications.

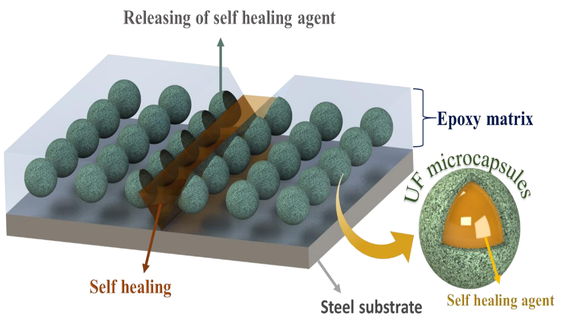
Experimental



Schematic representation of the structure of as synthesized LMMMCs and TMMCs

Preparation of Coatings

- Coatings containing LMMCs and TMMCs were prepared using 3.0 wt% and 5.0wt% of microcapsules for comparison.
- The coatings were subjected to a controlled damage, self healing and corrosion resistance was analyzed after different time interval.



Schematic diagrams of smart coatings

Result and Discussion

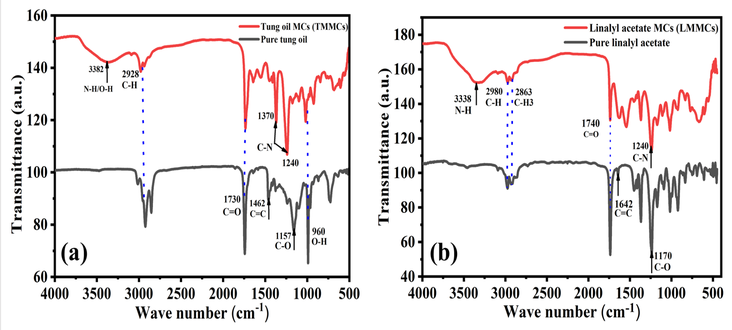


Fig. 1: FTIR spectra of (a) pure linalyl acetate and LMMCs (b) pure tung oil and TMMCs

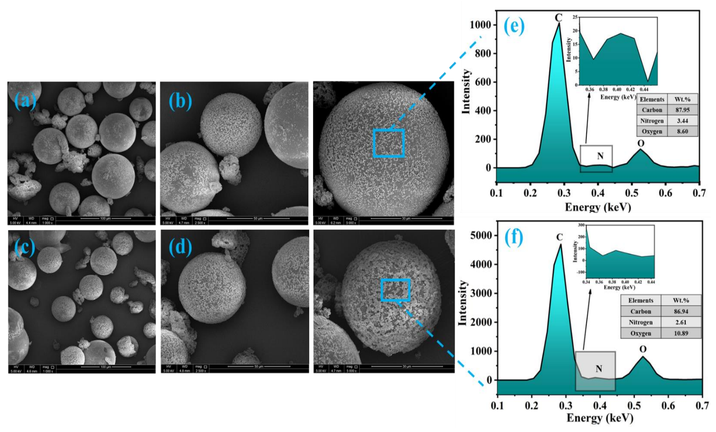


Fig. 2: Surface morphology of the microcapsules at different resolution (a, b) urea-formaldehyde microcapsules loaded with linalyl acetate-LMMCs (c, d) urea-formaldehyde microcapsules loaded tung oil-TMMCs d (e, f) EDX analysis of LMMCs and TMMCs.

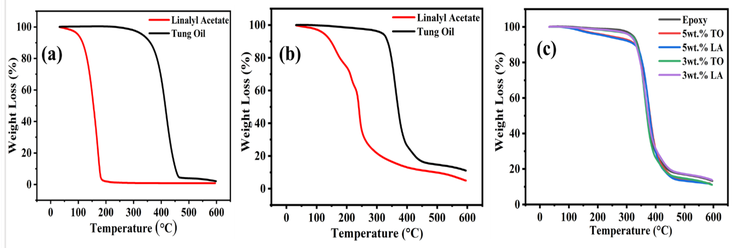


Fig.3: TGA results; (a) pure LA and TO, (b)urea-formaldehyde microcapsules loaded with linalyl acetate-LMMCs and urea-formaldehyde microcapsules loaded with tung oil-TMMCs, (c) Reference coatings and TMCOATs and LMCOATs.

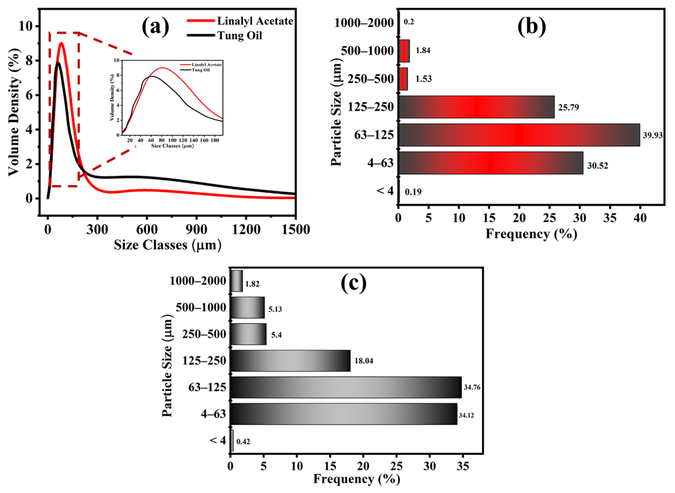


Fig. 4: Particle size analysis. (**a**) Gaussian particle size distribution in LMMCs and TMMCs, (**b**) bar chart showing distribution of LMMCs and (**c**) bar chart showing distribution of TMMCs.

