MACRO AND MICRO ELECTROCHEMICAL MEASUREMENT OF EPOXY COATING

Marina Samardžija [1], Marin Kurtela[2], Gabrijela Ljubek[1], Ivan Stojanović[2], Vesna Alar[2]

[1] University of Zagreb, Faculty of Mining-Geology-Petroleum Engineering, Department of Chemistry, Zagreb, Croatia,

[2] University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Department of Welded Structures, Zagreb, Croatia

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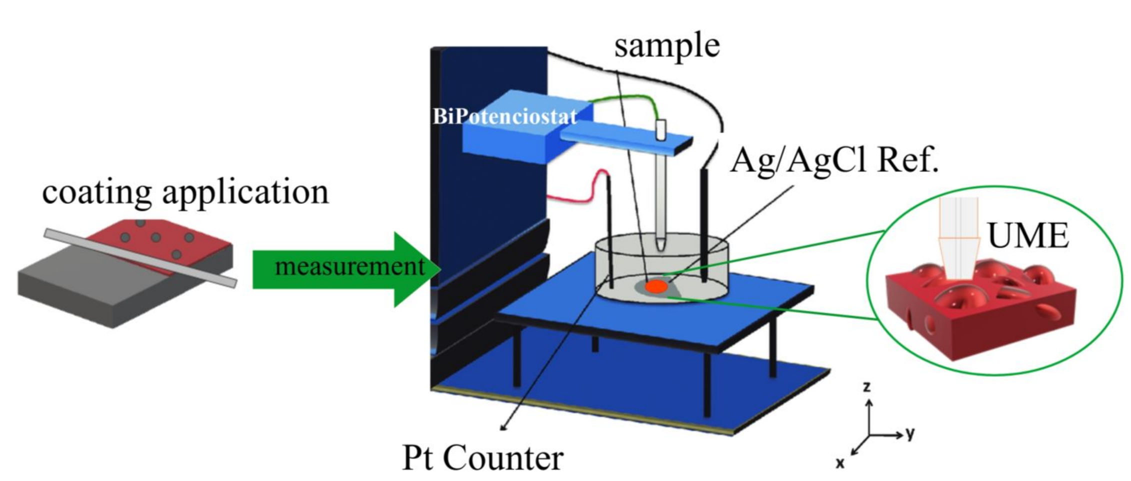
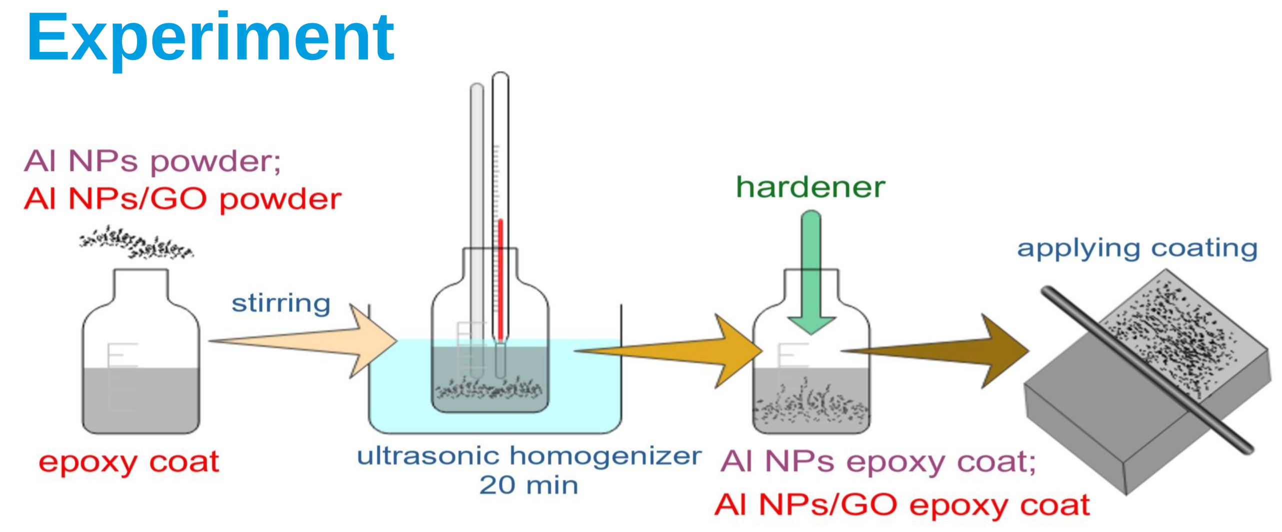
Abstract

