

Hybrid microcapsules reinforced smart coatings for corrosion protection in oil and gas industry

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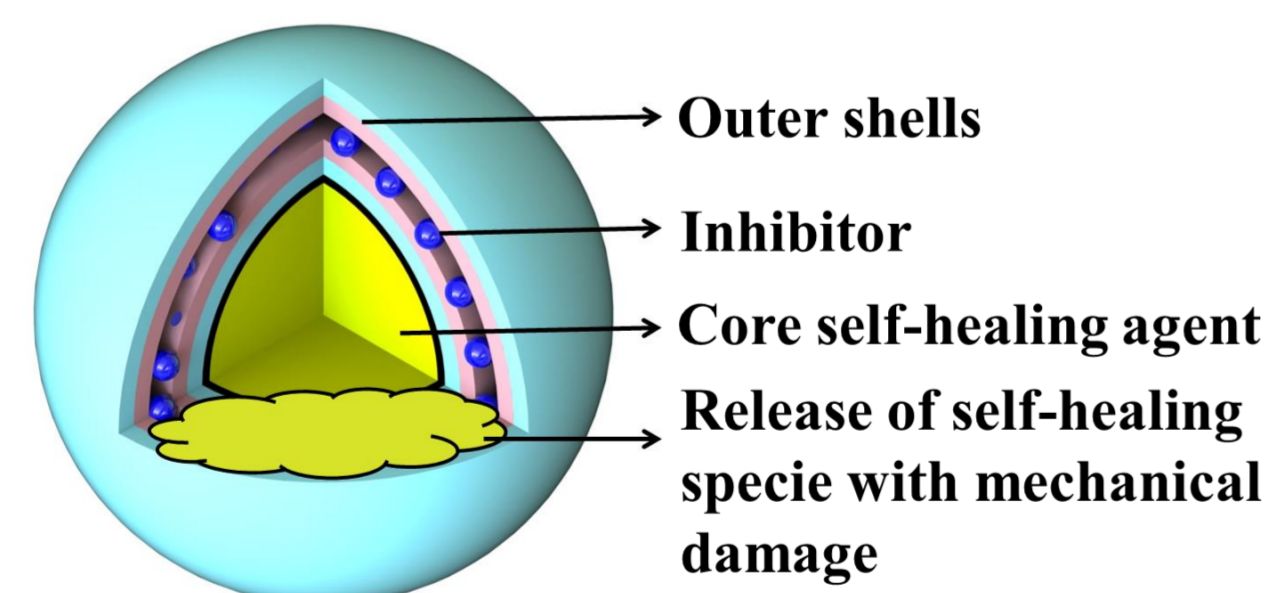
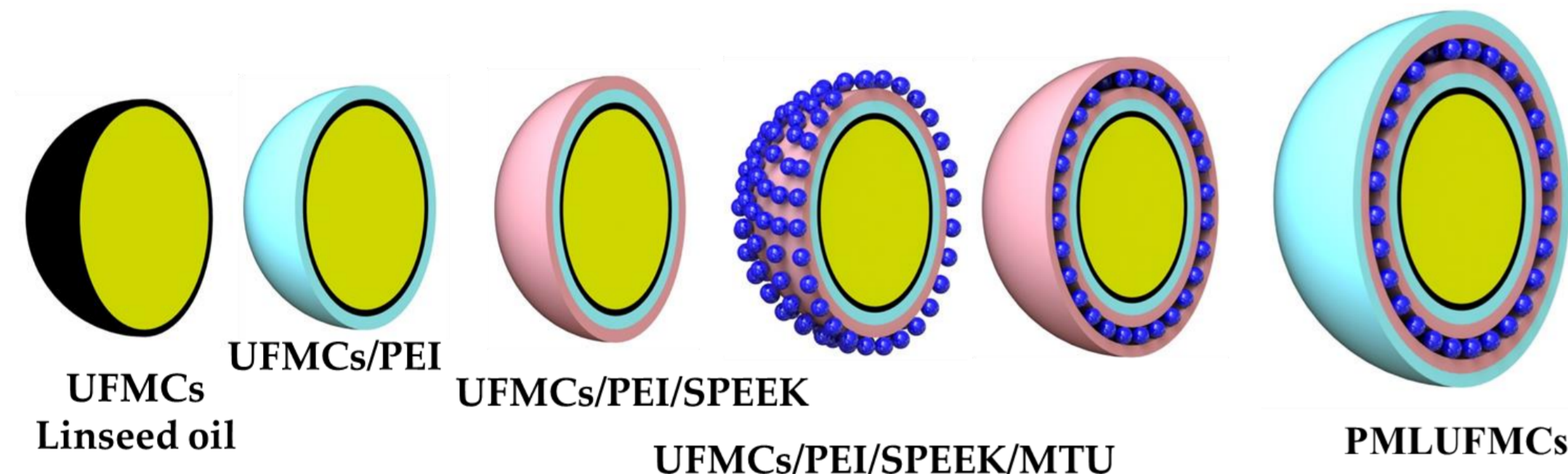
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Abstract

Materials and equipment failure in the oil and gas industry is usually observed because of corrosion. According to one survey, about 1/4 to 1/3 of the total downtime in plants is contributed due to deleterious effects of corrosion. It is, therefore, essential to prevent corrosion to ensure reliability of the assets.

