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Synthesis and characterization of the fourth generation of zinc phosphate pigment in the presence of benzotriazole

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ABSTRACT

A novel potassium zinc phosphate (PZP) pigment was synthesized in the presence of benzotriazole (BTA) by a co-precipitation method. The chemical composition of the pigment was investigated by Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy, thermal gravimetric analysis and scanning electron microscope. The inhibitive performance of the pigment was studied in comparison with PZP and conventional zinc phosphate pigments by polarization technique. The mild steel panels were dipped in the 3.5 wt% NaCl solutions containing pigments extracts. Energy-dispersive X-ray spectroscopy analysis and visual investigation was performed on the mild steel panels after immersion. Results showed that PZP-BTA pigment was synthesized successfully. The chemical bonding between PZP and BTA was demonstrated by different techniques. The greater inhibitive action of the PZP-BTA in comparison with PZP and zinc phosphate was demonstrated in this study.

1. Introduction

Applying organic coating is the most widespread method to protect metal surfaces from corrosion [1–4]. Pigments are one of the major components of the organic coatings [5], and some of them can act as inhibitors increasing the corrosion resistance of the metals [2]. Zinc phosphate (ZP), as a classical replacement of toxic chromate compounds has been widely used [4,6,7]. Different researches have focused on the anticorrosive role of ZP but the inhibitive mechanism of this pigment has not been well understood [8,9]. Most of the researchers reported that ZP has a weak inhibitive behavior which is related to its low solubility under neutral conditions. It can lead to insufficient participation in inhibitive corrosion reactions and therefore its barrier role is more highlighted than its inhibitive action [8,10–14]. This issue has led to the development of the second and third generations of ZP through modification of anionic part as well as cationic constituent. In this regard the aluminum zinc phosphate, iron zinc phosphate, zinc molybdenum phosphate, potassium zinc phosphate and sodium zinc phosphate were introduced a second generation [10,15–19]; and zinc tripolyphosphate and zinc aluminum polyphosphate as third generation [7,8]. Recently, the synthesis of a new generation of zinc phosphate has been considered by introducing an organic compound in the pigment composition [20,21,23]. Most of these organic compounds have nitrogen atom owned to amine group that could be bind to inorganic part [20–22]. However the investigations on the inhibitive performance of the ZP pigments of forth generation are limited to a few articles on commercial hybrid ZP pigments and some patents [23,24]. To the best of our knowledge there is no systematic study on developing potassium zinc phosphate pigment coupled with benzotriazole.

In this study, we have synthesized and characterized a new hybrid zinc phosphate of fourth generation named PZP-BTA. This hybrid pigment contains two parts: PZP as an inorganic corrosion inhibitive pigment and BTA as an organic corrosion inhibitor.

2. Experimental

2.1. Materials

Synthetic grade zinc chloride, phosphoric acid (85%), potassium hydroxide and BTA were obtained from Merck Co. The commercial grade of ZP was purchased from Nubiola Co. (Density: 3.7 g/cm^3, Average particle size: 2–3.5 μm) for comparison.

