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Double layered polymeric coatings for corrosion protection of steel

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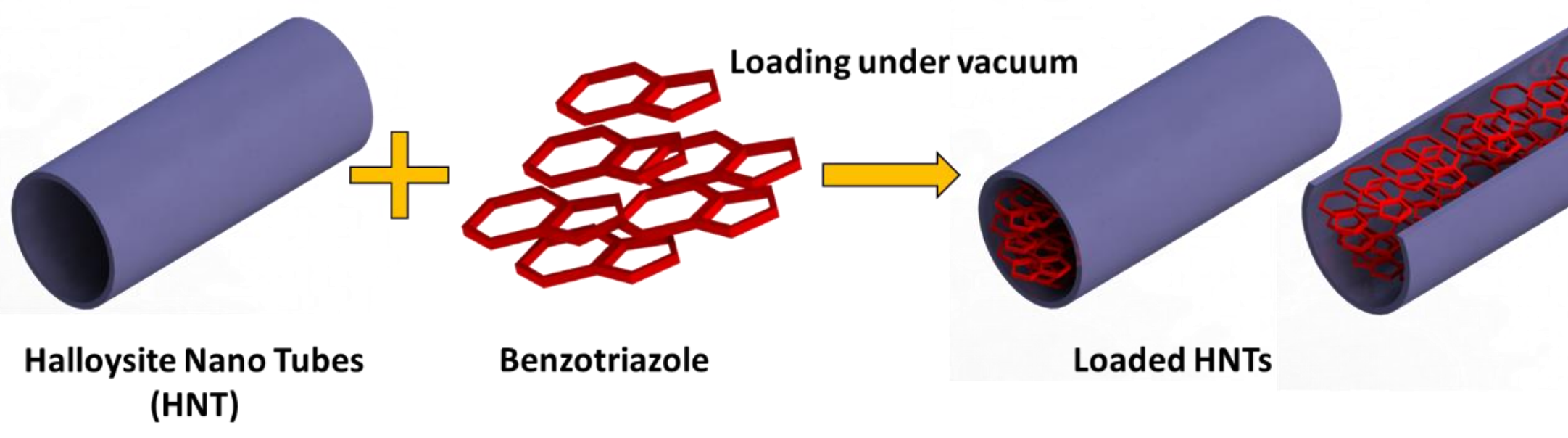
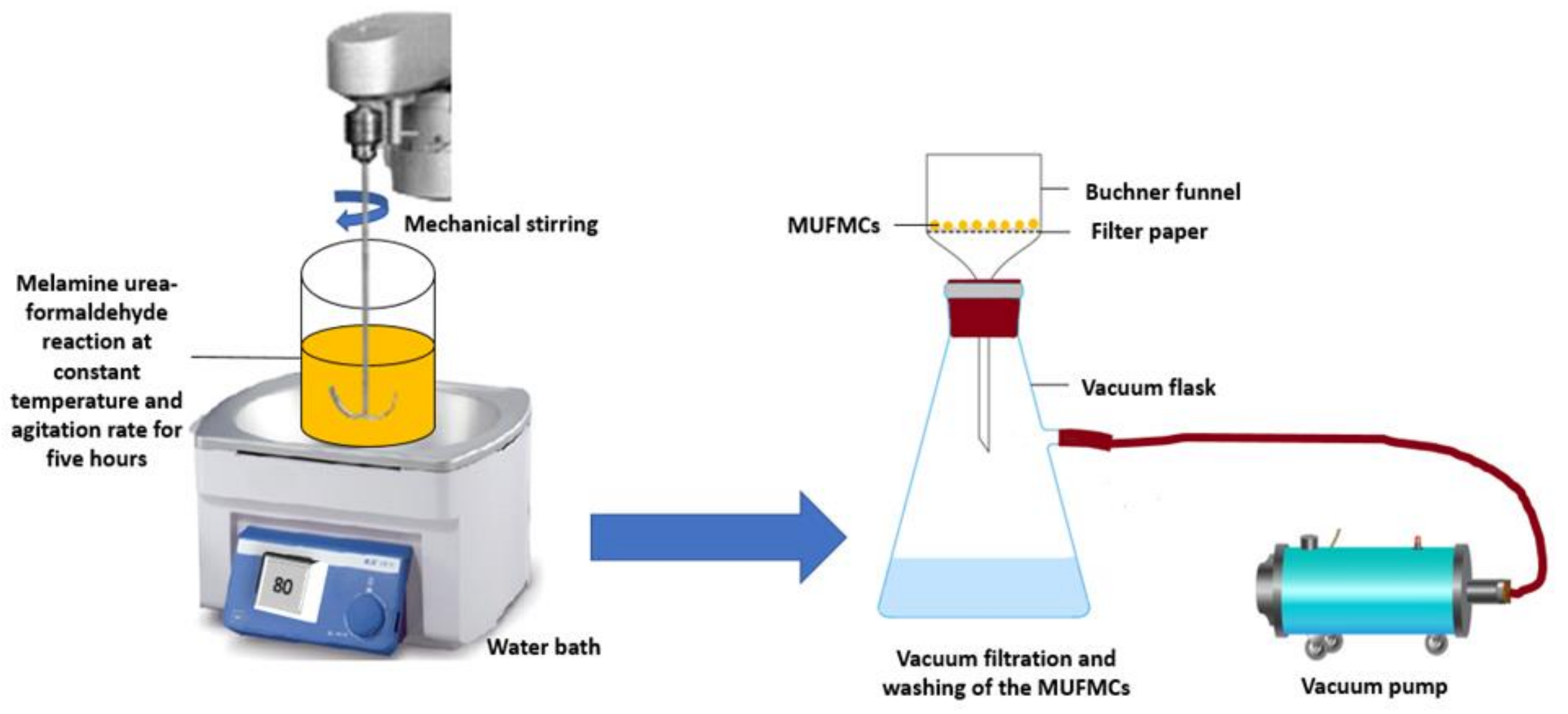
Abstract