The current research work summarizes the synthesis and characterization of polymeric smart coatings developed by reinforcing monolayer urea formaldehyde microcapsules (MLMCs) and polyelectrolyte multi-layered microcapsules (PMCs) into epoxy matrix. In situ polymerization technique was used for the synthesis of MLMCs encapsulated with linalyl acetate whereas layer by layer technique was adopted to develop PMCs containing alternative layers of Polyethyleneimine (PEI) and sulphonated polyether ether ketone (SPEEK). Phenylthiourea (PTU) was loaded as an inhibitor in between polyelectrolyte layers of PEI and SPEEK. The prepared MLMCs and PMCs (each 6.0 wt.%) were uniformly dispersed into the epoxy resin to develop single layer smart coatings (SLSCs) and multi-layered smart coatings (MLSCs) respectively. Experimental results confirm that MLSCs demonstrate improved self-healing and anti-corrosion properties when compared to SLSCs. This improvement can be attributed to efficient release of self-healing and corrosion inhibiting species from the PMCs.

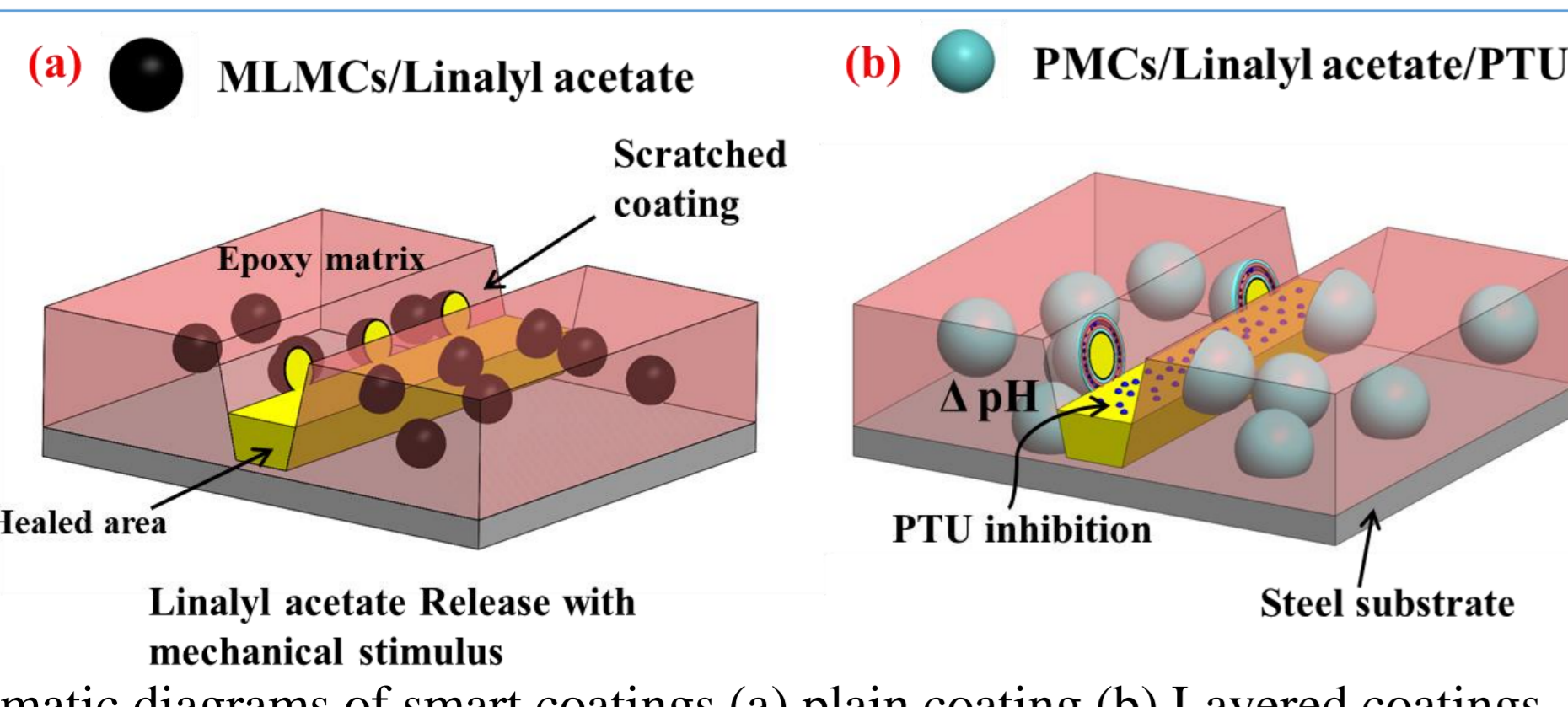
Experimental



Schematic representation of the structure of as synthesized layered microcapsules

Preparation of Coatings

- Coatings containing MLMCs and PMCs were prepared using 6.0wt% for direct comparison.
- The thickness of the coatings was 200µm approximately.
- The coatings were subjected to a controlled damage, self-healing and corrosion resistance was analyzed after different time intervals.



