Corrosion properties of electrodeposited zinc-iron coatings on steel substrate

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Zinc-(iron group) alloys such as Zn-Ni, Zn-Co and Zn-Fe have been widely studied in the last decades as a replacement for electrodeposited cadmium coatings. These binary coatings show better corrosion performance than zinc ones. Zinc-nickel coatings have been widely used, but the toxicity of nickel has led to favour researches on more eco-friendly coatings, such as zinc-iron ones. Several baths have been developed to obtain Zn-Fe deposits with various iron contents. Contrary to Zn-Ni coatings, the use of pulsed current for Zn-Fe coatings has not been much investigated. The objective of our work is to develop Zn-Fe deposits improving their metallurgical features and their corrosion behaviour by using pulsed current..

Zn-Fe alloys with different iron contents (up to 20 wt.%) have been deposited on a low alloy steel substrate (35NCD16) by electrodeposition from an additive-free bath composed of zinc oxide, ferrous gluconate and potassium hydroxide [1] using direct and pulsed currents. The morphology and composition of the coatings have been characterized by means of Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD), Energy Dispersive X-Ray Spectroscopy (EDS), X-ray micro fluorescence and atomic absorption spectroscopy. Adhesion and hardness have respectively been determined by scratch test and microindentation. Electrochemical tests have been performed in 3.5% NaCl solution to assess corrosion potentials and corrosion rates, and to evaluate the sacrificial behaviour of the coatings during extended immersion tests. Corrosion products have also been analysed by XRD and by Raman spectroscopy to understand the corrosion mechanisms.

Results show that both morphology and crystallographic phases of Zn-Fe alloys depend on the iron content. Zinc coatings are formed of hexagonal plates and several grain morphologies are found with the increase of the iron content: hexagonal, pyramidal or acicular grains. Furthermore, the use of pulsed current limits the impact of hydrogen evolution reaction during the deposition process and also improves the morphology with finer grains. These experiments led to establish a relationship between deposition parameters, the iron content of the coatings, their metallurgical features and their corrosion resistance.

[1] C. J. Lan, W.Y. Liu, T.S. Chin. Journal of The Electrochemical Society, 154 (1) D30-D33 (2007)