Supplementary information

Mechanically Robust Bi-functional Hydrophobic Polycarbazole Decorated Multiwall Carbon Nanotubes-Pithecellobium Dulce Oil Polyester-amide Nanocomposite Coatings: Fabrication, Characterization, Anticorrosive and Antimicrobial Studies

Abu Darda[1*], Weqar Ahmad Siddiqi[2]

[1]Department of Sciences and Humanities, Maulana Azad College of Engineering and Technology, Patna, India

[2]Department of Applied Sciences and Humanities, Jamia Millia Islamia, New Delhi-110025, India

Number of pages: 7 (S-1 to S-8)

Number of Figures: 3 (S-1 and S-3)

Number of tables: 5 (S-1 to S-5)

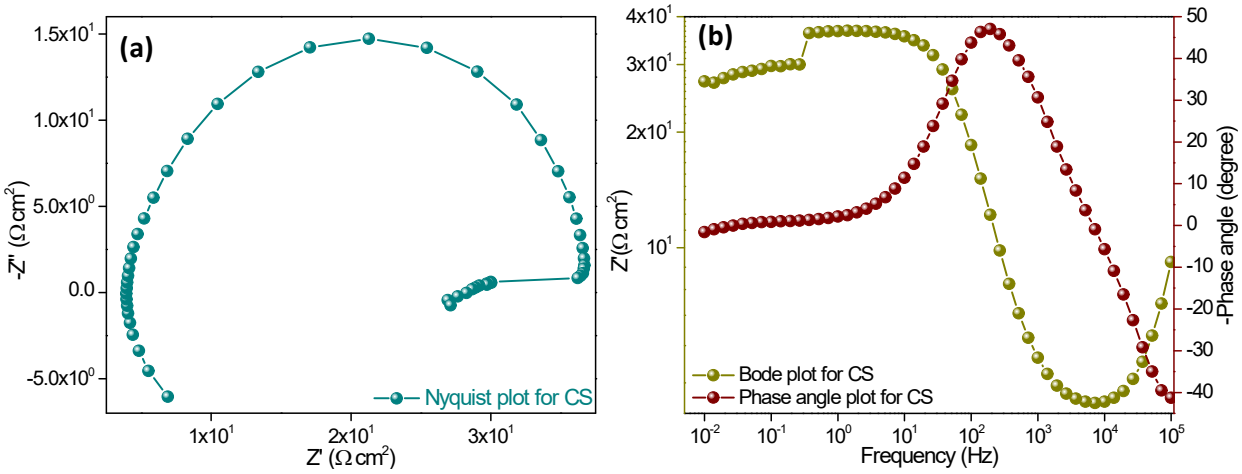

Figure S-1 Nyquist plots for (a) CS as well as Bode and Phase angles plots for (b) CS are illustrated.