Schematic diagrams of smart coatings (a) plain coating (b) Layered coatings

Result and Discussion

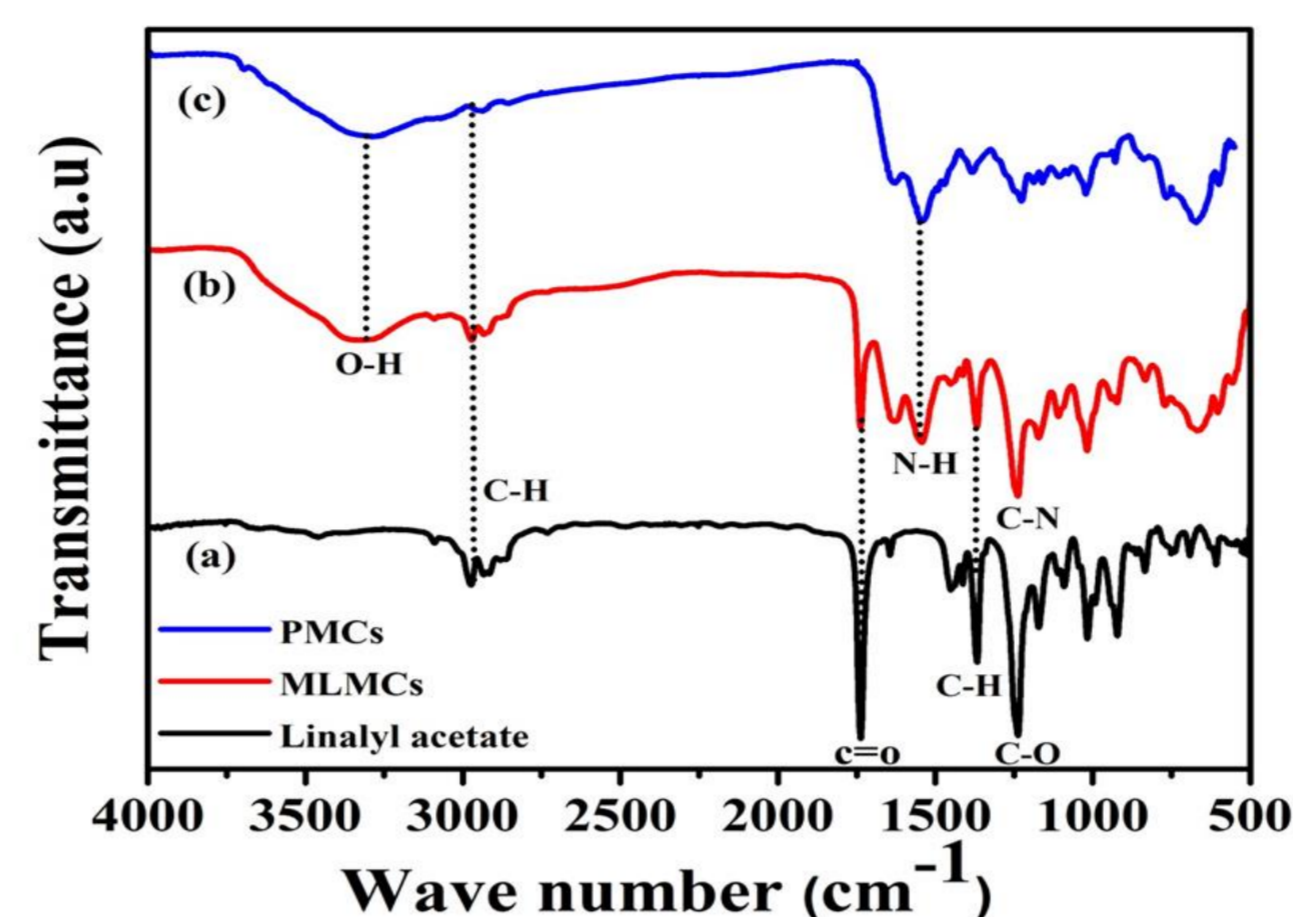


Fig. 1: FTIR spectra of the (a) linalyl acetate (b) MLMCs loaded with linalyl acetate (c) and PMCs

