Analysis of degradation process during the incorporation of ZrO_2:SiO_2 ceramic nanostructures into polyurethane coatings for the corrosion protection of carbon steel

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Abstract

Three different molar ratios of ZrO_2:SiO_2 mixed oxides (25:75, 50:50, 75:25) were produced by the sol-gel technique and sintered at different temperatures (400, 600, 800, and 1000 C) in order to analyze differences in mechanical and electrochemical properties of a wide variety of organic-inorganic hybrid coatings on AISI 1018 commercial carbon steel. For this purpose, 2, 4, and 6 wt% of the obtained ZrO_2:SiO_2 nanoparticles were incorporated to the polymeric matrix under vigorous stirring and spread on metallic substrates to reach between 40 and 55 μm of dry film. Light microscopy, scanning electron microscopy, confocal laser scanning microscopy studies, atomic force microscopy, and nanoindentation tests were used to evaluate morphological, topographical, and mechanical properties; whereas atmospheric corrosion and electrochemical impedance spectroscopy (EIS) were performed using a 3 wt% NaCl medium in continuous immersion for 226 days. The crystallite size of the as-prepared ZrO_2:SiO_2 nanoparticles changed according to the sintering temperature from 4 to 9 nm. It was found that an adequate dispersion and homogeneity was achieved when 2 wt% of sintered ZrO_2:SiO_2 nanoparticles were mechanically mixed with polymer (MDI) to produce hybrid coatings on the metallic substrate. Free-bubble surface and hardness enhancement can be achieved by adding nanostructures assuming fact that the particles are capable of occupying the gas bubble sites. Atmospheric corrosion in the coatings without reinforced particles was more severe than that observed in hybrid coatings, and for these, corrosion was higher according to the increasing zirconia molar ratio. The EIS studies indicated that the synergetic effect between the organic-inorganic phases to seal the surface enhances the barrier properties on this metallic substrate. © 2012 Springer Science+Business Media, LLC.

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