Classical electrochemical methods, such as electrochemical impedance spectroscopy (EIS) provide insight into the average behaviour of the entire tested surface. However, the results of these methods are sometimes difficult to interpret due to local phenomena of coating degradation, such as blistering. In addition, EIS does not provide information on the location of micropore or microcrack formation and is therefore not a suitable method for studying coating degradation mechanisms [1]. To overcome these obstacles, Scanning Electrochemical Microscopy (SECM) was developed, opening up the possibility investigating the initial stages of electrochemical corrosion. The primary goal of this research is to complement EIS measurements with SECM results on different samples of epoxy coating enriched with aluminum nanoparticles (Al NPs) and graphene oxide (GO). Macro and micro electrochemical measurements, including cyclic voltammetry (CV) and EIS, were carried out in a 3.5 wt.% NaCl solution. The test results showed that SECM measurements can identify active and passive areas, facilitating the study of local degradation of nanoparticles within the epoxy coating. Additionally, the addition of nanoparticles provides greater resistance, thereby improving anti-corrosion protection.



Scheme of the SECM device and preparation and measurement of the sample at the micro level

Experiment

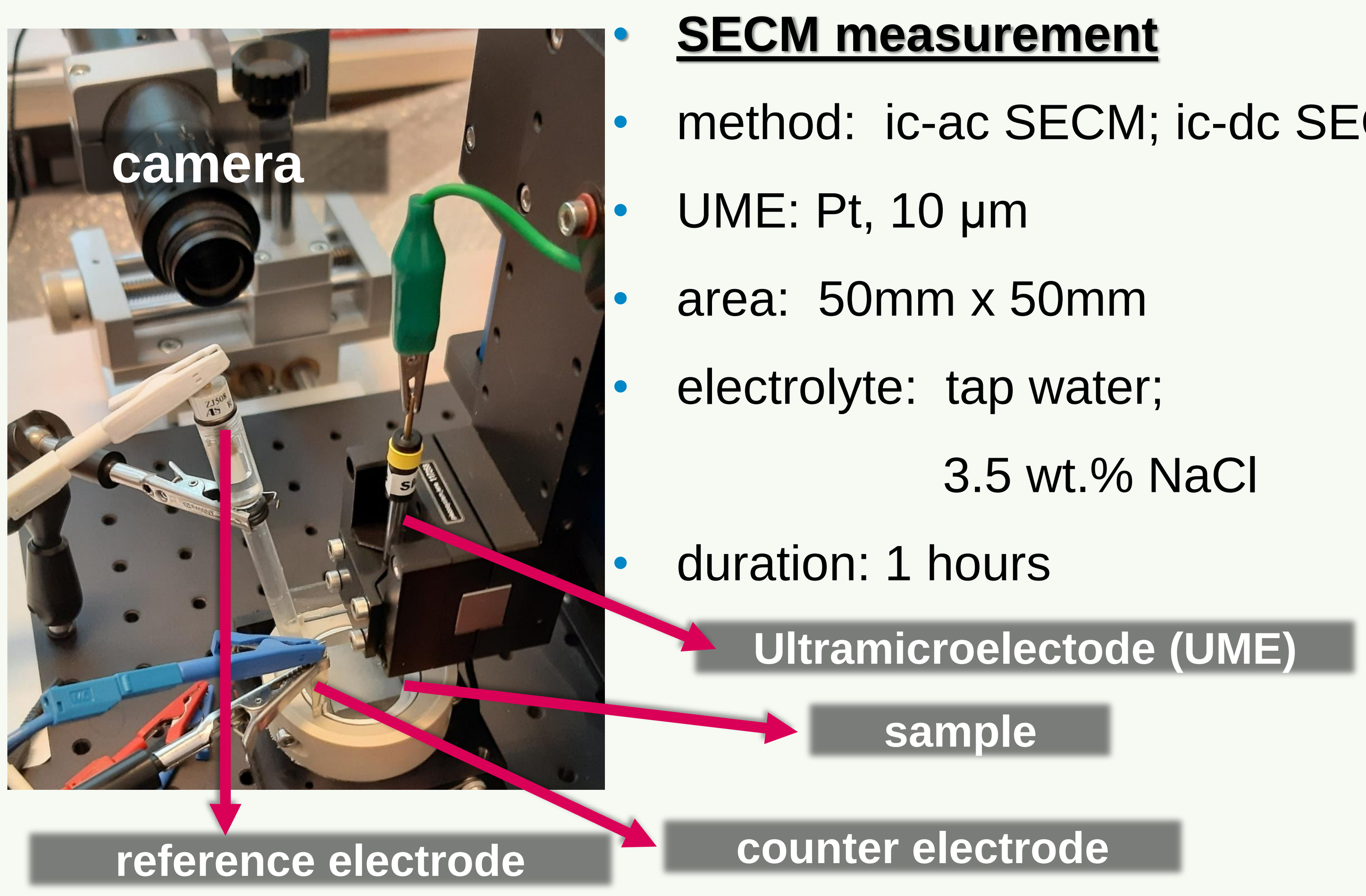


Preparation of the Al/GO epoxy coating.

MACRO LEVEL

- **EIS measurement**
- method: EIS
- electrolyte: 3.5 wt.% NaCl
- duration: 1 hours

MICRO LEVEL



- **SECM measurement**
- method: ic-ac SECM; ic-dc SECM
- UME: Pt, 10 µm
- area: 50mm x 50mm
- electrolyte: tap water;
  3.5 wt.% NaCl
- duration: 1 hours