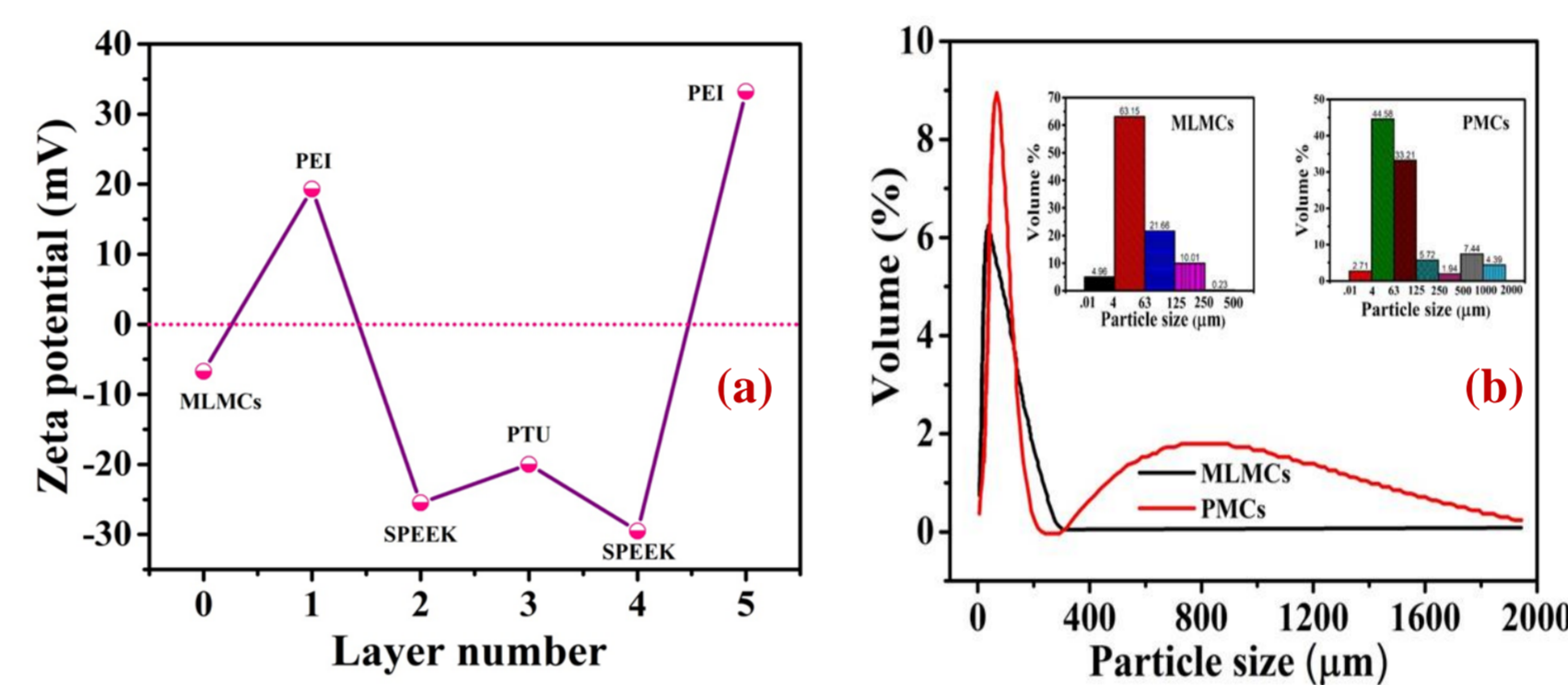


Fig. 2: (a) Zeta potential measurements, (b) Particle size analysis

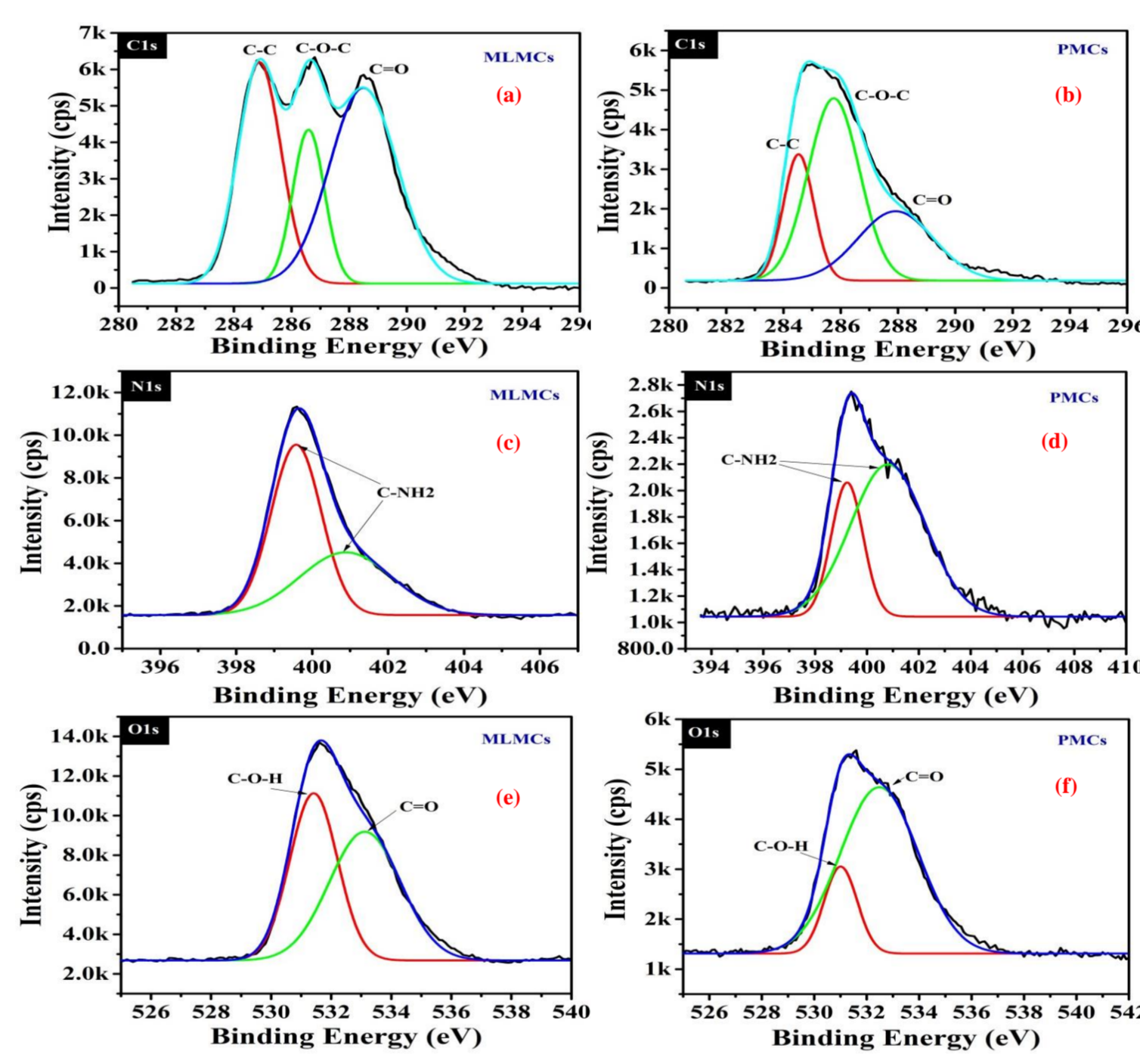


Fig. 3: XPS survey spectra of MLMCs and