Structure and anticorrosive properties of silica-epoxy hybrid coatings

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One of the main industrial challenges is the reduction of reposition costs and risks of accidents resulting from the corrosion of metallic components. One of the most applied corrosion prevention methods of metallic surfaces, especially in aeronautic industry, is the hexavalent chromium-conversion, forming insoluble trivalent chromium species. However, chromate coatings contain a fraction of toxic hexavalent chromium, which can be released into the environment. In this context protective organic-inorganic coatings based on epoxy resin constitute an environmentally compliant alternative, combining high mechanical, thermal and chemical stability of the inorganic silica component with and the processability and flexibility of the cured epoxy resin. Silica-epoxy hybrids were prepared from the curing reaction of poly(bisphenol A-co-epichlorohydrin) (DGBEA) with diethyltriamine (DETA) and (3-glycid-oxypropyl)methyltriethoxysilane) (GPTMS) combined with the sol-gel hydrolysis and condensation reactions of tetraethoxysilane (TEOS) and GPTMS. Structural and morphological characteristics of films, prepared by dip-coating on carbon steel, have been studied by nuclear magnetic resonance, X-ray photoelectron, infrared and Raman spectroscopies, atomic force microscopy and thermogravimetry. The anticorrosive properties of coated carbon steel were evaluated in 3,5% NaCl solution using electrochemical impedance spectroscopy. Several interesting results were obtained for hybrid coatings at a TEOS : GPTMS : DGBEA = 1 : 1 : 1 ratio, having a dense, highly cross-linked structure, which results in improved thermal stability and excellent corrosion resistance of up to $10^{10}\ \Omega\ cm^{-2}$, remaining essentially unchanged after more than 1 year exposure to aggressive environment. These results demonstrate that epoxy-silica hybrid coating could become a promising alternative to conventional corrosion prevention methods.