

Micro and nano- layers against material deterioration in aggressive environment

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Aim of study

➤ Study of

- formation of self assembled molecular layers (SAM) on carbon steel and aluminum.
- influence of different variables (solvent, oxide layer, working system (open or closed), temperature, pH, chloride ions, perchloride) on the protective layer formation.

➤ Characterization of the formed layers using:

- Contact angle measurement (presence of the layer)
- Atomic force microscopy (morphology of the layer)
- Electrochemical measurements: cyclic voltammetry (compactness of the layer), potentiodynamic polarization techniques, and electrochemical impedance spectroscopy (anticorrosion activity).



Fulfillment of the fifth semester

➤ Characterization of the formed layers by:

- Electrochemical potentiodynamic measurements
- Cyclic voltammetry measurements
- Open circuit measurements
- Atomic force microscopy (AFM)

➤ Study of the effect of

- Chloride ions
- Perchloride ions



Publication on the fifth semesters

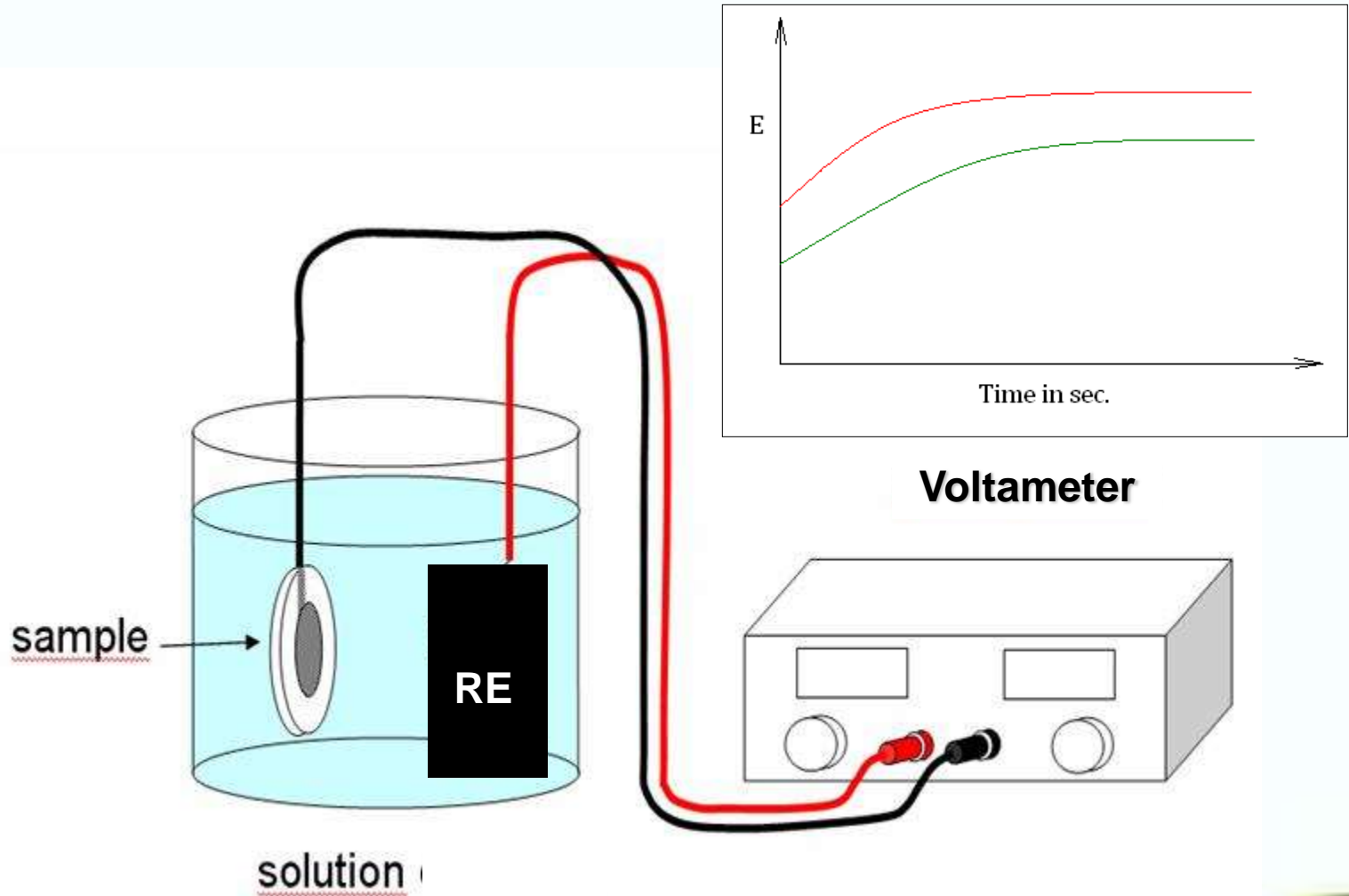
- A presentation “*Protection of mild steel against corrosion by flourophosphonic acid and undecenyl phosphonic acid nanolayers*”, 14th Conference Day of PhD Students, Veszprém,- Hungary 24th November 2014.
- A journal publication “*Corrosion protection of carbon steel by special phosphonic acid nanolayers*” **Materials and Corrosion**