PMCs samples: (a, b) C1s, (c, d) N1s, (e, f) O1s

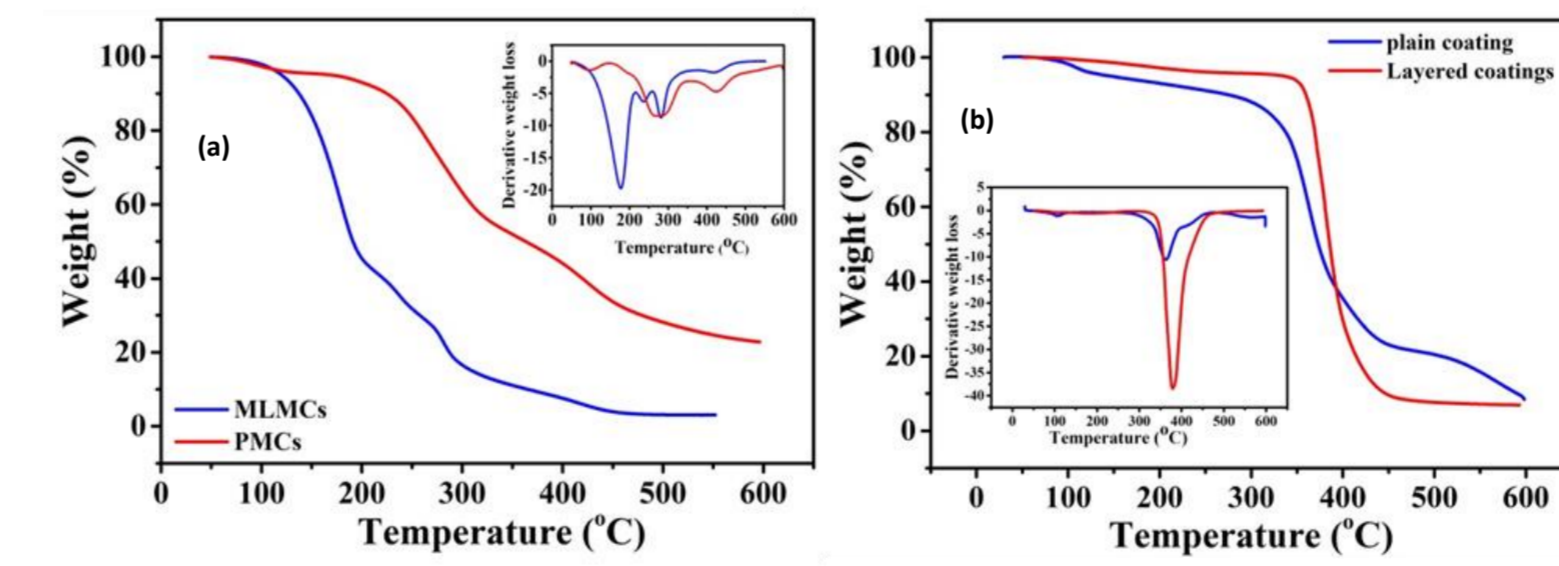


Fig. 4: Thermal stability analysis (TGA) of (a) MLMCs and PMCs (b) the plain and layered coatings