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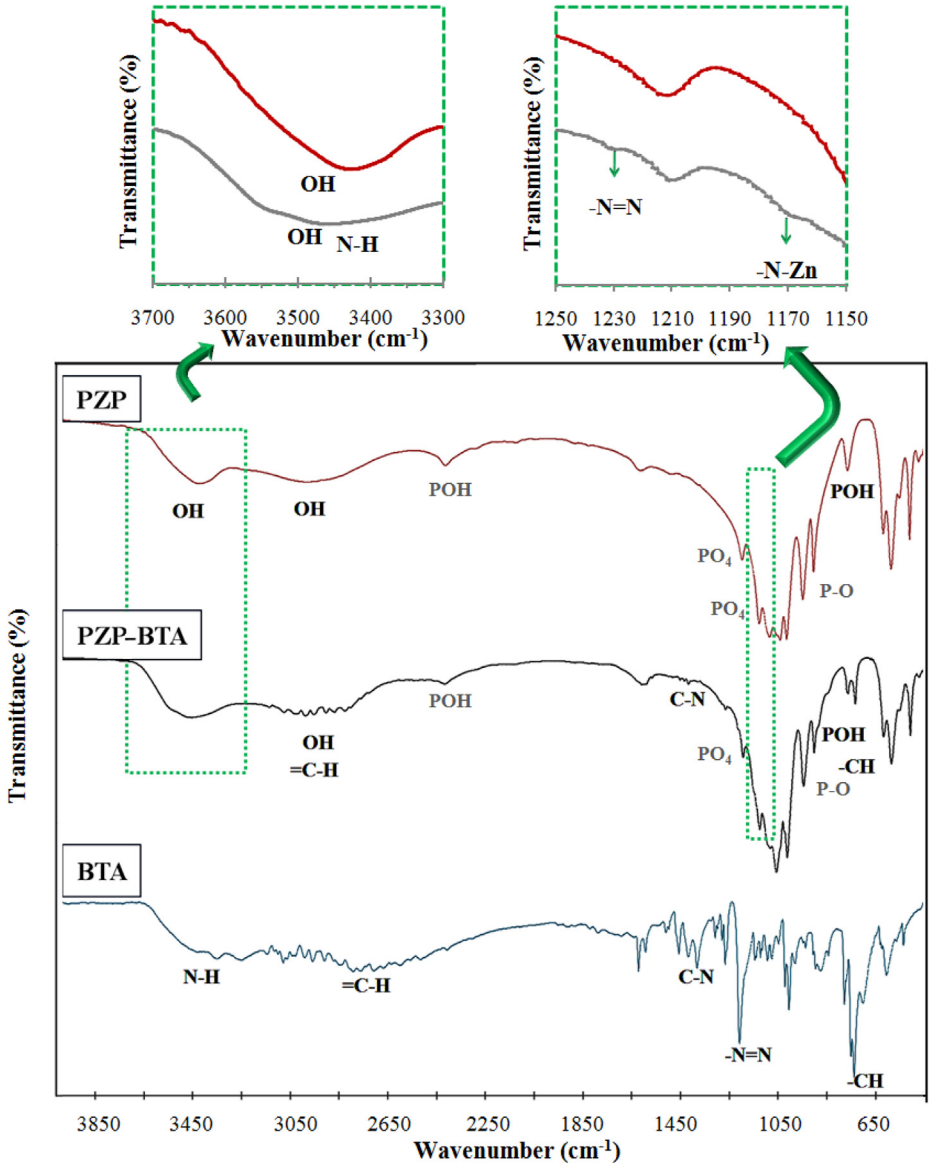

Fig. 1. FTIR spectra of the PZP-BTA, PZP and BTA.

2.2. Pigments synthesis procedure

2.2.1. PZP synthesize procedure

To synthesize of PZP pigment, firstly, 0.06 mol of zinc chloride was added into an aqueous solution of phosphoric acid that was prepared by dissolving 0.06 mol in 100 ml of distilled water. This mixture was stirred for 1 h this solution was named S1. In the next step, 80 ml of aqueous solution of 0.15 mol hydroxide potassium was added to the S1. After stirring the mixture for 3 h, it was heated at 100 °C for 12 h. Finally, the products were obtained by recovering

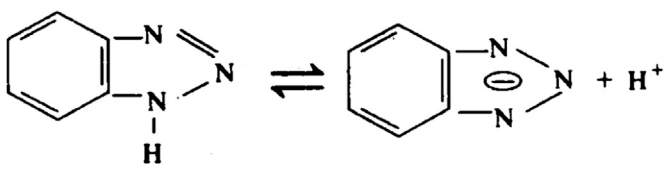

Fig. 2. Deprotonation procedure of BTA [32].

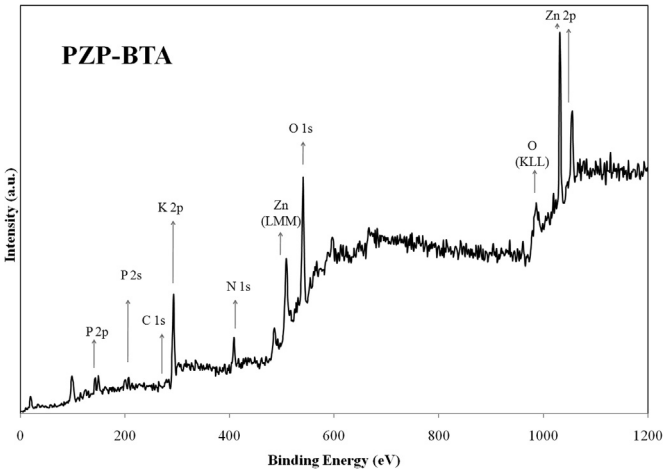

Fig. 3. XPS overview spectrum of the synthesized PZP-BTA pigment.