Supporting information

Synergistic Effect of WO_3 on Physico-chemical, Physico-mechanical, Hydrophobic, and Anticorrosive Performance of Poly-(*melamine-co-formaldehyde)*-Cured *Pithecellobium dulce*-Alkyd Nanocomposite Coatings

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Number of Section: 1 (S-1)

Section S-1. FTIR Spectroscopic Analysis of WO_3 Nanoparticles

The FT-IR spectrum of WO_3 nanoparticles, as shown in Figure S-1, displays characteristic peaks at 940.90 cm^{-1} and 678.84 cm^{-1} corresponding to the asymmetric and symmetric stretching vibrations of crystalline W=O and O-W-O bonds, respectively. Additionally, the peak observed at 1626.74 cm^{-1} is attributed to the presence of hydroxyl groups bonded to tungsten atoms, while the peak at 3444.01 cm^{-1} is likely due to surface moisture associated with these hydroxyl groups. These observations confirm the successful formation of WO_3 nanoparticles (Figure S-1) [1–4].

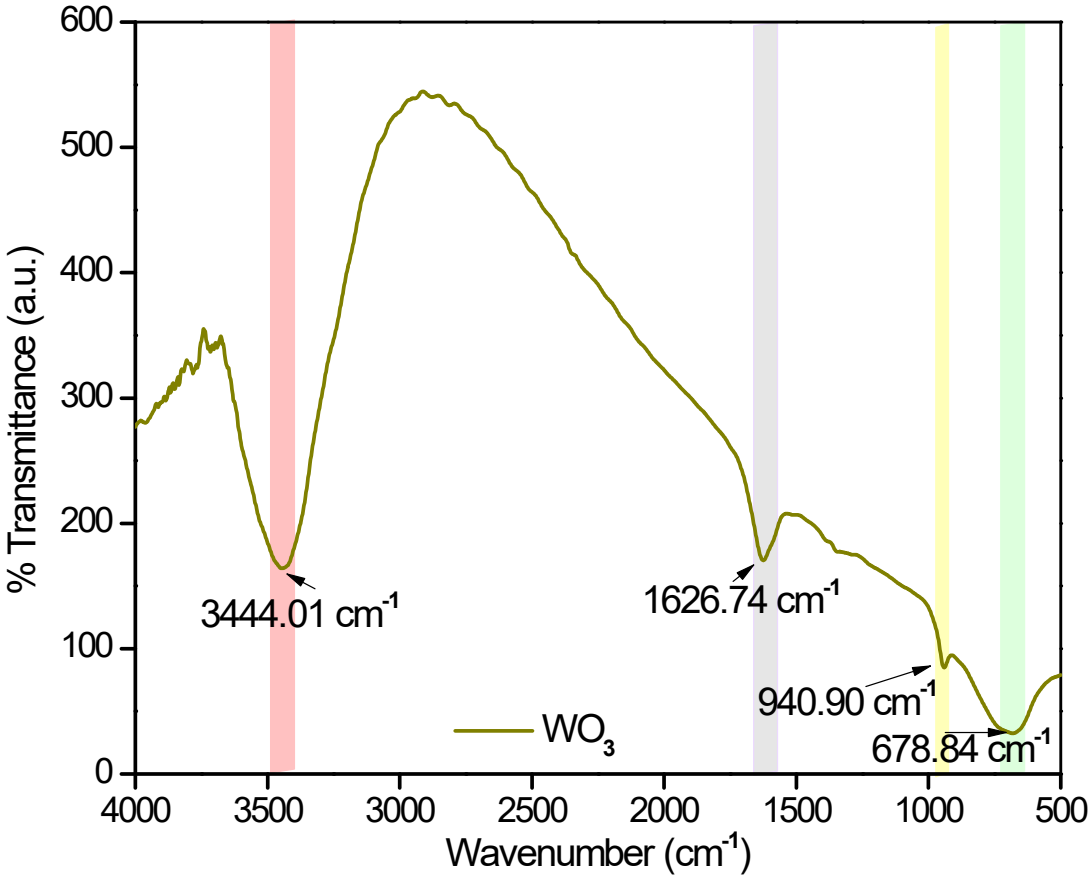

Figure S-1 FTIR spectra confirming the functional characteristics of WO_3 nanoparticles.