Corrosion is one of the challenging issues faced by many industries, causing substantial economic losses every year due to the degradation of metallic parts and raising many safety concerns. Therefore, it is of utmost relevance to developing strategies that can repair the damaged part of the coatings to protect the base metal and restrict the initiation of corrosion. Towards this direction, the concept of double-layered polymeric coatings (DLPCs) for corrosion protection is introduced as a novel strategy to bring different healing functionalities into coating matrices. The developed DLPCs are composed of a top layer containing 5wt. % of melamine urea-formaldehyde microcapsules (MUFMC) encapsulating boiled linseed oil (self-healing agent), and bottom layer having 3wt. % benzotriazole (corrosion inhibitor) loaded into halloysite nanotubes (HNTs). The DLPCs were developed on mild steel substrate employing a doctor blade technique. The electrochemical analyses indicate that The DLPCs demonstrate improved corrosion resistant properties. This improved performance can be ascribed to the efficient triggering of the individual carriers in the quarantined matrix, resulting in enhanced corrosion efficiency of the DLPCs. The promising characteristics of DLPCs make them suitable for many potential industrial applications.

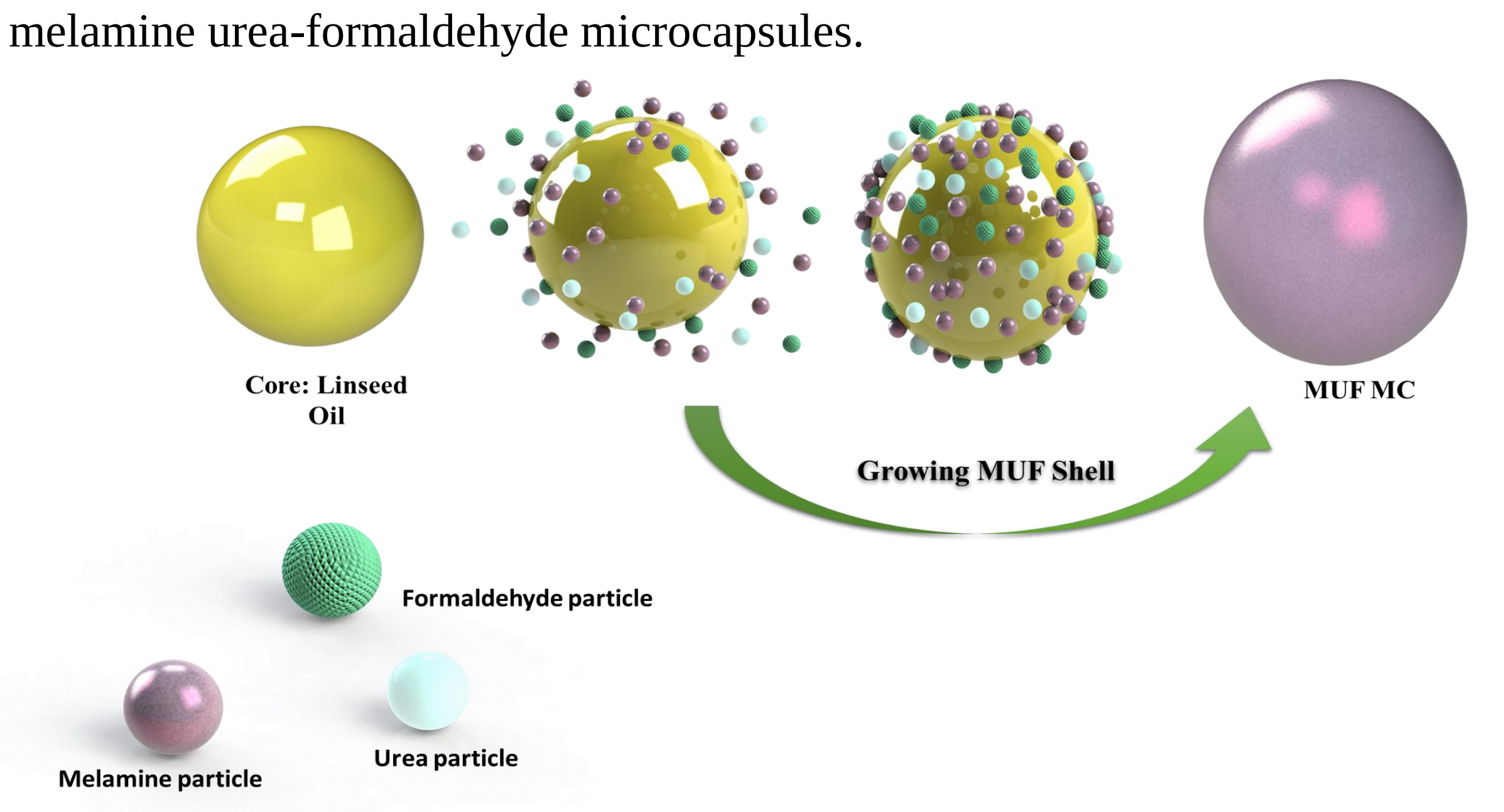
Experimental



Schematic representation of loading benzotriazole into as-received HNTs.

