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Polymer nanotechnology

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The issue of corrosion is a well-known problem and it causes the weakening of metal and its properties and makes it unfit for use. Corrosion causes enormous economic losses consistently over years in equipment maintenance, repair, and its substitution. In Gulf Cooperation Council (G.C.C) countries, money spent into corrosion control and repair are extremely dependent on production of oil, refining and petrochemicals sector shall be noteworthy as it comprises more than 33% of gross domestic products. Until now, various coatings have been developed to tackle this problem like sacrificial coatings, barrier coatings, noble metal coatings and electrically resistive coatings. In this study, self-healing smart anti-corrosion coatings were synthesized as it is a much lesser investigated area of research. Functionalized particles from mesoporous carbon along with mesoporous silica etc. were used as Nano containers for encapsulation of corrosion inhibitor for self-healing purpose using layer-by layer (lbl) self-assembly method and their effect on performance of coatings were studied after adding in commercially available polymer matrix against the corrosion of mild carbon steel in seawater. A series of tests were conducted on the resultant coatings to investigate their corrosion resistance, self-healing performance etc. This study will evaluate the protection offered by coatings of commercially available porous materials against the corrosion of mild steel in seawater, along with addition of different encapsulated nano containers in the polymer matrix. Benzotriazole (BTA) was used as a corrosion inhibitor in this study for synthesizing Nano containers. Self-healing smart anti-corrosion coatings, is a much lesser explored area of research with the major challenge of low adhesion properties and release of Nano containers to heal the corroded metal substrate. This calls for preparation of substrate surface and treatment of coatings to establish good interfacial interaction of the nano containers with the porous material and their successful release in the medium upon a pH change to avoid delamination/corrosion of coatings in water. The potential of the functionalized carbon materials to further enhance anticorrosion performance of the self-healing coatings was also evaluated. The coatings were prepared by brush coatings as well as dip-coating methods in determined optimal conditions on clean polished mild carbon steel coupons. The coating degradation behavior and corrosion resistance was investigated by the immersion tests (performed in 3.5 wt. % sodium chloride solution) and Potentiostatic Electrochemical Impedance Spectroscopy (PEIS). Brunauer–Emmett–Teller (BET) testing was done only initially in order to determine the degree of impregnation in the pores of the carbon and silica materials. Corrosion monitoring was performed using Linear Polarization (LP) technique. Other nanocapsules characteristics were studied using techniques such as Fourier Transform Infrared Spectroscopy (FTIR), X Ray Diffraction (XRD) was used to characterize the composition of the multilayers of the Nano capsules, Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) were used to analyze the surface morphology of coatings as well as nanocapsules. The visual appearance of coating and corrosion products was studied using Optical Microscopy (OM). Coating thickness measurements were done using a standard PosiTector gauge. Zeta Potential was also analyzed continuously during the synthesis of nanocapsules in order to optimize the layer-by-layer assembly of a self-healing coating. Ultraviolet–visible spectroscopy (UV-Vis) was also studied to analyze the release behavior of the synthesized Corrosion Inhibitor encapsulated Nano containers in different pH of water. Self-healing testing of the synthesized coatings based on ASTM D7027-13 standards was also carried out to analyze the coating performance when exposed to corroding conditions. The electrochemical impedance spectroscopy (EIS) results illustrated the improved corrosion resistance of the coating based on carbon materials. The proposed coating also had a rapid self-healing ability in the presence of water. The mesoporous carbon based coatings produced, were highly stable and protective in nature. The self-healing coatings possessed high impedance good barrier characteristics. The mesoporous carbon and functionalized mesoporous carbon coatings were compared with coatings of mesoporous silica and commercially available vinyl acrylate. The SEM analysis also revealed successful release of BTA onto the corroded surface thus verifying the self-healing effect. UV-Vis predicted that the carbon based capsules had more impregnation of the corrosion inhibitor than the silica based nanocontainers. It was observed that carbon based coatings and its 5 wt. % composition in the polymer matrix had better anticorrosive performance and adhesion than the silica coatings and provided much greater substrate protection as explained in the work in detail.

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