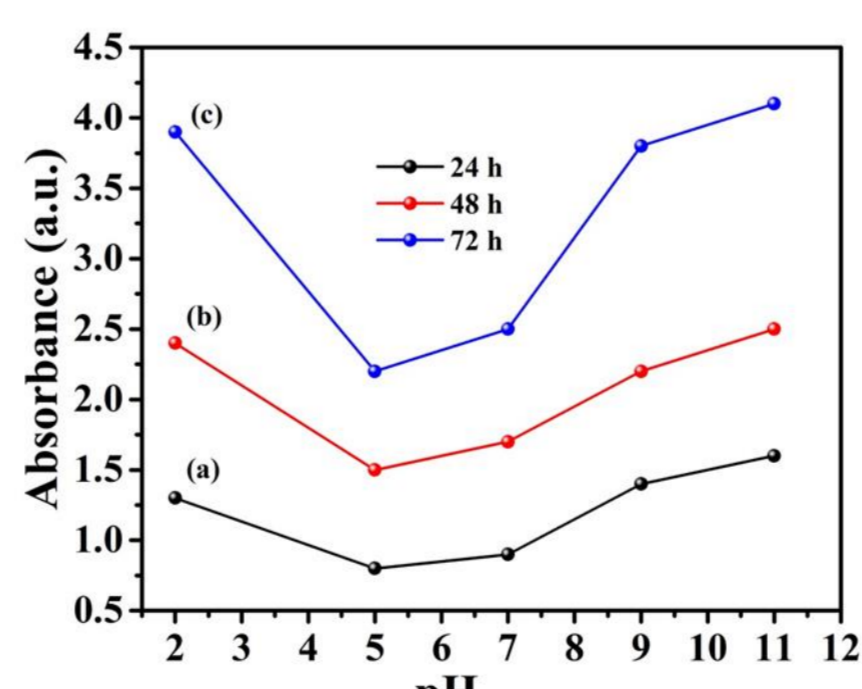


Fig. 5: UV spectroscopy of polyelectrolyte multilayered microcapsules after (a) 24 h (b) 48 h (c) 72 h of the immersion in 0.1 M NaCl solution with different pH values.