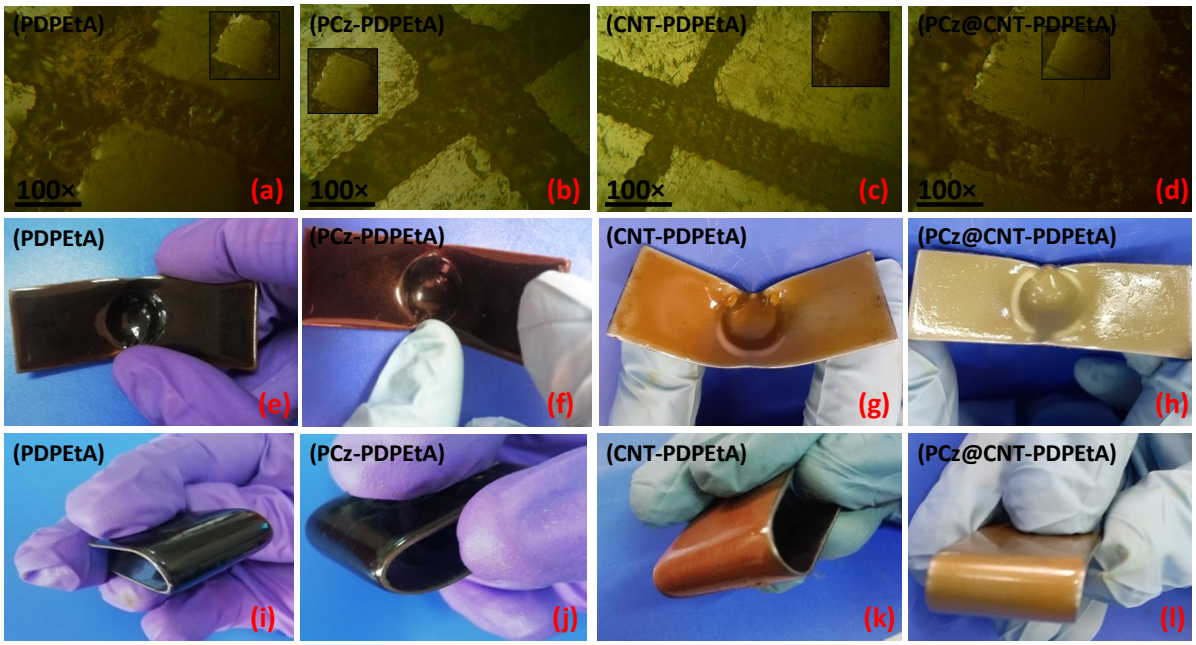

Figure S-2 Optical micrographs of crosshatch test, digital images after impact resistance, and bend test of (a, e, i) PDPEtA, (b, f, j) PCz-PDPEtA, (c, g, k) CNT-PDPEtA and (d, h, l) PCz@CNT-PDPEtA respectively.

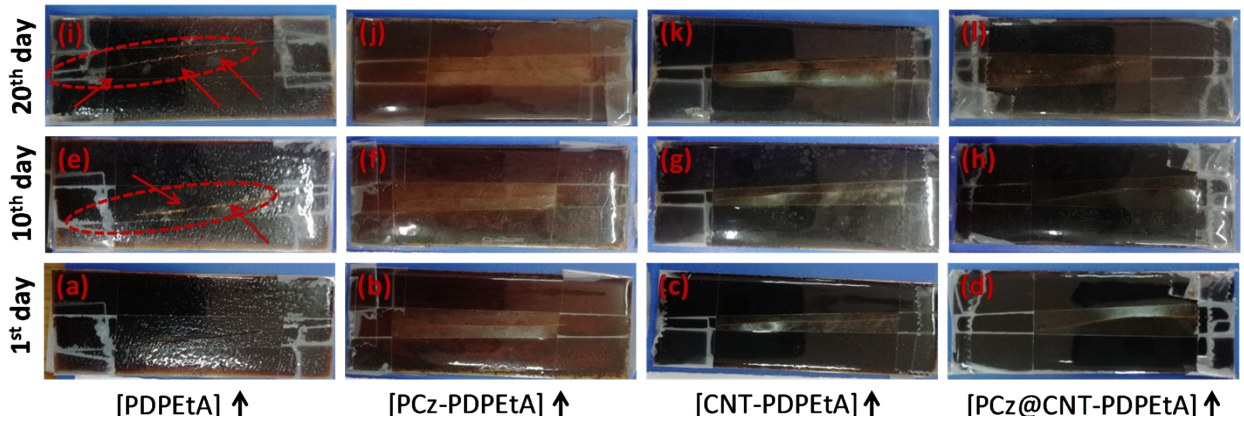

Figure S-3 Digital images after salt-mist test of (a, e, i) PDPEtA, (b, f, j) PCz-PDPEtA, (c, g, k) CNT-PDPEtA and (d, h, l) PCz@CNT-PDPEtA for 1st, 10th, and 20th day, respectively

Table S-1 Physico-chemical/mechanical properties

Resin Code/ Properties	**PDSO**	**PDFA**	**PDPEtA**	**PCz-PDPEtA**	**CNT-PDPEtA**	**PCz@CNT – PDPEtA**
Specific Gravity	0.912	0.947	1.029	1.127	1.125	1.142
Refractive index	1.417	1.425	1.439	1.571	1.539	1.612
Acid value (mg KOH/g)	0.59	1.8	4.0	3.8	3.8	3.8
Gloss (45˚C)	……	……	61	58	55	49
Scratch hardness (kg)	……	……	5.50	9.0	9.50	12.00
Impact resistance (150 lb/inch)	……	……	Pass	Pass	Pass	Pass
Cross hatch test	……	……	Pass	Pass	Pass	Pass
Bend Test (1/8'' inch)	……	……	Pass	Pass	Pass	Pass
Dry to touch (min.)	……	……	45	41	40	36
Dry to hard (h)	……	……	26	24	24	22

