



EW

Functional Coatings for Corrosion Protection

Volume 1

Editor and Lead Author
Vikas Mittal

Contents

Preface	XI
1. Polymer Coatings for Corrosion Protection at Oil and Gas Facilities	1
1.1 Introduction	1
1.2 High Performance Polymer Coatings	2
1.2.1 Epoxy Resins	2
1.2.2 Polyurethane Resin	6
1.2.3 Polyetherimide	12
1.2.4 Conducting Polymer Composite Coatings	14
1.2.5 Polymer/Graphene Nanocomposite Coatings	22
1.2.6 Smart Polymer Coatings with Microcapsules and Nano-containers	28
1.3 Conclusions	34
References	34
2. Polyetherimide Coatings for Corrosion Protection of Mild Carbon Steel: Effect of Residual Solvent and Temperature on Coating Performance	51
2.1 Introduction	51
2.2 Experimental	53
2.2.1 Materials	53
2.2.2 Substrate Preparation	53
2.2.3 Preparation of PEI Solutions	53
2.2.4 Preparation of PEI Coatings and Films	53
2.2.5 Immersion Tests	54
2.2.6 Electrochemical Analysis	54
2.2.7 Characterization Techniques	55
2.3 Results and Discussion	56
2.4 Conclusions	70
References	70
3. Polyaniline-Graphene Composite Nanoparticle Pigments for Anti-Corrosion Coatings	75

3.1	Introduction	75
3.2	Experimental	80
3.2.1	Materials	80
3.2.2	Preparation of Graphite Oxide (GO) and r-GO	80
3.2.3	Preparation of Polyaniline and r-GO Composite Nanoparticles	81
3.2.4	Characterization of PANI/r-GO Composite Nanoparticle Pigments	81
3.2.5	Generation of PANI/r-GO/PVB Coatings	82
3.2.6	Corrosion Performance Analysis	83
3.3	Results and Discussion	84
3.3.1	Characterization of PANI/r-GO Hybrid Nanoparticles	84
3.3.2	Anti-corrosion Performance and Protection Mechanism	88
3.4	Conclusions	94
	References	96
4.	Recent Developments in Self-healing Coatings for Corrosion Protection	101
4.1	Introduction	101
4.2	Self-healing Nano-containers	105
4.3	Layer by Layer (lbl) Assembly of Polyelectrolyte Self-healing Coatings	110
4.4	Ceramic Materials as Self-healing Filler	110
4.5	Conducting Polymers as Self-healing Fillers	113
4.6	Miscellaneous Systems	117
4.7	Conclusion	119
	References	119
5.	Polymers and Polymer Composite Coatings for Marine Applications: A Review	127
5.1	Introduction	127
5.2	Marine Biofouling	129
5.3	Polymers for Marine Applications	130
5.4	Polymer Nanocomposites based Fouling-resistant Coatings for Marine Applications	131

<i>Contents</i>	VII
5.4.1 Hydrogel based Nanocomposite Coatings	131
5.4.2 PEG based Fouling-resistant Nanocomposite Coatings	132
5.4.3 Hyperbranched Polymers based Anti-fouling Nanocomposite Coatings	133
5.4.4 Polyzwitterionic Polymers based Anti-fouling Nanocomposite Coatings	134
5.5 Polymer Brush Coatings for Combating Marine Biofouling	137
5.6 Other Examples	137
5.7 Conclusions	138
References	138
6. Polymeric Coatings Loaded with Benzotriazole Incorporated Silica Containers for Smart Corrosion Protection of Carbon Steel Substrates	149
6.1 Introduction	149
6.2 Experimental	151
6.2.1 Materials	151
6.2.2 Silica Based Containers by the LBL Addition of the Polyelectrolyte and Benzotriazole	152
6.2.3 Preparation of Coatings with Silica Containers on Carbon Steel	153
6.2.4 Characterization	153
6.2.5 Self-healing Performance	155
6.2.6 Electrochemical Analysis	155
6.3 Results and Discussion	156
6.4 Conclusions	176
References	178
7. Anti-corrosion Behavior of Layer-by-Layer Coatings of Crosslinked Chitosan and Poly(vinyl butyral) on Carbon Steel	183
7.1 Introduction	183
7.2 Experimental	185
7.2.1 Materials	185
7.2.2 Lbl Coatings of Chitosan and PVB	185

