Assessment of microbial corrosion in marine and hypersaline environment

EUROCORR 2018 Young Scientist Grant – Short report

Work carried out by Leonardo Iannucci and hosted by Dr. Régine Basséguy at LGC, Université de Toulouse-CNRS (Toulouse, France) during the periods 17th September- 5th October 2018 and 4th March- 17th April 2019

The purpose of this collaboration was to experiment innovative techniques to study microbial corrosion in marine and hypersaline solutions. Actually, great interest can derive from the development of new testing techniques for material characterization; moreover, marine and hypersaline environments represent challenging case studies for corrosion assessment, as the presence of many different salts in solution often leads to complex corrosion processes.

This study focused on the corrosion assessment in hypersaline Starkey medium (a solution containing chlorides as well as phosphates and sulfates) inoculated with salt marsh sediments, in order to have a wide variety of bacteria in the solution and simulate a real environment. Two different stainless steels, AISI 304 and AISI 316, have been tested in order to investigate their corrosion behavior in this environment. Two experimental set-up were used: the classic electrochemical cell to perform classical corrosion tests and the Microbial Fuel Cell (MFC) technique, developed by the applicant and his research team as an innovative approach to assess corrosion resistance of materials in an environment containing bacteria. Monitoring of open circuit potential, electrochemical impedance spectroscopy and cyclic voltammetry have been performed to characterize the two materials as a function of the immersion time in the aggressive solution. Moreover, the effect of the presence of bacteria in the medium has been monitored by means of solution absorbance, pH and dissolved oxygen measurements, as these parameters primarily affect the electrochemical behavior of the stainless steels.

Experiments showed that the microorganisms populating the medium are able to completely consume the oxygen in the solution, leading to strictly anaerobic conditions. These are less aggressive for the studied steels, which are able to better preserve their passive layer. Moreover, electrochemical impedance spectroscopy highlighted the different behavior of the two materials. Actually, AISI 316 was characterized by a superficial oxide layer that was more protective if compared to that of AISI 304. Formation of corrosion pits on AISI 304 samples was highlighted first by electrochemical measurements and then using scanning electron microscopy, as shown in Figure 1.

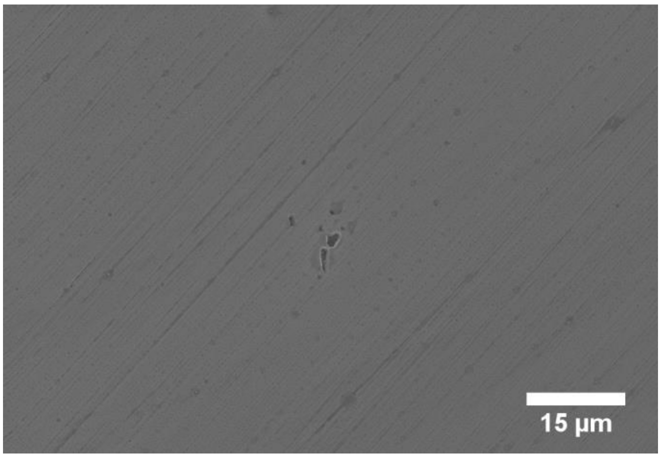
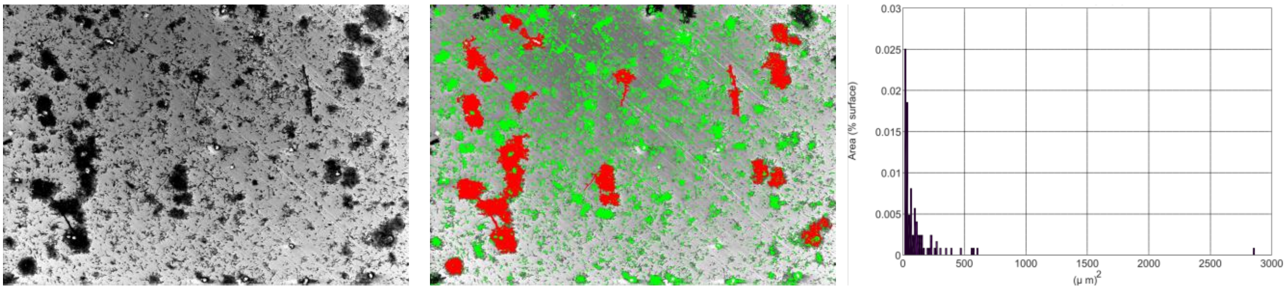


Fig. 1 - Corrosion pits on the surface of AISI 304 sample after immersion in the electrolytic solution

The experiments employing the MFC setup made it possible to monitor the progressive colonization of the sample surface by bacteria. Moreover, the different corrosion behavior of the two stainless steels was highlighted through the measure of the current flows in the system and good accordance was found between these data and those obtained from the electrochemical measurements.

As part of the collaboration, an imaging algorithm has been developed to assess and quantify the effects of microbial corrosion on steel surface. The system, which is a simple and self-contained solution, is able to process images taken with the Scanning Electron Microscope (SEM) to provide information on biofilm coverage and dimensional distribution of bacteria aggregates present on the metallic surface. It is based on the open source Open-CV library, which is used to identify the microorganisms, as they appear like black spots on the bright background represented by the metal surface. An example of the results that can be obtained from the imaging process is presented in Figure 2.



a) b) c)

Fig. 2 - Example of results from the imaging process:
a) SEM image acquired by the operator *b) Results of the identification process*
c) Histogram showing dimensional distribution of bacteria aggregates on sample surface

These data, coupled with the electrochemical measurements, can provide a deeper insight in the study of the microbial corrosion behavior of different metals and alloys.

The scientific outcomes of this collaboration will be presented at EUROCORR 2019 in Seville:

- L. Iannucci et al., *Microbial corrosion assessment of stainless steel in anaerobic saline solutions*, Microbial Corrosion in Marine Environment (WP9 + WP10)
- L. Iannucci et al., *Contours detection imaging algorithm for microbial corrosion assessment,* Microbial Corrosion (WP10)