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Influence of newly synthesized titanium phosphates on the corrosion protection properties of alkyd coating

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ABSTRACT

This study reports the effect of three new titanium phosphates $Li_{0.5}M_{0.25}Ti_2(PO_4)_3$ (where M = Mn, Co and Ni) on the protective properties of alkyd resin films applied on carbon steel substrate in 3.5% sodium chloride solution. The performance of the coatings was evaluated by electrochemical impedance spectroscopy, oxygen and water permeability and pull-off adhesion measurements. It was found that titanium phosphates improve the corrosion resistance as well as the adhesion strength of alkyd resin coatings. The incorporation of titanium phosphates into the alkyd resin coating significantly enhances the pore resistance of the alkyd resin and decreases the coating capacitance. Lower water and oxygen permeability were observed for alkyd resin containing titanium phosphates, confirming formation of a protective layer on the surface. The order of anticorrosion performance of the three coatings was as follows: $Li_{0.5}Mn_{0.25}Ti_2(PO_4)_3 > Li_{0.5}Co_{0.25}Ti_2(PO_4)_3 > Li_{0.5}Ni_{0.25}Ti_2(PO_4)_3$.

1. Introduction

The preparation of coating systems consisting of new anticorrosive pigments has been continued in order to find the most effective coating systems [1–3].

Chromates have been used for many years as an anticorrosive pigment in classical coating systems [4]. The employment of chromates is being restricted because they contaminate the environment and cause health problems to humans [5]. Therefore, it is necessary to find alternative pigments with low toxicity and high performance.

The use of inorganic phosphate materials in anticorrosive paints has recently attracted great attention [6–7].

Although the first generation of phosphate pigments $Zn_3(PO_4)_2\cdot nH_2O$ (n = 2 or 4) [8] gives good results, in certain cases, but generally it has lower anticorrosive performance than zinc chromate [9]. The second and third generations of phosphate pigments are the results of modification of the chemical structure of zinc phosphate [10–11]. These generations have a better anticorrosive behavior than zinc phosphate [12]. This behavior was related to the low solubility of zinc phosphate in comparison to the second and third generations of phosphate pigments [12].

In this work, the influence of three new titanium phosphates $Li_{0.5}M_{0.25}Ti_2(PO_4)_3$ (where M = Mn, Co and Ni) on the corrosion protection properties of alkyd coating is evaluated by incorporating titanium phosphates in an alkyd resin. The measurements are conducted on coated carbon steel substrates in 3.5% sodium chloride solution under the influence of various experimental conditions using electrochemical impedance spectroscopy, oxygen and water permeability and pull-off adhesion techniques. Titanium phosphates have been characterized by XRD and SEM analysis.

2. Experimental

2.1. Titanium phosphates synthesis and characterization

Titanium phosphates $Li_{0.5}M_{0.25}Ti_2(PO_4)_3$ (where M = Ni, Co and Mn) were synthesized and characterized according to a procedure previously reported in the literature [13]. X-ray diffractograms and SEM images of $Li_{0.5}M_{0.25}Ti_2(PO_4)_3$, were extracted according to previously our work [13] and shown in Figs. 1 and 2.

The crystal of $Li_{0.5}M_{0.25}Ti_2(PO_4)_3$ have a Nasicon-type structure [14]. The polyhedral view of framework as projected in the (a, b) plane of $Li_{0.5}Ni_{0.25}Ti_2(PO_4)_3$ was shown in Fig. 3.

2.2. Preparation of coating

Long oil alkyd resin (SOAL660-Knightsbridge Chemicals FZE Co) with isophorone diamine as a cross-linker in the mixing ratio of 70:30 (wt.%) was developed and used as a base matrix for coating preparation. 1.0 wt.% of $Li_{0.5}M_{0.25}Ti_2(PO_4)_3$ (where M = Ni, Co and Mn) powder