Results & Discussion

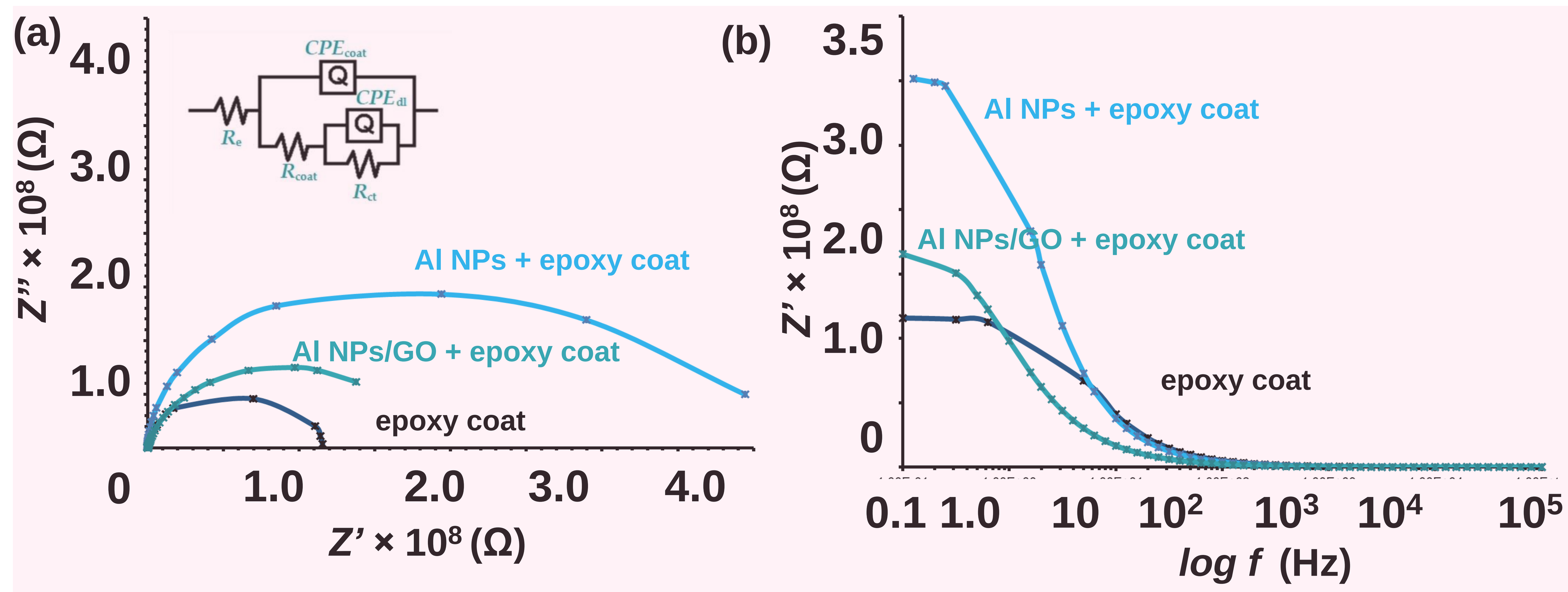


Figure 1. Nyquist and Bode plots of (**a**,**b**) epoxy coating, and epoxy coating filled with Al NPs/GO powder, and Al NPs immediately after immersed in 3.5 wt.% NaCl solution.

- The addition of graphene oxide and aluminum nanoparticles enhances the efficience and electrochemical properties of the coating.