Coating Thickness (µm)	……	……	88	90	91	93

Table S-2 PDP and EIS parameters obtained from Tafel curves for coated and uncoated CS samples before and after immersion under 5wt% NaCl solutions

Sample	**E_{corr} (Volt)**	**I_{corr} ($A.cm^{-2}$)**	**Corrosion Rate(mpy)**	**Rp (Ω)**	**f_b z(H)**	**ηi (%)**
CS	─0.8613	3.3394×10^{-5}	----	----	……..	----
Initial immersion						
PDPEtA	─0.4362	3.06×10^{-7}	3.56×10^{-3}	3.00×10^{6}	1.22×10^{-3}	99.08
PCz-PDPEtA	─0.4355	8.15×10^{-8}	9.47×10^{-4}	5.95×10^{6}	9.85×10^{-2}	99.75
CNT-PDPEtA	─0.4710	6.05×10^{-8}	7.04×10^{-4}	8.24×10^{6}	4.20×10^{-2}	99.81
PCz@CNT-PDPEtA	─0.3976	4.44×10^{-8}	5.16×10^{-4}	1.54×10^{7}	1.15×10^{-2}	99.86
After 20 days of immersion						
PDPEtA	─0.4681	2.92×10^{-7}	3.39×10^{-3}	2.57×10^{6}	1.16×10^{-3}	99.12
PCz-PDPEtA	─0.3128	1.62×10^{-8}	1.88×10^{-4}	2.51×10^{7}	5.99×10^{-2}	99.95
CNT-PDPEtA	─0.5048	2.33×10^{-8}	2.71×10^{-4}	1.33×10^{7}	1.39×10^{-2}	99.93
PCz@CNT-PDPEtA	─0.0443	9.46×10^{-9}	1.09×10^{-4}	1.50×10^{7}	7.90×10^{-1}	99.97

Table S-3 Comparison between anticorrosive properties of present work with such reported previous systems under saline (NaCl aqueous solution) environment

Sr.No	Coating system	Immersion medium	Ecorr (Volt)	Icorr ($A.cm^{-2}$)	Corrosion rate (mpy)	Rp (Ω)	ηi (%)	Ref.
1.	**PCz@CNT-PDPEtA**	**5 wt% NaCl**	**−0.0443**	**9.46×10^{-9}**	**1.09×10^{-4}**	**1.50×10^{7}**	**99.97**	**P.W.**
2.	**HBPEA-PMF-80-TiO_2**	3.5 wt% NaCl	−0.229	7.44×10^{-7}	1.1×10^{-3}	2.86×10^{6}	**.....**	[1]
3.	**HBSA-PUC**	3.5 wt% NaCl	−0.499	6.66×10^{-7}	5.6×10^{-1}	8.24×10^{3}	**……**	[2]
4.	**CPUEA-30**	5 wt% NaCl	−0.395	1.37×10^{-7}	1.58×10^{-3}	**…..**	**……**	[3]
5.	**5wt% RGO/PANI**	3.5 wt% NaCl	−0.714	1.21×10^{-5}	1.4×10^{-4}	1.12×10^{5}	81.8	[4]
6.	**HBA-Fe_3O_4-1.5**	3.5 wt% NaCl	−0.752	3.50×10^{-8}	1.1×10^{-3}	4.40×10^{5}	**……**	[5]
7.	**0.5-TA-DBSA-POA-ES**	3.5 wt% NaCl 5 wt% NaCl 7 wt% NaCl	−0.2050 −0.5002 −0.340	2.48×10^{-6} 5.22×10^{-8} 3.42×10^{-7}	**…….**	2.22×10^{3} 8.87×10^{3} 2.97×10^{4}	**……**	[6]
8.	**WPEA-PMF-80-RGO-1.5**	pH^{7}	−0.121	6.62×10^{-8}	3.0×10^{-5}	1.67×10^{7}	**….**	[7]

