Electrochemical techniques for patinas and coatings assessment in conservation studies

I. Rute Fontinha[(1)], Maria João Correia[(1)] and Elsa Pereira[(1)]

(1) Laboratório Nacional de Engenharia Civil, Av. do Brasil, 101, 1700-066 Lisboa, Portugal

Electrochemistry can provide valuable information on metallic artifacts patinas stability and conservation treatments performance. Therefore, the use of electrochemical techniques in multi-analytical studies on the conservation-restoration of outdoor copper statuary alloys has increased over the last two decades. However, despite some recent developments, for reaching their full potential, especially as regards in situ nondestructive testing there is still subject matter to be explored [1-3].

The two case studies included in this communication highlight the usefulness of the non-destructive electrochemical techniques within the framework of conservation studies of copper alloy outdoor monuments.

One case study refers to a 220-year-old bronze monument. Within a multi-analytical approach for the conservation state diagnosis [4], *in situ* measurements of electrochemical potential and resistivity were carried out over representative areas of the surface patinas. The electrochemical test results, in agreement with the other findings, revealed the less protected zones of the statue and contributed to prioritize the required interventions.

The other case study aimed the assessment of conservation treatments developed for outdoor bronze monuments [5]. In this study, the electrochemical impedance spectroscopy (EIS) was used to evaluate the efficacy and the durability of innovative treatments comprising eco-friendly products and procedures, such as organo-silanes coatings, limewater and cuprite deposition. These were applied to copper/bronze (85Cu5Sn5Pb5Zn) substrates with natural and artificial patinas representing urban and marine environments. Electrochemical impedance spectroscopy was carried out before and after weathering, according to the patina type, under natural exposure in a marine environment (C5, Cabo Raso test site) and artificial weathering in UV+sulphate salt spray chambers [6]. Untreated and Incralac® (reference) treated specimens were also evaluated for comparison. The EIS testing results showed that some of the new treatments presented better protective properties (higher and more durable corrosion resistance) than the reference treatment, being a viable eco-friendly option for bronze conservation. EIS is an important tool not only for testing and predicting the corrosion protection performance of conservation treatments applied to copper alloys, but also for understanding the processes involved in their degradation.

[1] P. Letardi, B. Salvadori, M. Galeotti, A. Cagnini, S. Porcinai, A. S. Barbone, A. Sansonetti, Microchemical Journal 125, 2016, 151.
[2] B. R. Barat, B. P. Letardi, E. Cano, Metal 2019: Proceedings of the Interim Meeting of the ICOM-CC Metals Working Group September 2-6, 2019 Neuchâtel, Switzerland, Pulido & Nunes (Eds), 2019, 77.
[3] G. P. Cicileo, M. A. Crespo, B. M. Rosales, Corrosion Science 46, 2004, 929.
[4] M. M. Salta, I. R. Fontinha, Relatório nº313/98 - NQ, LNEC, Lisboa, 1998.
[5] S. Bittner, G. Farron, R. Fontinha, D. Job, E. Joseph, P. Letardi, M. Mach, R. Mazzeo, S. Prati, M. Salta, A. Simon, Conservation Science 2007, J. Twonsend, L. Toniolo, F. Cappitelli (Eds), London, 2008, 40.
[6] I. R. Fontinha, M. M. Salta, Relatório 395/2008-NMM, LNEC, Lisboa, 2008.