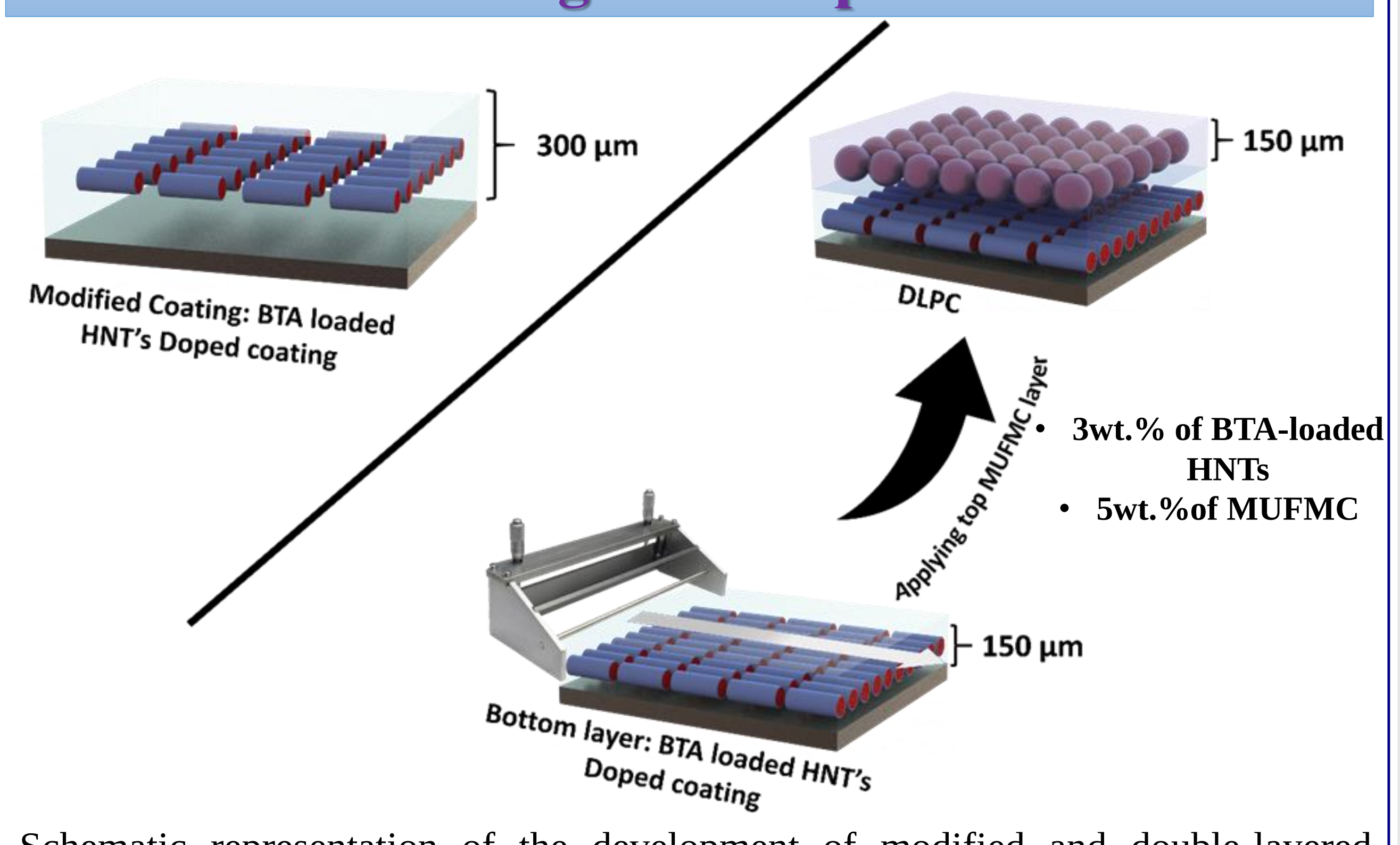


Schematic representation of the experimental set-up for the synthesis of melamine urea-formaldehyde microcapsules.



Schematic representation of encapsulation of linseed oil by melamine urea-formaldehyde shell process.

Coatings' development



- 3wt.% of BTA-loaded HNTs
- 5wt.%of MUFMC

Schematic representation of the development of modified and double-layered polymeric coatings with doctor blade technique

