Electrodeposition and characterization of Zn–Mo coatings for corrosion protection of steel

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Zinc-molybdenum alloy layers are proposed as a new environment friendly anticorrosion coatings. They are especially interesting as replacement materials for cadmium layers and for zinc coatings with Cr(VI) based conversion layers, which were widely used but proved to be carcinogenic and highly toxic. Hence their use is restricted by the European Union's Restriction of Hazardous Substances directive. By comparison, hexavalent molybdenum has self-passivation properties similar to hexavalent chromium, but it is much less toxic and it has no genotoxic effects. Electrodeposition can be the way to obtain such alloys, moreover it is relatively simple and low cost method of coatings production. Nevertheless, it should be emphasized that molybdenum cannot be electrodeposited in pure state from an aqueous solution. It requires the presence of another metal, which causes molybdenum codeposition. This mechanism is described as induced co-deposition. To date, it was known that ferrous metals induce molybdenum deposition, forming an alloy. However, recent investigation of Kazimierczak and Ozga [1] prove that electrodeposition of Zn-Mo alloy is possible, from aqueous citrate solutions.

The purpose of this work was to analyze the mechanism of electrochemical co-deposition of molybdenum with zinc from citrate solutions, characterize the obtained alloy layers and investigate the corrosion resistance of Zn-Mo layers on steel.

The mechanism of electrodeposition process was analyzed using mainly the partial polarization curves method. The surface composition of deposits was determined by chemical analysis (WDXRF) and profile chemical analysis (GDOES). The electronic states of elements in the alloy were analysed by XPS. The morphology of coatings was studied by SEM. X-ray diffractometry was used to identify the phase composition of alloy samples. The corrosion of Zn-Mo coatings was studied by a neutral salt spray test (NSS) and electrochemical methods (OCP, LPR) together with analysis of structural changes and changes of chemical composition of alloy during corrosion processes by XRD, SEM and WDXRF methods.

[1] H. Kazimierczak, P. Ozga, R.P. Socha , Electrochimica Acta 2013, 104, 378–390.