Test Methods

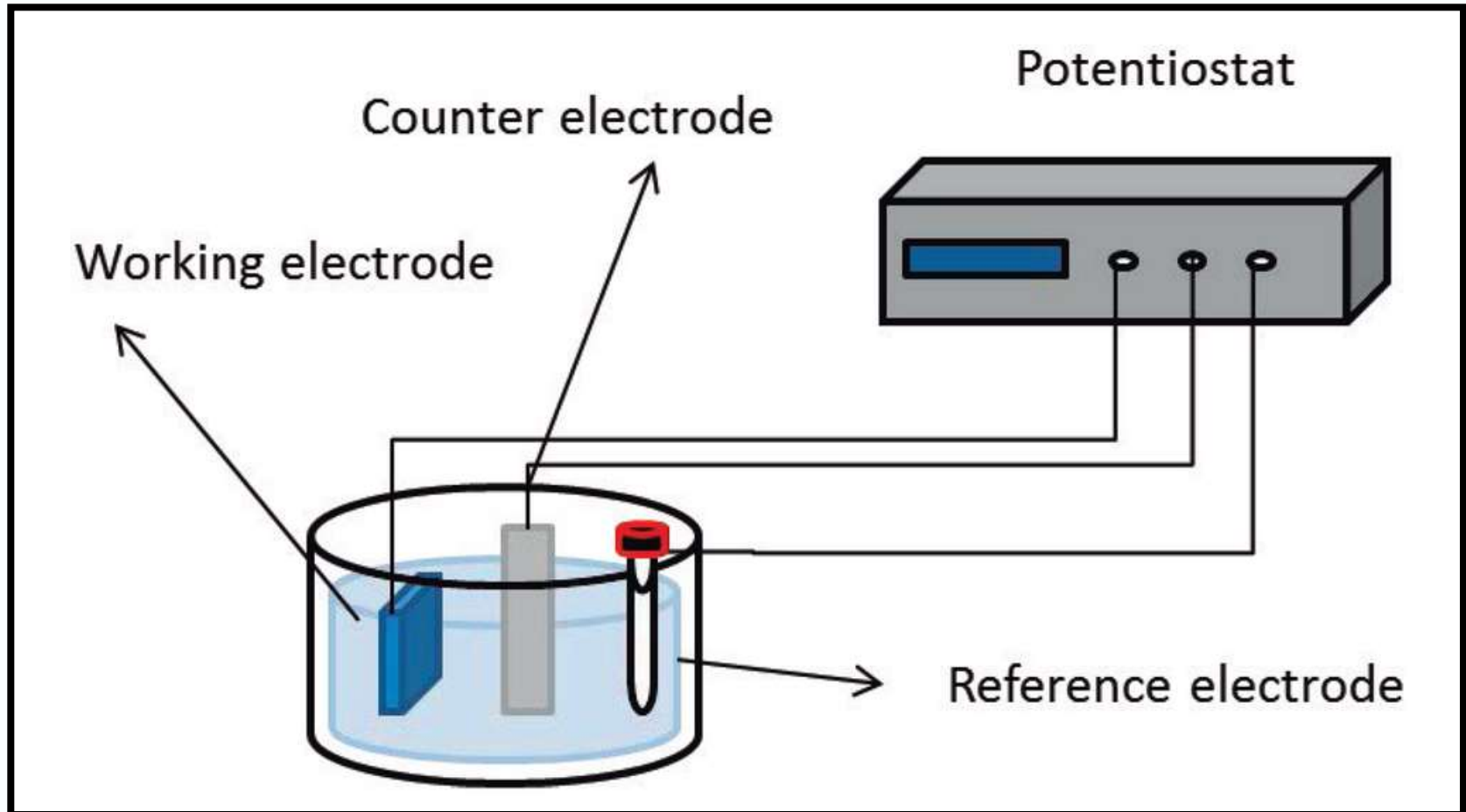


