Corrosion Study of Electroless Deposited Nickel-Phosphorus Solar Absorber Coatings on Carbon Steel

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One of the big challenges to sustainability is the solar energy conversion efficiency, and particularly in the case of conversion to thermal energy, is the absorbent surface, which has a leading role. In this work, coatings for solar-to-thermal energy conversion have been deposited onto carbon steel substrates from a nickel sulfate electroless bath, as a source of nickel and sodium hypophosphite as a reducing agent. Electroless black nickel surfaces were obtained, through etching of electroless nickel-phosphorous deposits with an oxidizing acid solution. EDX studies suggested that the coatings were constituted by 11% phosphorous. Surfaces predominantly covered by NiO were identified through XPS. By observing those problems that bring corrosion to metal surfaces, this work aims to determine the corrosion mechanism that degrades the surfaces of black nickel, and consequently, brings about the deterioration of their absorbent properties. Corrosion resistances of black electroless nickel-phosphorus coatings were investigated by polarization measurements, electrochemical impedance spectroscopy (EIS), electrochemical frequency modulation (EFM) and electrochemical noise in 0.5M NaCl solutions at room temperature and without stirring. The equivalent circuit for electrochemical impedance measurement, on the corrosion resistance of black electroless Ni-P deposits, consisted of the following elements: resistance of solution (Rₛ), the charge transfer resistance of the coating (Rₑᶜᵗ) and a constant phase element. The EFM measurements were performed with 0.02 Hz and 0.05 Hz potential perturbation frequencies. The results of these studies show a decrease of corrosion resistance but associated with the increase of about four times the surface area of black coatings. The composition and roughness of each studied surface were directly associated with their corrosion rates.

Keywords: Electroless, Ni-P black, corrosion; steel; renewable energy.