Results and discussion

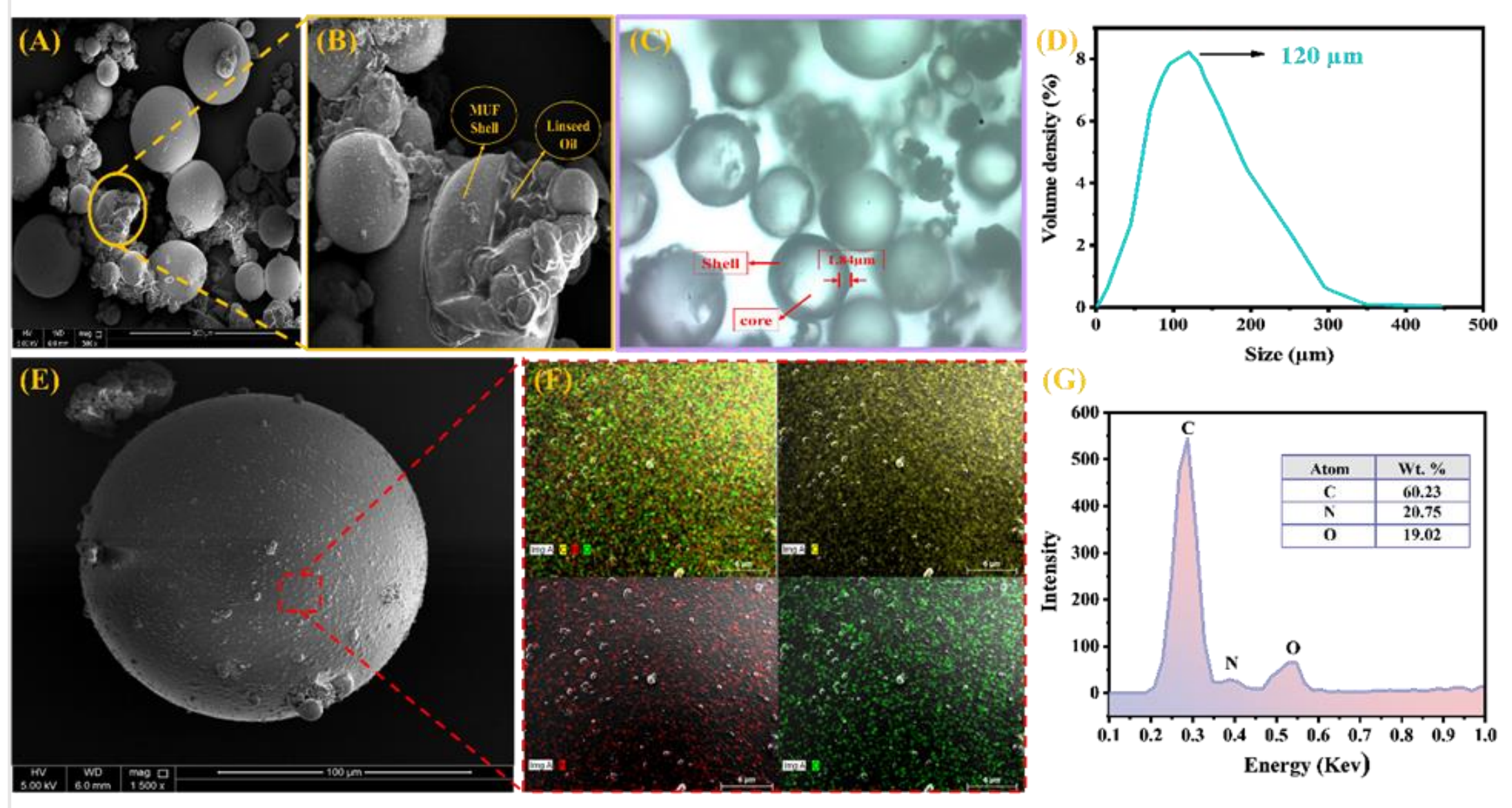


Figure 1: MUFMCs' SEM (A, B, E), Optical microscope images (C), particle size distribution (D), elemental mapping (F), and EDX (G).

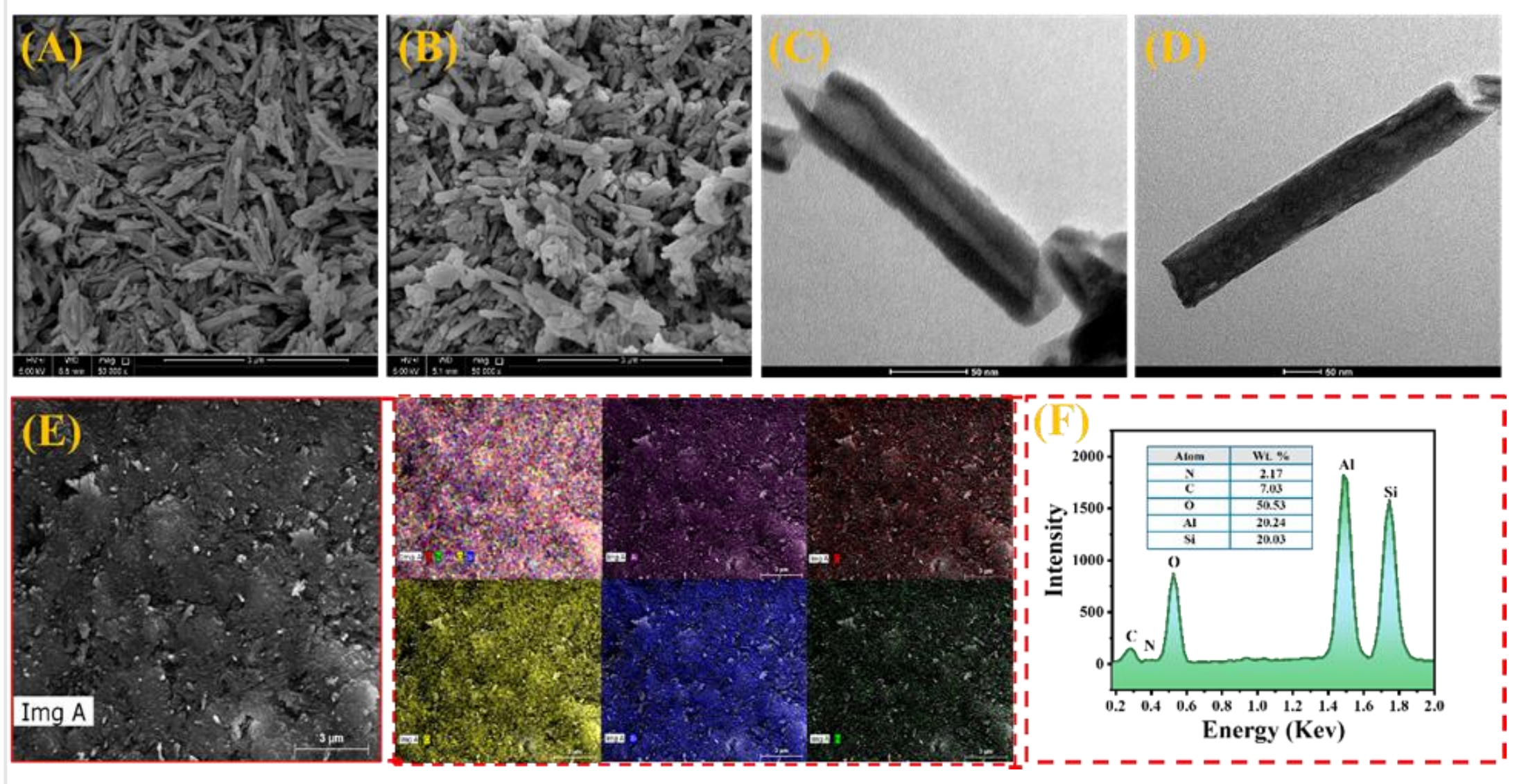


Figure 2: SEM of; HNT (A), BTA-loaded HNT (B), Bulk of BTA-loaded HNT with elemental mapping (E). BTA-Loaded HNTs' EDX (F). TEM of; HNT (C), BTA-loaded HNT (D).

