THERMAL EFFECTS ON THE PROCESS OF ELECTROPOLYMERIZATION OF PYRROLE ON MILD STEEL

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Polypyrrole (PPy) can be synthesized by either chemical or electrochemical (electropolymerization) methods. The later method usually gives higher PPy conductivity, but is difficult on oxidizable metals such as mild steel because the metallic electrode undergoes dissolution before oxidation potential of the monomer (pyrrole) is reached. A few electrochemical methods have been proposed to polymerize pyrrole on various steel substrates successfully[1-4]. These methods are evaluated to select the best one, from the corrosion protection point of view[5]. In this work, a parametric study was undertaken on the selected method (with oxalic acid as supporting electrolyte) to study the effect of electropolymerization parameters namely; applied current density, electrolyte pH and temperature[5].

The polypyrrole films were electrosynthesized on mild steel with oxalic acid electrolyte at varying temperatures (25 to 65 °C), current density (0.5 to 6.0 mA/cm2) and pH (2.0, 4.0, 7.0 and 8.5). The concentrations of pyrrole and oxalic acid were maintained at 0.1 M each in galvanostatic experiments. The parametric study on the selected method shows that increasing the current density enhances the deposition but the surface becomes rough. The time needed for passivating the steel surface (induction time) decreases with increased applied current density while the electropolymerization potential increases with current density as shown in Figure 1.

The induction time increases as the pH increases up to 7.0 while it is minimum at pH 8.5. The electropolymerization potential for the neutral or alkaline solution is much higher than that for acidic solution[6-7]. The temperature has negative effects on the deposition in both acidic and neutral medium. On the other hand, it has positive effects on the deposition for the alkaline solution.

A new oscillatory phenomenon in potential was observed at temperature higher than 25 °C in acidic media as shown in Figure 2. However, the oscillations in current were observed at room temperature while potentiosatatic electropolymerization of pyrrole in aqueous solution containing tetrabutylammonium-hexaflourophosphate[8]. Occurrence and nature of the oscillation depend on current density, pH and temperature. This phenomenon is explained by two reactions competing each other, namely, corrosion reaction and the oxidation reaction for formation of polypyrrole. Apparently, corrosion reaction dominates at high temperature for acidic and neutral solution while the deposition reaction is favored as the temperature increases for alkaline solution.

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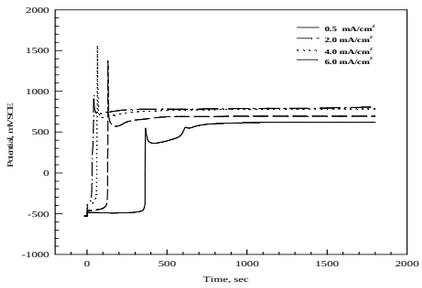

Figure 1. Potential vs time at pH=2 and T=25 °C

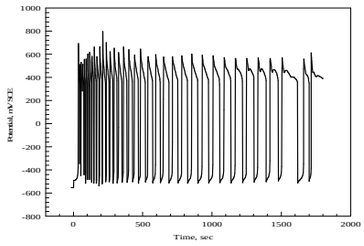

Figure 2. Potential vs time at pH=2, T=65°C and current density of 4.0 mA/cm^2