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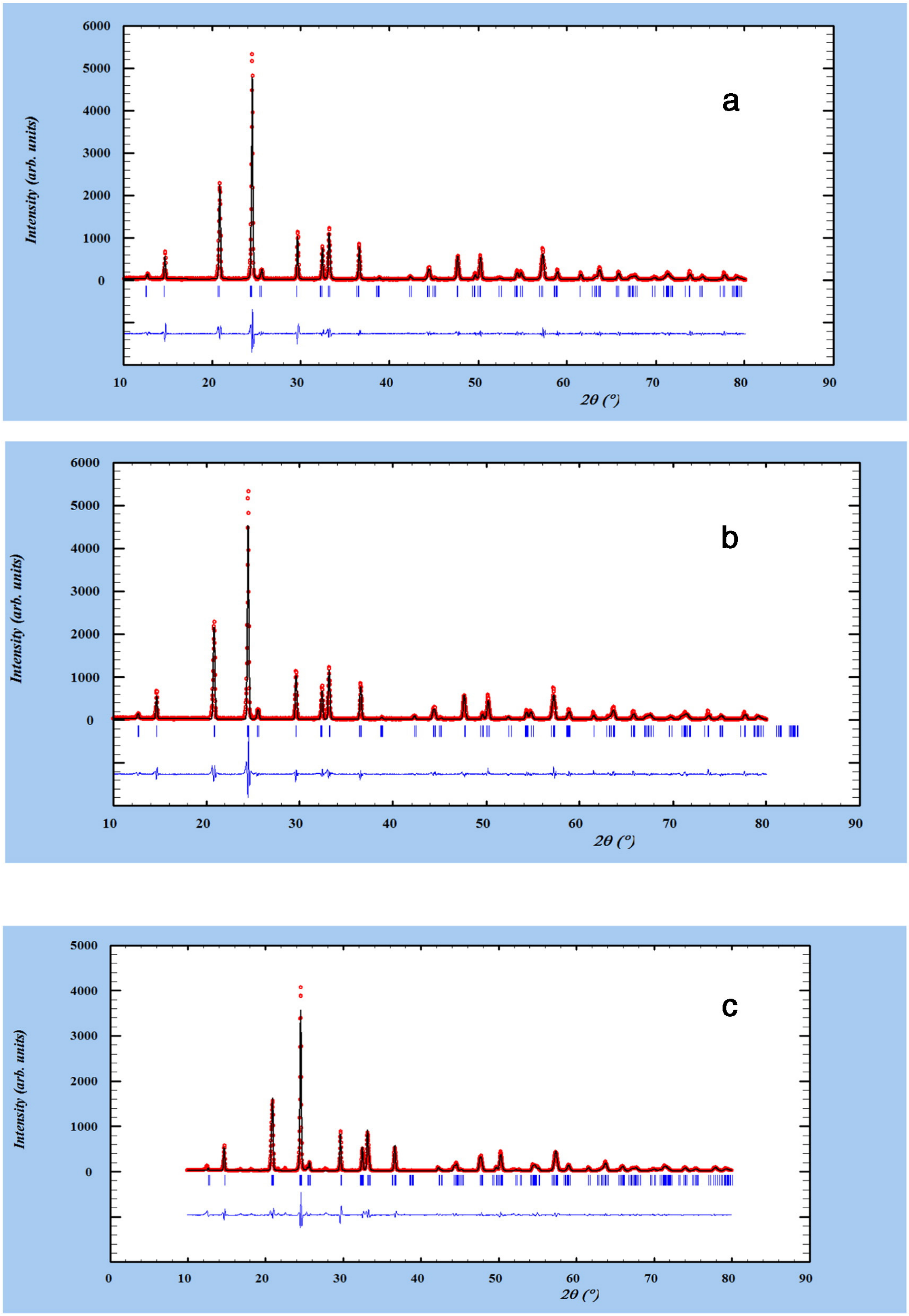

Fig. 1. X-ray diffractograms of $Li_{0.5}M_{0.25}Ti_2(PO_4)_3$, Mn (a), Co (b) and Ni (c).

were added to the base matrix. The particles were dispersed by using a high speed mechanical with speed 2500 rpm. The prepared coating was mixed with xylene solution to facility the application of coating on the metal surface. Before testing, the coated panels were left in a laboratory under ambient conditions for 48 h to dry.

2.3. Material and medium

Carbon steel electrode with the following chemical composition: (wt %); 0.06 C; 0.06 Si; 0.7 Mn; 0.005 P; 0.001 S; 0.012 Ni; 0.015 Cr; 0.004 Mo; 0.002 V; 0.02 Cu and Fe (bal.), was used as the substrate.