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Hydronium Detection in Hardened Concrete

Ana Martínez Ibernón[1], José M. Gandía Romero[1,2], Isabel Gasch[1] and Manuel Valcuende[2]

[1] Instituto Interuniversitario de Investigación de Reconocimiento Molecular y Desarrollo Tecnológico (IDM), Universitat Politècnica de València, Camino de Vera, s/n 46022 Valencia, Spain. E-mail: anmarib@arqt.upv.es

[2]Departamento de construcciones arquitectónicas. Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, España. E-mail: mvalcuen@csa.upv.es

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1 Introduction

The detection of hydronium and hydrogen availability variations in the reinforcement concrete structures is interesting due to the presence of H+/H2 are involve in reactions that produce the durability loss of the structures.

The reaction and molecular recombination of the hydrogen with metals have a greatly impact on their mechanical properties (Zapfpe *et al.*, 1941). In the case of reinforcement concrete structures these problems can produce the brittle failure of the structure (Ramón Zamora, 2018), which seriously threatens the people safety, also the failure generates high economical costs.

These phenomena affect in structures particularly in those industries that work with environments or substances that contain hydrogen. For instance: nuclear reactors, chemical industry, etc. Also, the hydrogen can be generated in structures where is used without any control of the potential the cathodic protection (impressed current).

In order to prevent or control this problem will be effective use monitoring systems. In this preliminary study evaluated the detection capability of the Rh voltammetric sensor, which is part of a multisensory system under development called Electronic-Tongue, to detect the hydronium or hydrogen in the hardened concrete matrices.

To perform the study a concrete sample (10x10x10 cm) of water/cement ratio 0.4 was made, in the sample was embedded one Electronic Tongue (Figure 1).

The samples were studied in two different humidity conditions: State 1: Concrete in atmospheric conditions (dry conditions) and State 2: Concrete saturated with water. In the state 2, was applied a high amplitude cathodic potential pulse, -1.6V, during 3 min, to generate atomic and molecular hydrogen. The results of cyclic voltammetry before and after to apply the cathodic potential pulse were compared.

About the results obtained, the Rh voltammetric sensors used in the Electronic Tongue are capable to detect the presence of hydronium and hydrogen in the concrete matrix. As we can see in the Figure 2, the morphology of the electric current density curve, obtained with the embedded sensor in the conditions of the state 2, is similar to the curve obtained in an alkaline system in solution, we can identify the same peaks associated with reactions that involve H^+/H_2.

The Figure 2 shows how after to apply the cathodic pulse (AP), the peaks associated with the desorption and adsorption of the H^+/H_2 risen. The increasement of the desorption peaks causes the curve is displaced up, due to now in this potential range the mainly reaction is with H^+/H_2, whereas previously to the potential pulse the mainly reaction was the water reduction.

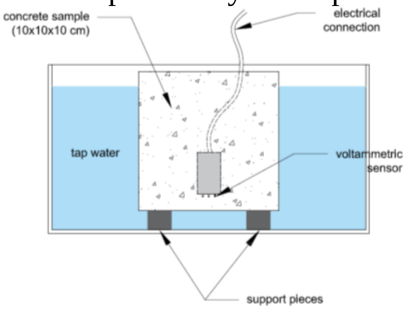

Figure 1. Test set-up, for submerged conditions (state 2).

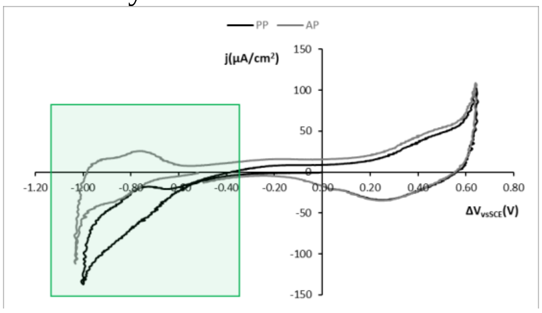

Figure 2 Results of Experience 2: Line black: Voltagram of the system previously cathodic pulse (PP). Line grey: Voltagram of the system after cathodic pulse (AP). Green square: Indicates the zone where the response is associated to reactions where are involved H^+/H_2.

This demonstrates that the Rh electrode has a region of potential sensitive to the generation and adsorption/desorption processes of H^+ / H_2. Therefore, this sensor could be used in hardened concrete matrix to detect the species involved in the redox couple.

2 Conclusions

According to the results, the developed voltammetric sensors are capable to detect variations in the presence of the system hydronium-hydrogen inside of the hardened concrete matrix, and thus the Rh electrode could be useful to determine the pH or the hydrogen activity inside of the materials.

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ORCID

Ana Martínez: https://orcid.org/0000-0003-2136-5650
José M. Gandía: https://orcid.org/0000-0003-0257-3286
Isabel Gasch: https://orcid.org/0000-0001-7036-4481
Manuel Valcuende: https://orcid.org/0000-0002-9967-1554

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