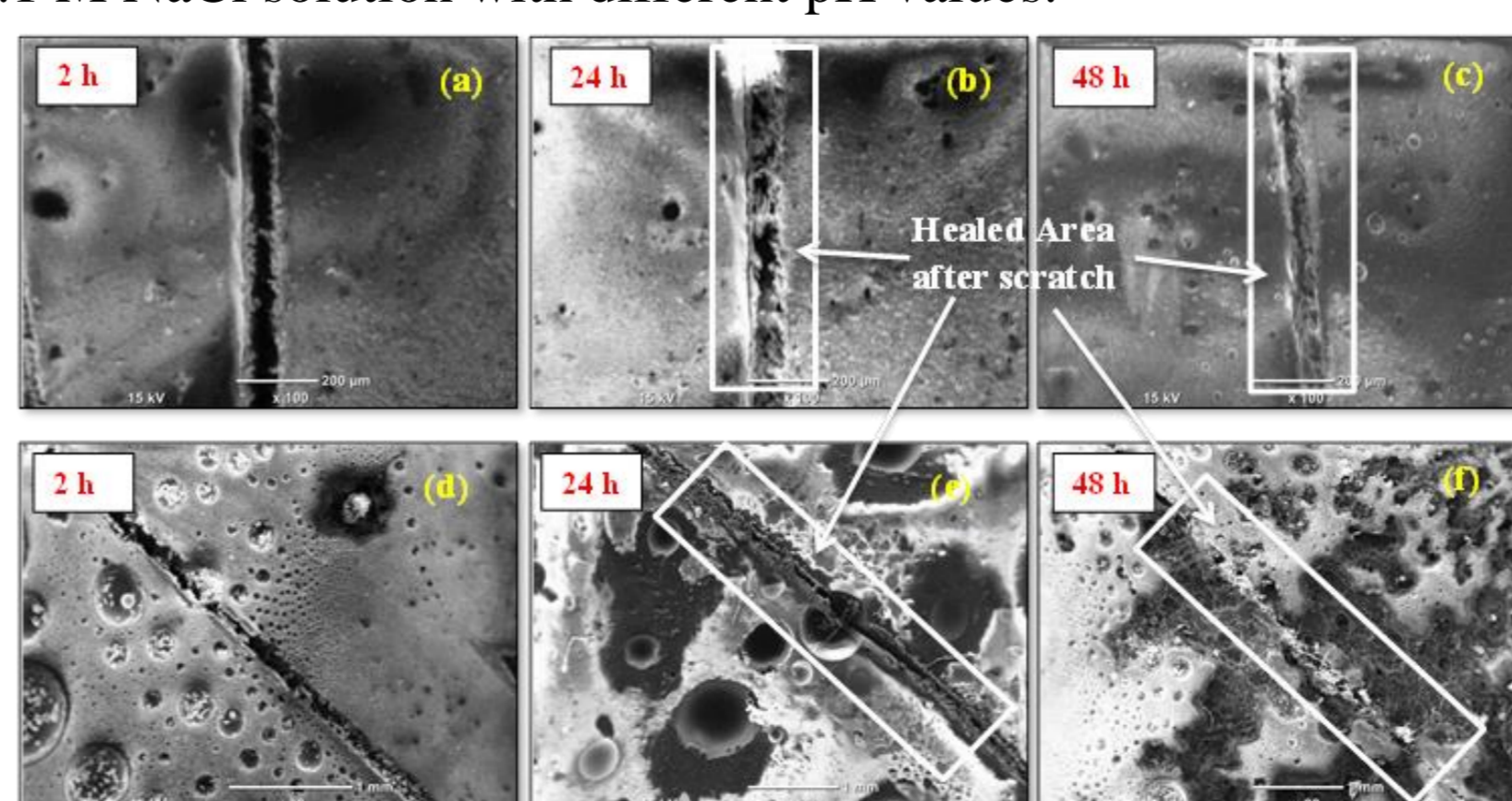


Fig. 6: SEM images of the scratched samples (a, b, c) MLMCs and (d, e, f) PMCs after different time intervals.

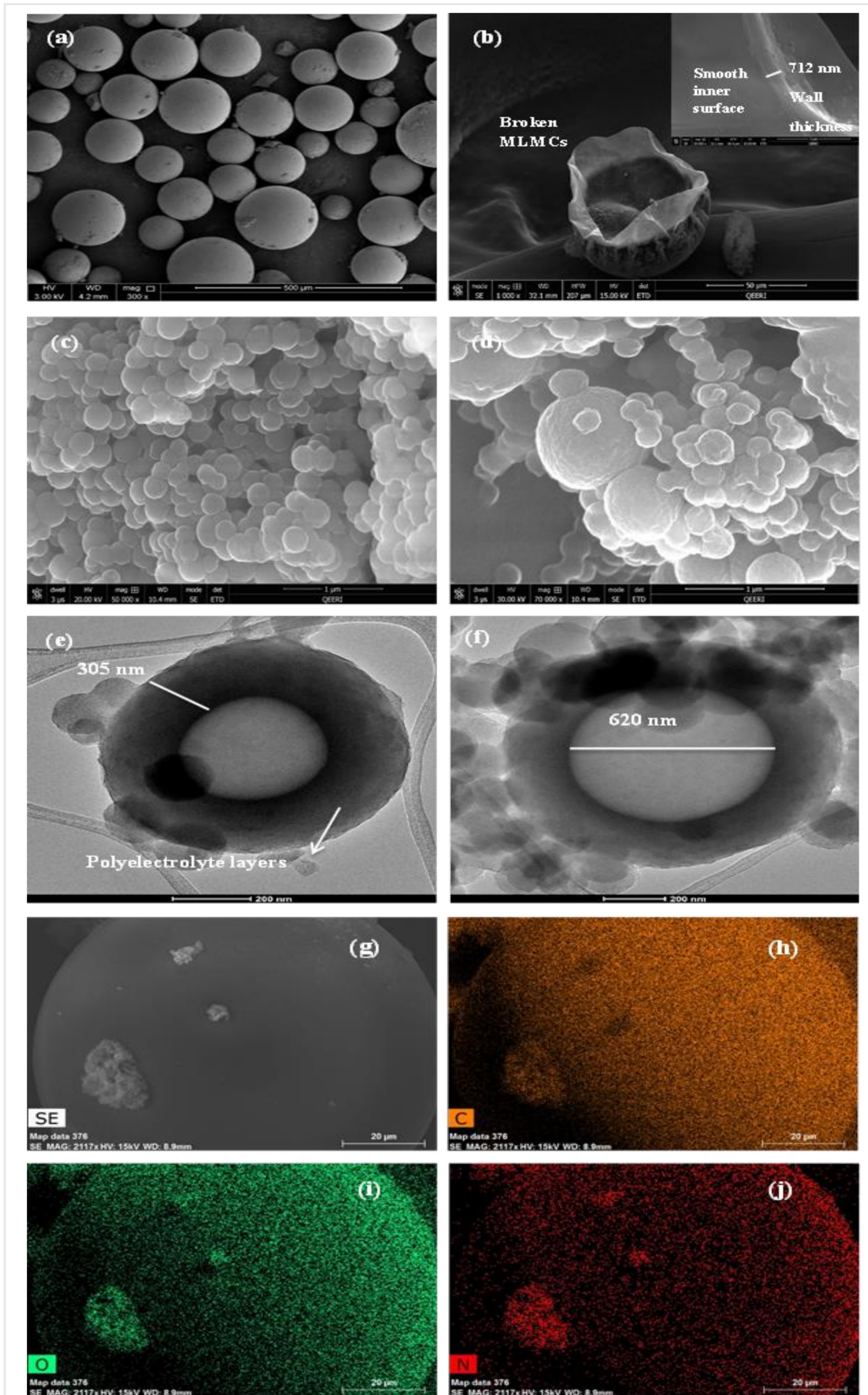


Fig. 7: The structural and morphological study of the synthesized microcapsules (a, b) SEM of the UF microcapsules (c, d) the SEM of the multilayered microcapsules (e, f) TEM of the multilayered microcapsules. (g, h, i, j) elemental mapping of MLMCs

