Electrochemical evaluation of hot-dip galvanized steel (HDGS) coated with organic-inorganic hybrid sol-gel in cementitious materials

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Metal corrosion can be prevented, minimized and controlled by the application of coatings performing one or more of the following actions, namely: a) form a barrier that hinders the contact between the corrosive medium and the metallic substrate; b) work as a cathodic protection where the coating material replaces a sacrificial anode or act as inhibition/passivation including cases of anodic protection; c) contains embedded species that inhibit the action of the corrodant agents.

From the technological development emerged a large variety of coatings and materials that present a good performance in preventing corrosion such as inorganic coatings, paint coatings and surface treatments. Chromate based chemical conversion layers (CCC) are commonly used as surface treatment as they exhibit enhanced corrosion resistance and improved coatings adhesion. Nonetheless, hard restrictions on the use of hazardous compounds, e.g. VOCs (Volatile Organic Compounds), HAPs (Hazardous Air Pollutants) and hexavalent chromium, were imposed by health and environmental concerns.

On last decades, R&D efforts were focused on to search new coating materials that accomplish with regulations and economic constraints. We assist to the development of low VOC, low HAP, non-toxic, environmentally friendly surface treatments capable of providing effective corrosion protection. Among those new coatings materials sol–gel method shows to be environmentally and economically advantageous comparatively to the previously mentioned.

This paper describes the studies developed for applying a sol-gel method to produce organic-inorganic hybrid (OIH) coatings over HDGS reinforcement and evaluates their efficiency as a corrosion protection layer to prevent an initial excessive reaction between cement pastes and the zinc, during the first days after concreting [1-2].

Based on a well-established methodology [3-4] two different organic-inorganic hybrids (OIH) matrices synthesized by sol-gel method, were identified as having potential to be used as alternative pre-treatment to prevent the corrosion of HDGS in concrete. These OIH commonly termed as ureasilicates, U(X) [5] and amino-alcohol-silicates, AA(X), were synthesized using a functionalized siloxane and five oligopolymers (refereed as Jeffamine) with different molecular weight: 230, 400, 600, 900 and 2000. The ureasilicate OIH coatings U(X) were obtained using 3-isocyanatopropyltriethoxysilane (ICPTES) and the OIH AA(X) coatings were synthesized using 3-Glycidoxypropyltrimethoxysilane (GPTMS) derived siloxanes.

Besides the mentioned above ten different pure OIH matrix coatings, a similar set of HDGS samples were coated with the previously stated OIH matrices that were doped with Cr(III) which was tested as corrosion inhibitor. The coatings, doped and undoped with inhibitor, were applied using a single and a triple dip step. Dip coating was done using a draw speed of 10 mm/min in both. Coatings resistance, with a minimum thickness, low permeability and high stability were evaluated by electrochemical studies, namely EIS (electrochemical impedance spectroscopy) and corrosion potential monitoring [6]. The studies were carried out in mortars. SEM/EDS analyses of the coatings were performed before and after exposure to the cement based materials.

The analysis of the results by optical and scanning electronic microscopy (SEM/EDS) was consistent with the data obtained by electrochemical techniques. The HDGS samples coated with OIH presented better performance when compared with HDGS uncoated samples.

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Acknowledgements: The authors thanks the FCT for research the PhD grant SFRH/BD/62601/2009 and the financial support by Centro de Química [project F-COMP-01-0124-FEDER-022716 (ref. FCT Pest-C/Qui/UI0686/2011)-FEDER-COMPETE].