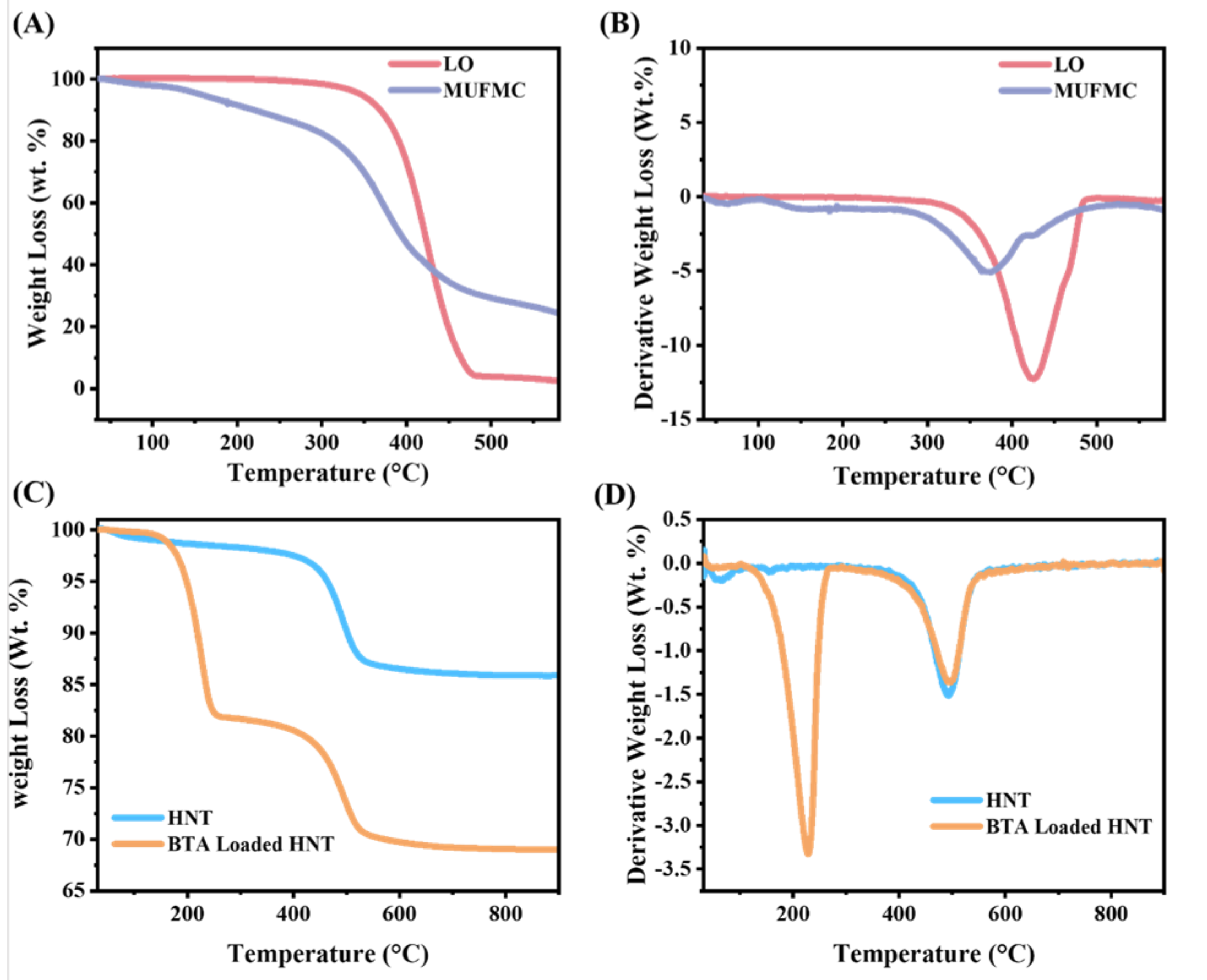


Figure 3: TGA of; LO and MUFMC (A), HNT and BTA-Loaded HNT (C). DTA of; LO and MUFMC (B), HNT and BTA-Loaded HNT (D).

