# Heterogeneous crystallization of $ZnSn(OH)_6$ through chemical bath deposition for enhancing the bond strength at the steel/concrete interface

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Reinforced concrete is nowadays one of the most used material for construction and building engineering. In almost all the cases, concrete is reinforced with carbon steel and, for this reason, it is quite cheap and readily available and it is suitable for many building and construction applications [1,2]. Despite their higher mechanical stability with respect to "simple" concrete structures, reinforced concrete structures have a durability limited sometimes to tens of years. In particular, long-term performances of reinforced concrete are usually assessed considering criteria such as serviceability and durability. The latter is limited by the corrosion of the carbon steel reinforcements that can be due to the presence of carbon dioxide (leading to the carbonation process) and to the presence of chloride ions [3,4]. Among many others, cathodic protection (CP) can be effective in slowing down corrosion process of carbon steel in concrete. CP can be achieved through the use of a metallic coating onto the surface of the carbon steel, for instance Zinc coatings that protect the carbon steel with a barrier-type action but, most of all, provide also the cathodic protection effect because the coating acts as a sacrificial anode whenever the underlying carbon steel is exposed. Nevertheless, Zn is an amphoteric metal, i.e., it dissolves (corrodes) in acid and alkaline solutions. This is a key point since concrete pore solution is alkaline, thus corrosion rate of a galvanized steel could be quite high and could lead to vigorous hydrogen evolution. The main consequence of the hydrogen gas evolution is the formation of pores at the galvanized rebar/concrete interface due to the trapping of bubbles, thus reducing the contact area between steel and concrete, leading to severe adhesion problems. In this frame, it is crucial to find a process that can be easily integrated in the industrial hot-dip galvanizing process, in order to modify the surface of the Zn coating to reduce the possible adhesion problems at galvanized steel/concrete interface, without detrimental effect on its cathodic protection action.

In the present work we propose a chemical bath deposition process to produce a $ZnSn(OH)_6$ coating through heterogeneous crystallization onto the Zn surface of galvanized carbon steel (GCS) rebars, that can be easily integrated in the common hot-dip galvanizing process. Electrochemical and gravimetric measurements were carried out to study the mechanism of formation of the $ZnSn(OH)_6$. Its structure, morphology and composition were investigated by Scanning Electron Microscopy, X-ray Diffraction and Raman Spectroscopy. Corrosion protection performances were studied by electrochemical measurements and by modeling electrochemical behavior of the system through the use of Electrochemical Impedance Spectroscopy. Finally, enhanced adhesion properties were assessed by pull-out test.

[1] S.R. Yeomans, Galvanized Steel in Concrete: An Overview, in: S.R. Yeomans (Ed.), Galvaniz. Steel Reinf. Concr., Elsevier Ltd., Oxford, UK, 2004.

[2] V. Kuklík, J. Kudláĉek, Hot-Dip galvanizing of steel structures, Elsevier Ltd., 2016.

[3] C.L. Page, K.W.J. Treadaway, Aspects of the electrochemistry of steel in concrete, Nature. 297 (1982) 109–115.

[4] L. Bertolini, B. Elsener, P. Pedeferri, E. Radaelli, R. Polder, Corrosion of Steel in Concrete, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2013.