- Pure aluminum nanoparticles provide better resistance than when embedded in graphene oxide.

ic-ac SECM

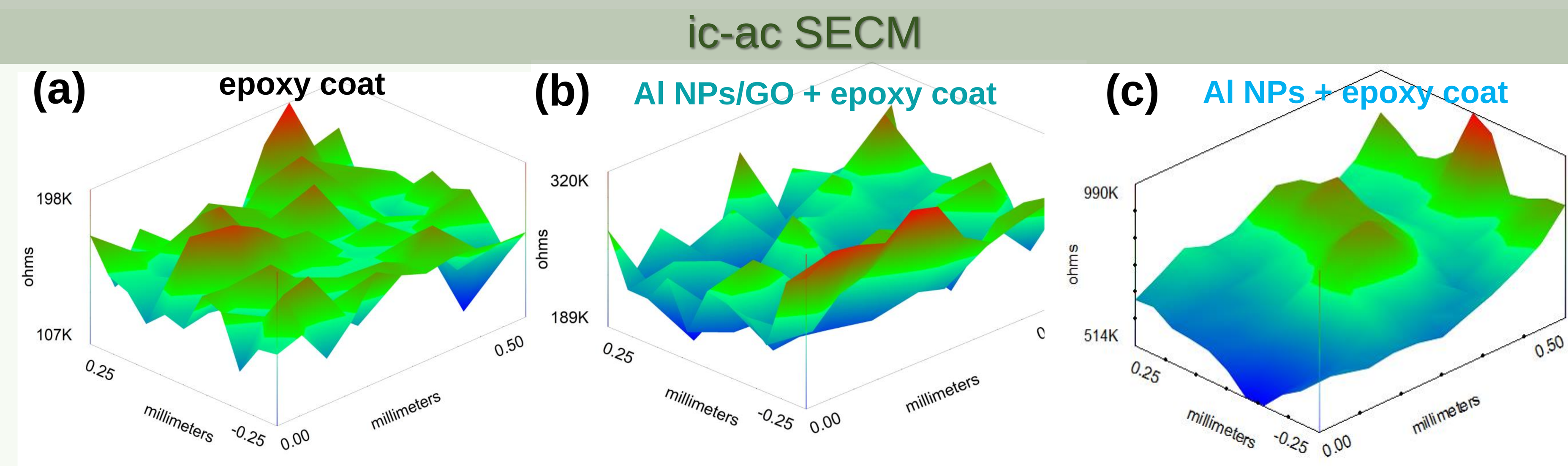


Figure 3. ic-dc SECM distribution of current of scratched samples of: (a) epoxy coating (b) epoxy coating with Al NP/GO powder, and (c,d) epoxy coating with Al NPs immediately after immersed in 3.5wt% NaCl solution at the tip potential of +60 V vs Ag/AgCl/KCl reference electrode.