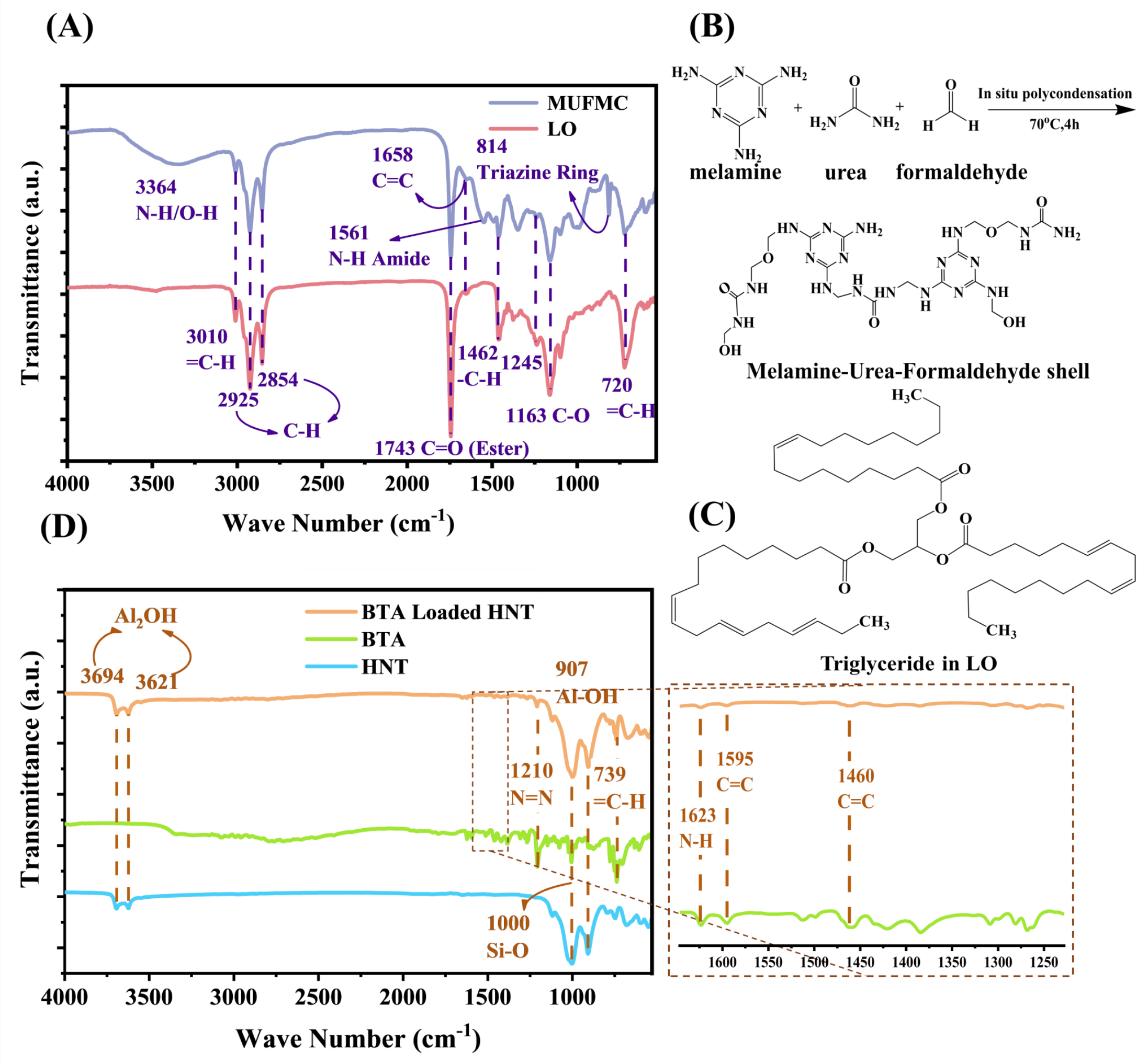


Figure 4: : FT-IR Spectra of; MUFMCs and LO (A), HNT, BTA, and BTA-loaded HNT (D), the chemical structure of; LO (B), Melamine Urea Formaldehyde shell(C).

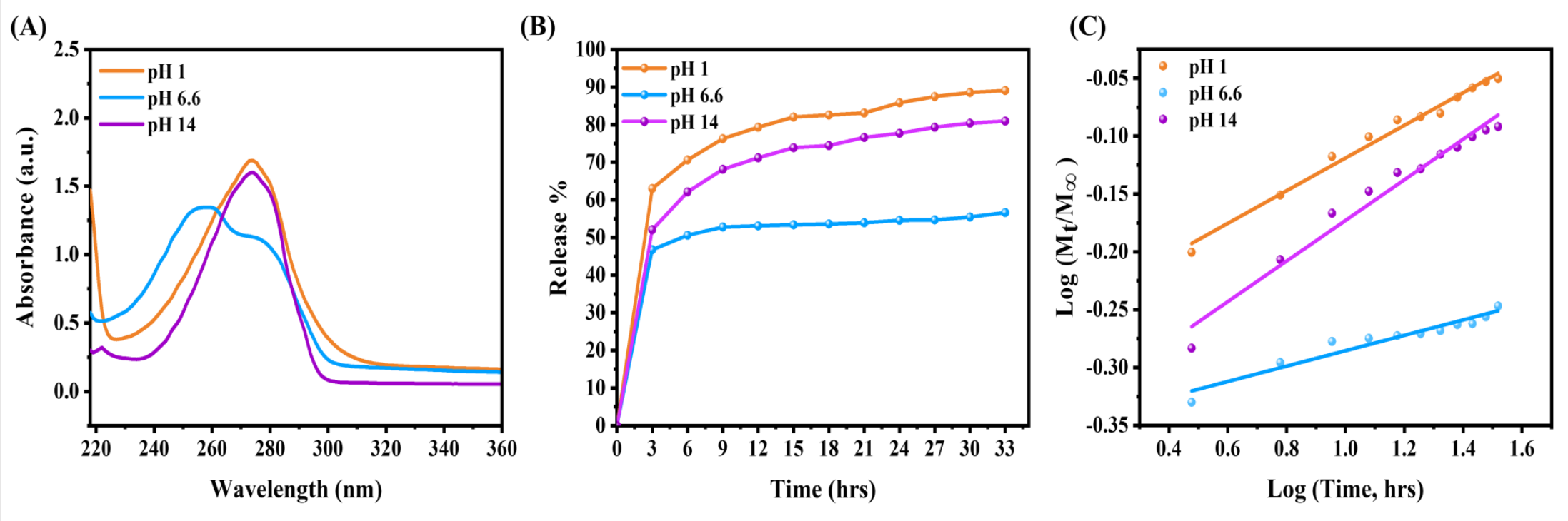


Figure 5: BTA-loaded HNT under acidic, neutral, and basic mediums'; UV-Vis spectra (A), release % profile (B), and release kinetics fitted based on Korsmeyer-Peppas equation (C).