9.	**JPEA-3**	3.5 wt% NaCl	−0.160	3.47×10^{-6}	4.03×10^{6}	3.89×10^{6}	**….**	[8]
10.	**UCPEA-13**	5 wt% NaCl	−0.107	8.27×10^{-7}	9.58×10^{6}	**….**	**….**	[9]
11.	**LMPEA/Ag**	3.5 wt% NaCl	−0.650	2.28×10^{-8}	6.89×10^{5}	3.37×10^{6}	99.94	[10]
12.	**PUMEA-0.8**	3.5 wt% NaCl	−0.5933	1.66×10^{-6}	1.35×10^{5}	2.23×10^{4}	**….**	[11]

Table S-4 Screening of antibacterial activity for (d) bare PDPEtA, (e) PCz-PDPEtA, (f) CNT-PDPEtA, and (g) PCz@CNT-PDPEtA nanocomposites

Sample	Bacterial pathogens (Zone of inhibition in mm)			
	B. subtilis	*P. aeruginosa*	*E. coli*	*S. aureus*
PDPEtA	11± 0.8	10.33± 1.2	11± 0.8	-
CNT-PDPEtA	10.33± 0.9	-	-	9.67± 0.5
PCz-PDPEtA	10± 0.8	-	-	-
PCz@CNT-PDPEtA	15± 0.8	14.67± 0.9	15.33± 0.5	14.67± 0.9

Table S-5 Comparative study on antibacterial activity of various reported antibacterial agents with present study

Sr. No.	**Antimicrobial Agent**	**Bacterial pathogens**	**ZOI (mm)**	**Ref.**
		B. subtilis *P. aeruginosa*	15.00± 0.8 14.67± 0.9	**Present**

1	**PCz@CNT-PDPEtA**	*S. aureus* *E. coli*	15.33± 0.5 14.67± 0.9	**Study**
2	**LOPU**	*S. aureus* *E. coli*	5 12	[12]
3	**LOPU**	*S. aureus* *E. coli*	**……** 13	
4	**ASO@MPDA/ZnO**	*S. aureus* *E. coli*	12-19 12-19	[13]
5	**NCPEA-2**	*P. aeruginosa* *S. aureus* *E. coli* *S. mutans*	11 13 13 14	[14]

References:

1 S. I. Bhat and S. Ahmad, *Prog. Org. Coatings*, 2018, **123**, 326–336.

2 R. S. Mishra and A. S. Khanna, *Prog. Org. Coatings*, 2011, **72**, 769–777.

3 M. Alam, N. M. Alandis and N. Ahmad, *Int. J. Polym. Anal. Charact.*, 2017, **22**, 281–293.

4 K. Cai, S. Zuo, S. Luo, C. Yao, W. Liu, J. Ma, H. Mao and Z. Li, *RSC Adv.*, 2016, **6**, 95965–95972.

5 O. U. Rahman, S. I. Bhat, H. Yu and S. Ahmad, *ACS Sustain. Chem. Eng.*, 2017, **5**, 9725–9734.

6 N. K. Rawat, S. Pathan, A. K. Sinha and S. Ahmad, *New J. Chem.*, 2016, **40**, 803–817.

7 M. Irfan, S. I. Bhat and S. Ahmad, *Waterborne reduced graphene oxide dispersed bio-polyesteramide nanocomposites: An approach towards eco-friendly anticorrosive coatings*, Royal Society of Chemistry, 2019, vol. 43.

8 M. Alam, E. Sharmin, N. M. Alandis and N. Ahmad, *E-Polymers*, 2017, **17**, 491–500.

9 M. R. Shaik, M. Alam and N. M. Alandis, *J. Nanomater.*, , DOI:10.1155/2015/745217.

10 M. Alam, N. M Alandis, E. Sharmin, N. Ahmad, F. M. Husain and A. Khan, *ACS Omega*, 2020, **5**, 30383–30394.

11 M. Alam, N. M. Alandis, J. Alam, N. Ahmad and M. A. Alam, *Int. J. Polym. Anal. Charact.*, 2021, **26**, 111–129.

12 E. Sharmin, S. M. Ashraf and S. Ahmad, *Int. J. Biol. Macromol.*, 2007, **40**, 407–422.

13 X. Ni, C. Li, Y. Lei, Y. Shao, Y. Zhu and B. You, *ACS Appl. Mater. Interfaces*, 2021, **13**, 57864–57879.

14 M. Alam, N. M. Alandis, N. Ahmad and F. M. Husain, *Ind. Crops Prod.*, 2020, **158**, 112955.