Cathodic Plasma Electrolysis & Recovery of Zinc as Coating [Elsevier Award]

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Galvanized steel, resulting from coating steel with a deposit of zinc, finds extensive use in several fields, from construction to automotive as well as for metal fittings and home appliances. Although the steelmaking industry has long understood the challenges of the circular economy (ca. 30% of the world output being secondary steel), further efforts should be done to improve the steel recycling processes, for example making more profitable the powdery waste obtained in the production of steel by electric arc furnaces (AEFs). In fact, when galvanized scrap is used to feed furnaces, about 30 wt.% of the AEF dust is made of zinc, the fourth more used metal worldwide.
Combining the Regenerative and Circular Economy vision with the real needs of steelmaking companies, our research group has started a feasibility study aimed at proposing a *direct strategy* to regenerate galvanized steel with two main goals: *i*) shortening the current multi-step processes for the recovery/reuse of zinc; *ii*) offering a possible process innovation in galvanizing. The rationale is to galvanize secondary steel by cathodic plasma electrolysis (CPE), by using directly Zn-containing aqueous solutions resulting from the leaching of EAF dust. The project aims also at improving scientific knowledge on CPE that is an electrochemical approach much less investigated [1] with respect to its anodic counterpart (plasma electrolytic oxidation, PEO).
In the present talk, some preliminary lab-scale data will be discussed concerning the employment of CPE for both *surface pre-treatment* and *galvanizing* of steel, in the form of plate and wire rod. Considering the good performance of NH_4Cl as zinc leaching agent of EAF dust (by preventing some drawbacks of the conventional approach with sulfuric acid), special attention will be devoted to ammonium-based solutions, as a still unexplored medium for CPE (Figure 1). After preliminary screening of electrolytes and operative parameters aimed to obtain a stable plasma by minimizing the power supplied, the effects of CPE on *i*) the surface morphology of the treated steel and *ii*) the features of the zinc deposit have been investigated by combining electrochemical and microscopic techniques. Finally, real leaching solutions have been implemented for CPE galvanizing, to identify any interfering species.
Collected data support the feasibility of the CPE process that allows to obtain zinc deposit with corrosion protection performance comparable to that of commercially available benchmarks (*i.e.*, hot dip galvanizing and electrogalvanizing processes).

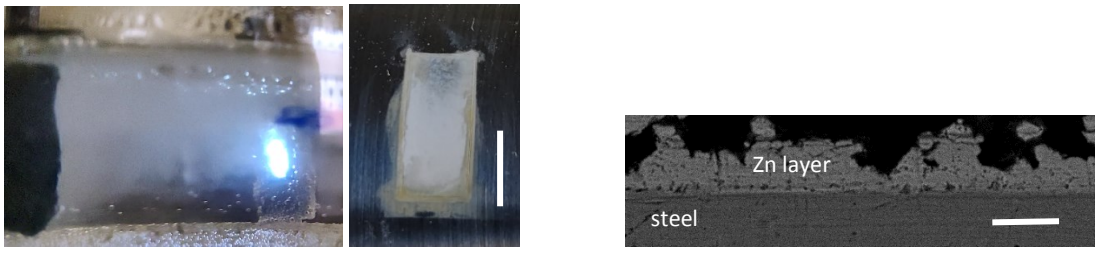

Figure 1. *Left: electrolytic plasma regime in 1.3 M NH_4Cl solution and effect of the treatment on a steel plate (marker = 0.5 cm). Right: BS-SEM micrograph of a cross section after CPE galvanizing (marker = 10 μm).*

[1] E.I. Meletis, X. Nie, F. Wang, J.C. Jiang , *Surf. Coat. Tech.* **2002**, *150*, 246.

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