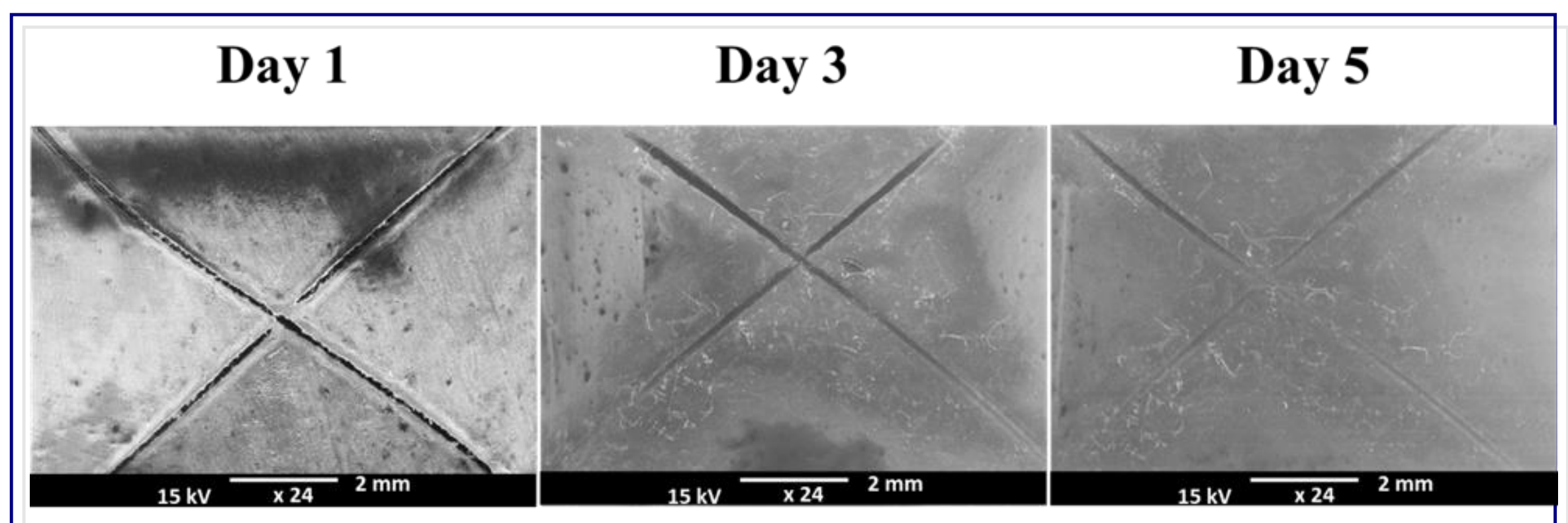


Figure 6: SEM of DLPC's self-healing behavior for five days.