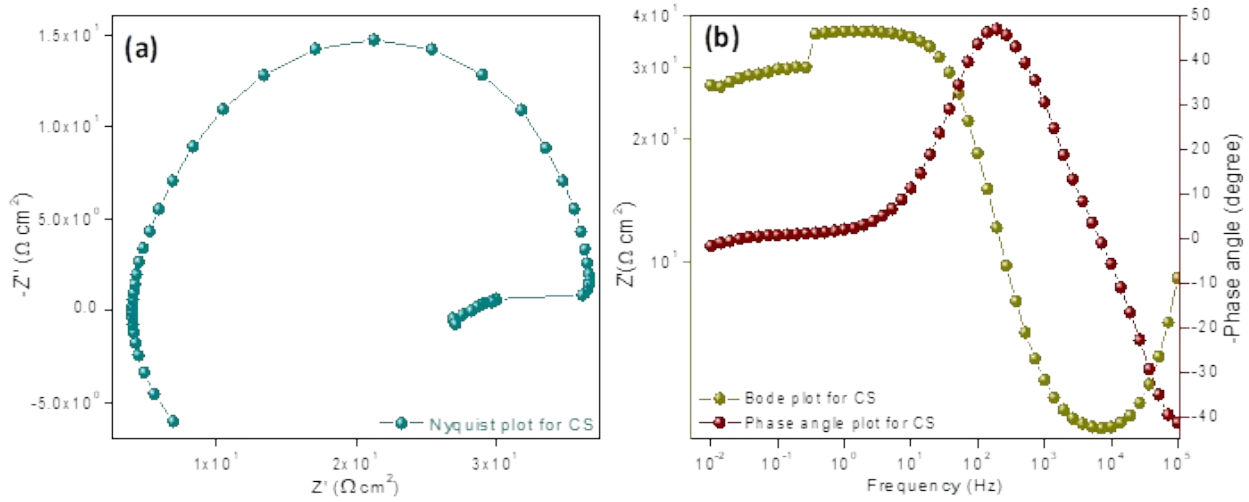

Figure S-2 (a) Nyquist and (b) [Bode and phase angle] plots of uncoated carbon steel (CS) in 5 wt.% NaCl solution.

Table S-1 Physico-chemical parameters of PDA, PDA-PMF_{80}, and WO_3@PDA-PMF_{80} nanocomposite coatings.

Resin Code	**PDA**	**PDA-PMF_{80}**	**WO_3@PDA-PMF_{80}**
Acid value (mg KOH/g)	0.025	0.019	0.011
Refractive Index (25˚C)	1.471	1.495	1.513
Specific gravity (g/ml at 25C)	1.09	1.13	1.25

Table S-2 Physico-mechanical parameters of PDA, PDA-PMF_{80}, and WO_3@PDA-PMF_{80} nanocomposite coatings.

Properties/Coating's Codes	**PDA**	**PDA-PMF_{80}**	**WO_3@PDA-PMF_{80}**
Bend test (1/8'' inch)	passed	passed	Passed
Coating thickness (µm)	85	89	91
Cross hatch test	Passed	Passed	Passed
DTH time (h)	48	30	24
DTT time (min)	54	36	30
Gloss (45º)	68	81	83

Impact test (250, lb.inch^{-1})	passed	passed	Passed
Scratch hardness (Kg)	5.5	10.5	12.0

Table S-3. Comparative thermogravimetric parameters of PDA-PMF$_{80}$ and WO$_3$@PDA-PMF$_{80}$ nanocomposite coatings derived from TGA analysis

Thermal Parameters	**PDA-PMF$_{80}$ (°C)**	**WO$_3$@PDA-PMF$_{80}$ (°C)**
Initial decomposition temperature (IDT, °C)	~136	~138
Onset degradation temperature, T_{onset} (°C)	~304	~336
Temperature at 5 wt.% loss, T_d5 / T_5 (°C)	~304	~336
First major degradation temperature (°C)	~304	~336
Second major degradation temperature (°C)	~428	~465
Maximum weight loss (%)	~85	~78
Residual char at 800 °C (%)	~5	~12
Thermal stability behavior	Moderate	Enhanced
Barrier/char-forming behavior	Lower	Higher
Overall thermal resistance	Lower	Improved due to WO_3 incorporation

Where;

IDT = Initial decomposition temperature;

T_{onset} = onset degradation temperature;

T_d5 = temperature corresponding to 5 wt.% weight loss.

The higher residual char yield and delayed degradation temperatures observed for WO_3@PDA-PMF_{80} indicate improved thermal stability due to the incorporation of thermally stable WO_3 nanofillers within the polymer matrix.

Table S-**4** Comparison of anticorrosive performance of WO_3@PDA-PMF_{80} nanocomposite coatings with reported systems in the literature.

Sr No	Coating system	Immersion medium	Icorr (Acm^{-2})	Corrosion rate (mpy)	Ref.
1	**WO_3@PDA-PMF_{80}**	5wt% NaCl	1.56×10^{-7}	4.81×10^{-4}	P.S.
2	**WCA-BMF_{80}**	5wt% NaCl	4.50×10^{-7}	5.23×10^{-3}	[5]
3	**Alk-DDS—Ppy-$PSCeO_2$**	1.5 M NaCl	3.0×10^{-1}	9.85×10^{-1}	[6]
4	**ASAR/10%SiO_2**	3.5wt% NaCl	7.03×10^{-7}	1.09×10^{-3}	[7]
5	**NLA-IPTES-III**	3.5wt% NaOH	7.20×10^{-7}	8.00×10^{-4}	[8]

References

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