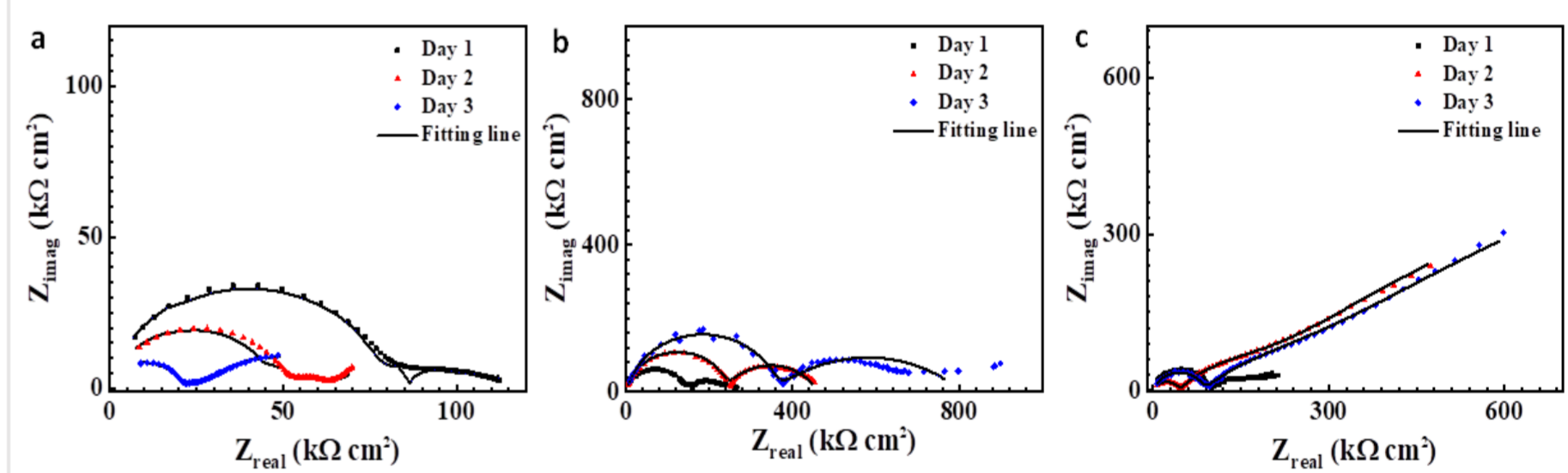
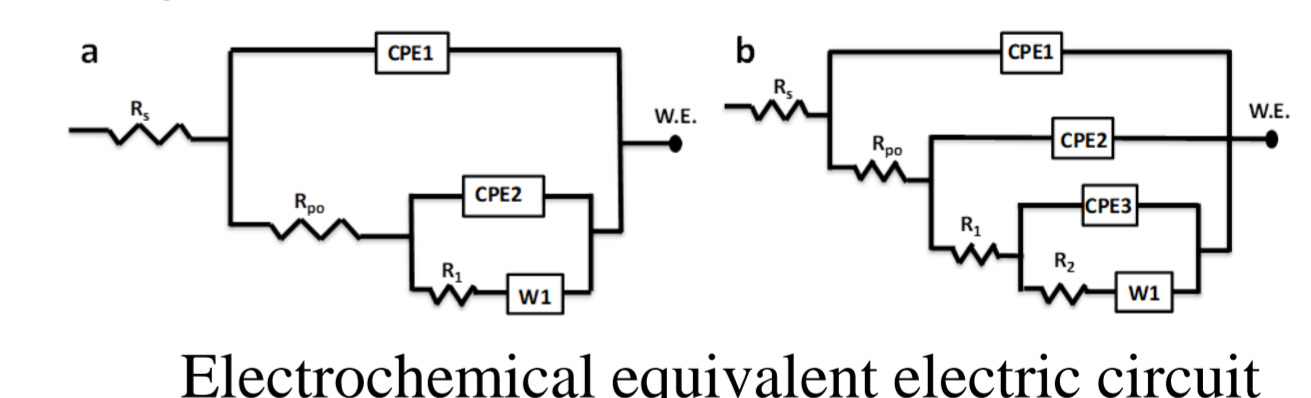


Fig. 8: Experimental Nyquist plots and respective fittings (solid lines) for different coatings immersed in 3.5% NaCl solution for different exposure times (a) neat coating, (b) plain coating, and (c) layered coatings.



Electrochemical equivalent electric circuit

Conclusion

- MLMCs and PMCs were prepared and used as additives to modify epoxy coatings for corrosion protection of steel.
- It is concluded that the modified coatings with PMCs show improved thermal and anticorrosive performance.
- The enhanced corrosion protection can be attributed to the release of the self-healing agent (linalyl acetate) stored in the core of the capsules and corrosion inhibitor (Phenylthiourea) stored between layers.

Acknowledgment

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