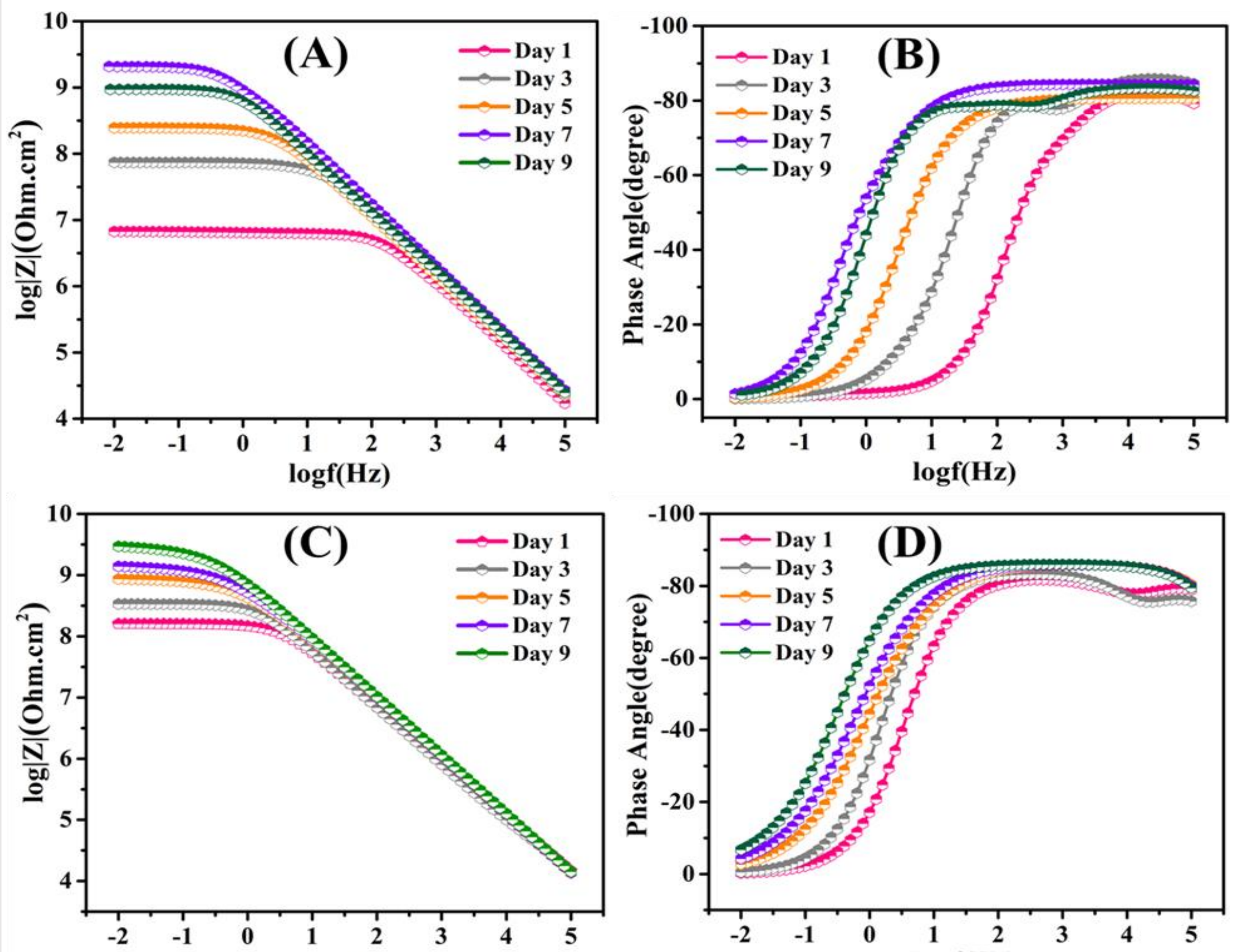
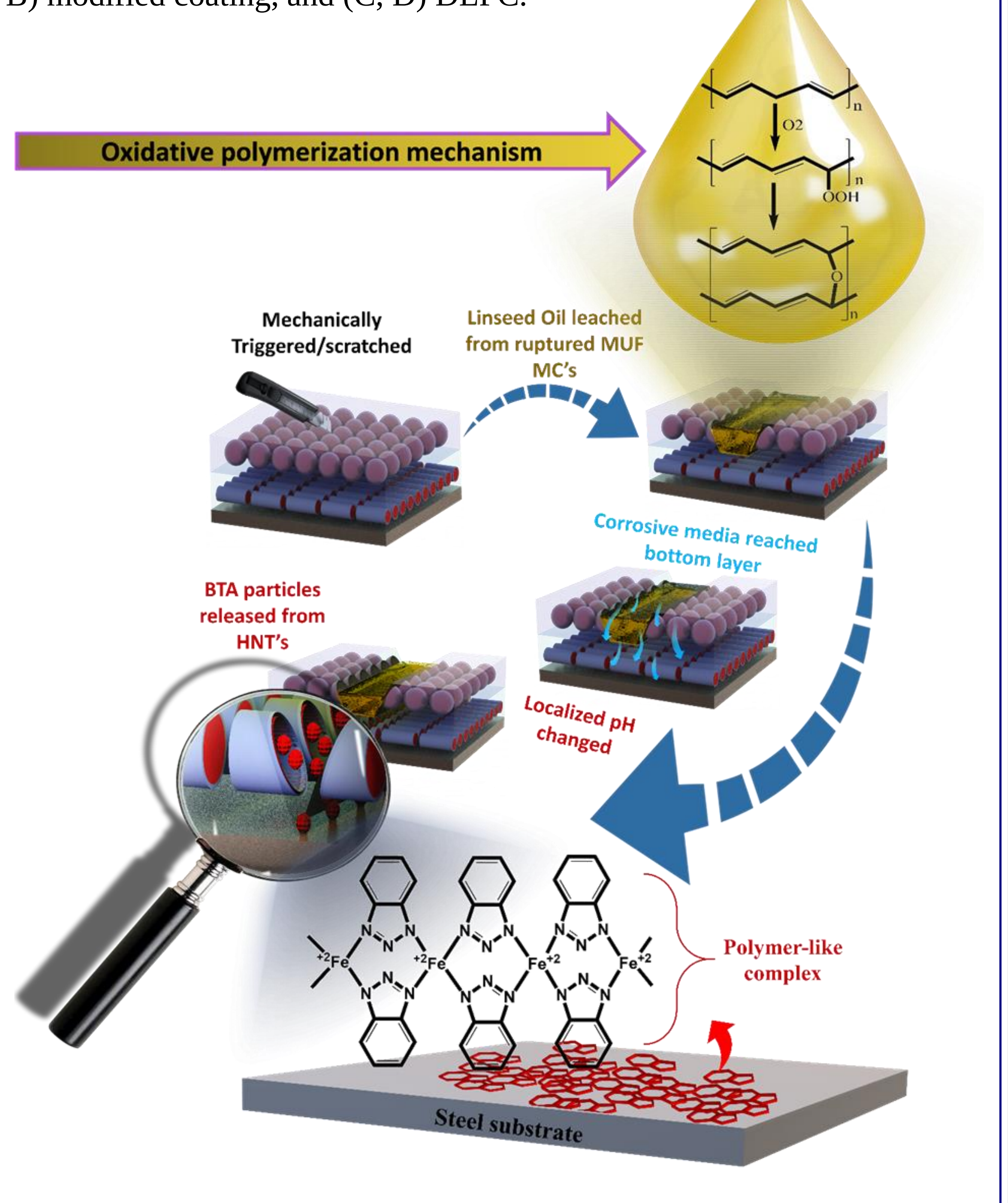


Figure 7: EIS Bode magnitude and phase angle of the developed coatings after immersion in 3.5wt% NaCl solution for various time, (A, B) modified coating, and (C, D) DLPC.



Schematic illustration of double-layered polymeric coating protection mechanisms

Conclusions

- MUFMC were synthesized with an averaged diameter of 120 µm with a wall thickness of ≈ 1.84 µm and encapsulating around 65% of boiled linseed oil.
- 18wt.% of BTA were loaded into HNT
- DLPSC exhibited a superior corrosion resistant property compared to BTA-loaded HNTs modified coatings

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