- Local electrochemical measurements of real impedance indicate an increase in the electrochemical properties of the coating with the addition of graphene oxide and aluminum nanoparticles

ic-dc SECM

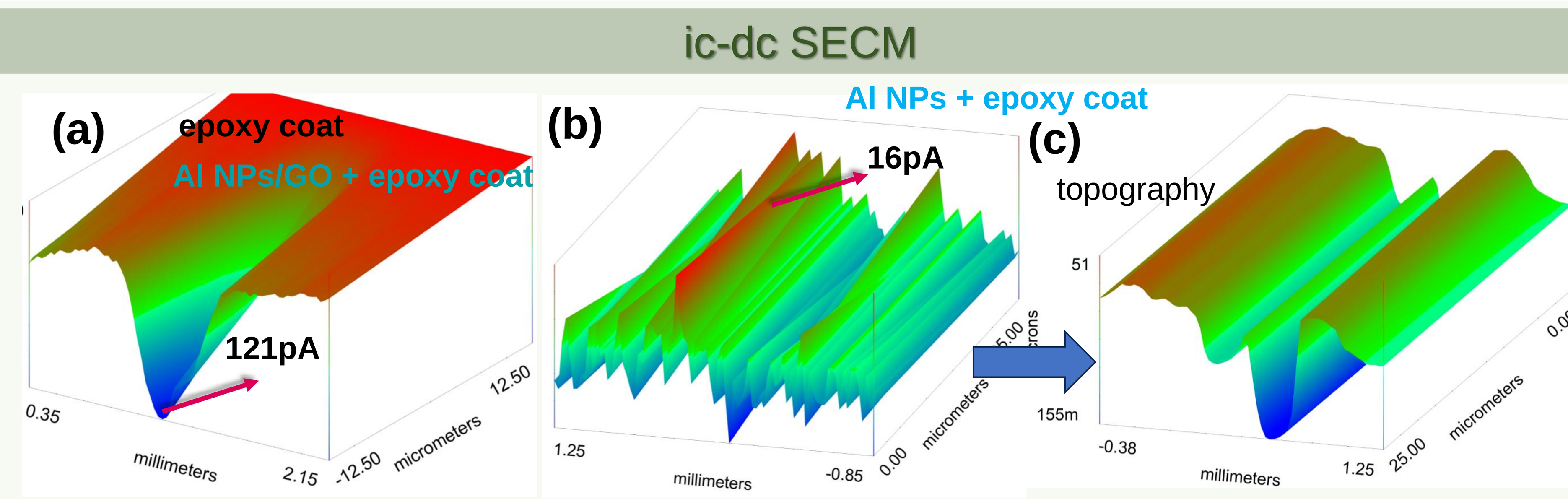


Figure 3. ic-dc SECM distribution of current of scratched samples of: (a) epoxy coating and epoxy coating with Al NPs/GO powder, and (b,c) epoxy coating with Al NPs immediately after immersed in 3.5wt% NaCl solution at the tip potential of +60 V vs Ag/AgCl/KCl reference electrode.

- Samples with epoxy coating and Al NPs/GO + epoxy coating show a similar value of Fe^{2+} ion dissolution current from the metal surface.
- The Al NPs + epoxy coating sample shows a lower value of Fe^{2+} ion dissolution current in the scratched area.

Conclusions

- The GO and Al NPs nanocomposite was successfully dispersed in the epoxy coating.
- The addition of GO and Al NPs in the epoxy coating improves the resistance to the electrolyte in macro and micro level.
- cyclic voltammetry (ic-dc SECM) demonstrated that aluminium nanoparticles oxidize and cover the damaged area on the epoxy coating, while the nanoparticles within the GO were not able to oxidize immediately.

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[1] S. Farrokhpay, Appl. Spectrosc. Rev. 47 (2012) 3.