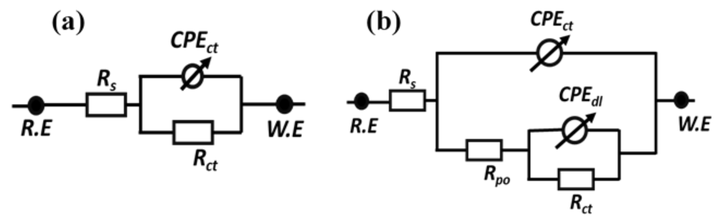


Fig. 5: Equivalent circuits used to fit the electrochemical impedance spectroscopy data (**a**) reference coatings (**b**) TMCOATs and LMCOATs.

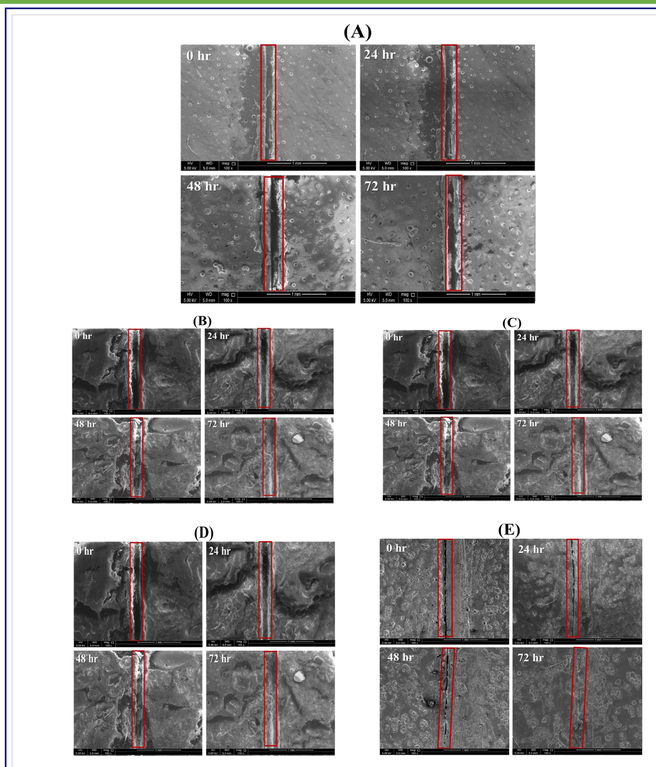


Fig. 6: Self-healing analysis of smart coatings at various time intervals, (A) Reference coating (plain epoxy), (B) 3wt% TMCOATs, (C) 3wt% LMCOATs, (D) 5wt% LMCOATs and (E) 5wt% TMCOATs

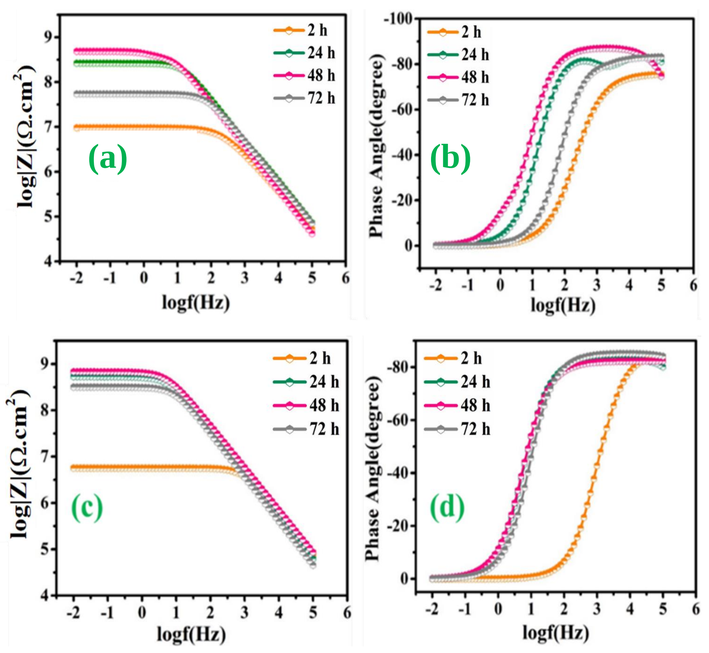


Fig. 7: (a) Bode graph of 5 wt.% TMMCs (b) phase angle graph 5 wt.% TMMCs, (c) Bode graph of 5 wt.% LMMCs, (d) phase angle graph 5 wt.% LMMCs.

Conclusion

- Self-healing smart coatings (TMCOATs and LMCOATs) containing 3 wt.% and 5 wt.% TMMCs and LMMCs were respectively developed and characterized.
- The developed smart coatings demonstrate superior corrosion resistance when compared to the reference coatings.
- The self-healing characteristics of smart coating are sensitive to the concentration of TMMCs and LMMCs.
- Comparatively, LMCOATs exhibit more stable barrier properties reaching ~1Gohm, when compared with other smart coatings depicting their usefulness for some industrial applications.

Acknowledgment

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