7.2.3	PVB_Ch/x%Glu_PVB Coatings	185
7.2.4	Immersion Test	186
7.2.5	Electrochemical Measurements	186
7.2.6	Fourier Transformed Infrared Spectroscopy and Raman Spectroscopy	187
7.3	Results and Discussion	187
7.3.1	Structure of lbl Coatings of Chitosan and PVB	187
7.3.2	Anti-corrosion Performance of Chitosan	190
7.3.3	Corrosion Protection Properties of lbl Coatings of PVB and Chitosan	192
7.3.4	Effect of Chitosan Crosslinking with Glutaraldehyde on the Protective Behavior of lbl Coatings	196
7.4	Conclusions	204
	References	206
8.	Stable Corrosion-Resistant Chitosan Coatings: Effect of Crosslinking with Silica, Poly(vinyl butyral) Over-coating and Graphene on the Coating Performance	211
8.1	Introduction	211
8.2	Experimental	216
8.2.1	Materials	216
8.2.2	Chitosan-Silica/PVB Hybrid Coatings	216
8.2.3	Structural Characterization	217
8.2.4	Immersion Test	217
8.2.5	Electrochemical Measurements	217
8.3	Results and Discussion	218
8.4	Conclusions	235
	References	237
9.	Eco-friendly Polylactic Acid-Silica Coatings for Corrosion Protection of Carbon Steel	243
9.1	Introduction	243
9.2	Experimental	247
9.2.1	Materials	247

<i>Contents</i>		IX
	9.2.2 Substrate Preparation	248
	9.2.3 Preparation of PLA Solutions, Silica Sol and Coatings	248
	9.2.4 Salt Spray Tests	249
	9.2.5 UV Weathering Test	249
	9.2.6 Electrochemical Analysis	249
	9.2.7 FTIR Spectroscopy	250
	9.2.8 Scanning Electron Microscopy	250
	9.3 Results and Discussion	250
	9.4 Conclusions	265
	References	267
10.	Epoxy Composite Coatings for Enhanced Corrosion Resistance	273
	10.1 Introduction	273
	10.2 Experimental Details	274
	10.2.1 Materials	274
	10.2.2 Substrate Preparation	275
	10.2.3 BADGE Composite Coatings	275
	10.2.4 Characterization Techniques	276
	10.3 Results and Discussion	277
	10.4 Conclusion	288
	References	289
Index		293

About the Book

Corrosion involves the degradation of metals due to the oxidation and reduction processes occurring during the interaction of the metallic surfaces with the aggressive environments. These electrochemical processes result in the impairment of materials' physical and mechanical properties such as strength and ductility. Application of coatings is the most widely used method for the corrosion protection of the metallic structures. Specifically, the polymeric coatings (or reinforced polymer coatings) protect the metal substrates from external corrosive agents by acting as an effective barrier. Besides that, depending on the morphology and structure of polymers, the coatings possess the properties like thermal, chemical and mechanical stability. These properties combined with the ability to strongly adhere to metal surfaces yield durable coatings with longer service lifetime compared with other metallic and inorganic coatings. The purpose of this book is to assimilate the recent advances in the field of functional coatings systems for achieving effective corrosion protection.

About the Editor

Dr. Vikas Mittal works as Associate Professor in the Department of Chemical Engineering at Khalifa University of Science and Technology, Abu Dhabi, UAE. Before, he was employed at BASF, Germany as polymer engineer and at SunChemical, UK as materials scientist. Dr. Mittal received his PhD degree in 2006 from Department of Materials and Department of Chemistry and Applied Biosciences at Swiss Federal Institute of Technology (ETH) Zurich, Switzerland. He has been an active researcher in the field of polymer nanotechnology and its applications in various streams. He has published more than 125 peer reviewed papers on these subjects, along with 35 edited and authored books. His research accomplishments have also resulted in many patents. In addition, he has published many book chapters and has also delivered numerous keynote and invited lectures.

