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Corrosion protection of stainless steel by organic–inorganic hybrid coatings

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Abstract — Organic–inorganic hybrid coatings acting as a corrosion barrier were deposited onto 316L stainless steel from a sol prepared by acid-catalyzed hydrolytic polycondensation of tetraethoxysilane (TEOS) and 3-methacryloxy propyltrimethoxysilane (MPTS) mixtures, at TEOS/MPTS molar ratios of 0, 1 and 2, followed by radical polymerization of methacrylate functions of MPTS. Structural analysis showed that the most compact hybrid network was obtained for TEOS/MPTS ratio of 2 due to the formation of a dense structure of siloxane nodes crosslinked with the organic phase. Thermal and electrochemical analysis confirmed for these films an elevated thermal stability and high corrosion protection efficiency.

Polysiloxane hybrids films were prepared by acid-catalyzed hydrolytic co-polycondensation of tetraethoxysilane (TEOS) and 3-methacryloxy propyltrimethoxysilane (MPTS), followed by radical polymerization of methacrylic moieties [1]. In this process the inorganic matrix produced by polycondensation of a mixture of TEOS and MPTS forms together with the polymeric phase a dense cross-linked network that acts as an efficient diffusion barrier in aggressive media. From the sol prepared with TEOS/MPTS ratios of 0 (P0), 1 (P1) and 2 (P2) films were deposited by dip-coating on 316L stainless steel substrates. Structural features of the polysiloxane hybrids and the efficiency of corrosion protection of the coated stainless steel in saline environment were studied using ^{13}C and ^{29}Si nuclear magnetic resonance (NMR), X-ray photoelectron spectroscopy (XPS), thermogravimetric analysis (TGA), electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization curves, as a function of the TEOS/MPTS ratio. NMR and TGA results indicate a high degree of polymerization and polycondensation, of up to 85% and elevated thermal stability up to 410 °C (Fig. 1). The XPS analysis confirmed the hybridized structure of the polysiloxane network, and showed that no corrosion-induced changes occurred on the coated steel surface after 3 weeks of immersion in 3.5% NaCl solution. Crosshatch and Tape Pull Test showed an excellent adhesion of the films to the steel surface. Electrochemical characterization by potentiodynamic polarization curves and EIS measurements confirmed that the hybrid coating prepared using a TEOS/MPTS ratio of 2 yields the best corrosion resistance. It acts as a very efficient physical barrier by increasing significantly the total impedance and polarization resistance at lower corrosion current densities (Fig. 2), compared to the bare electrode.

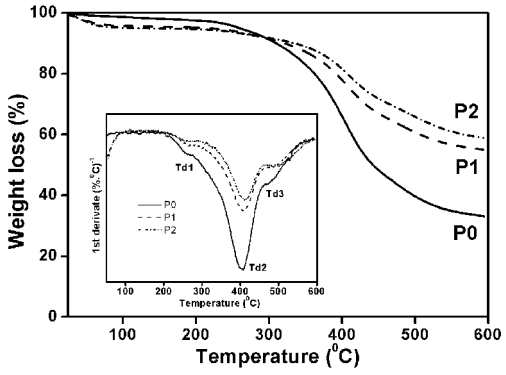

Fig1: TGA and DTG (insert) curves of the polysiloxane hybrids prepared with TEOS/MPTS ratios of 0 (P0), 1 (P1) and 2 (P2).

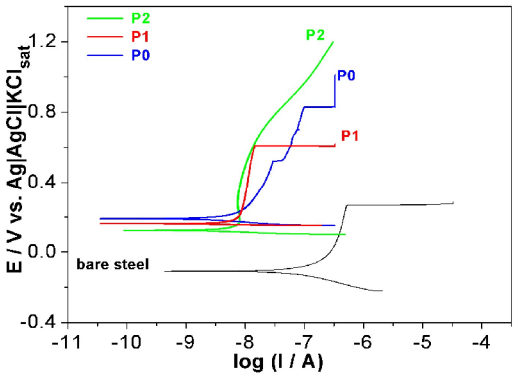

Fig2: Potentiodynamic polarization curves of P0, P1 and P2 in solution of 3.5% NaCl.

[1] JOSÉ, N. M. et al. Materiais híbridos orgânico-inorgânicos: preparação e algumas aplicações. **Quim. Nova**, v. 28, n. 2, p. 281-288, Mar. 2005.