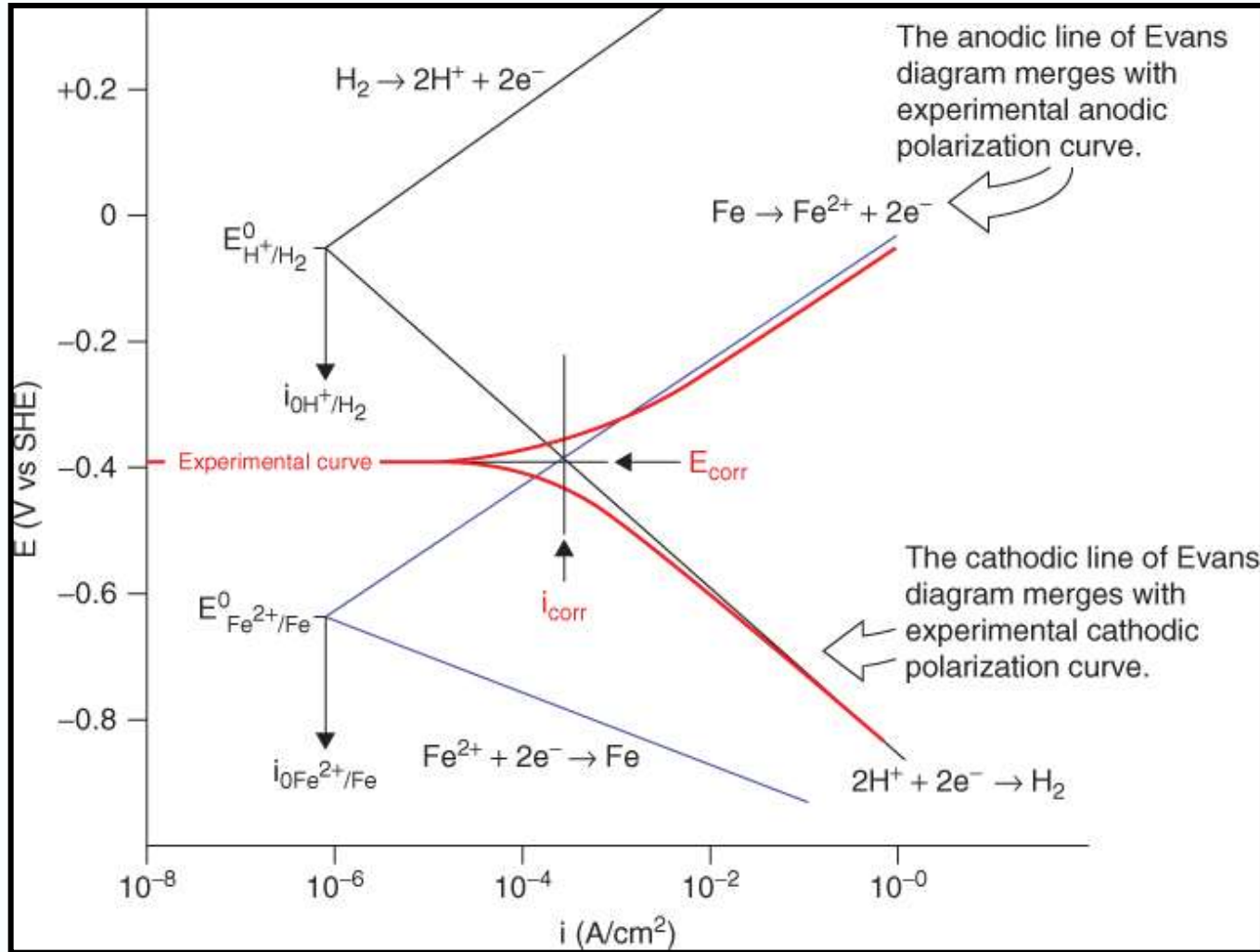
Open circuit potential measuring

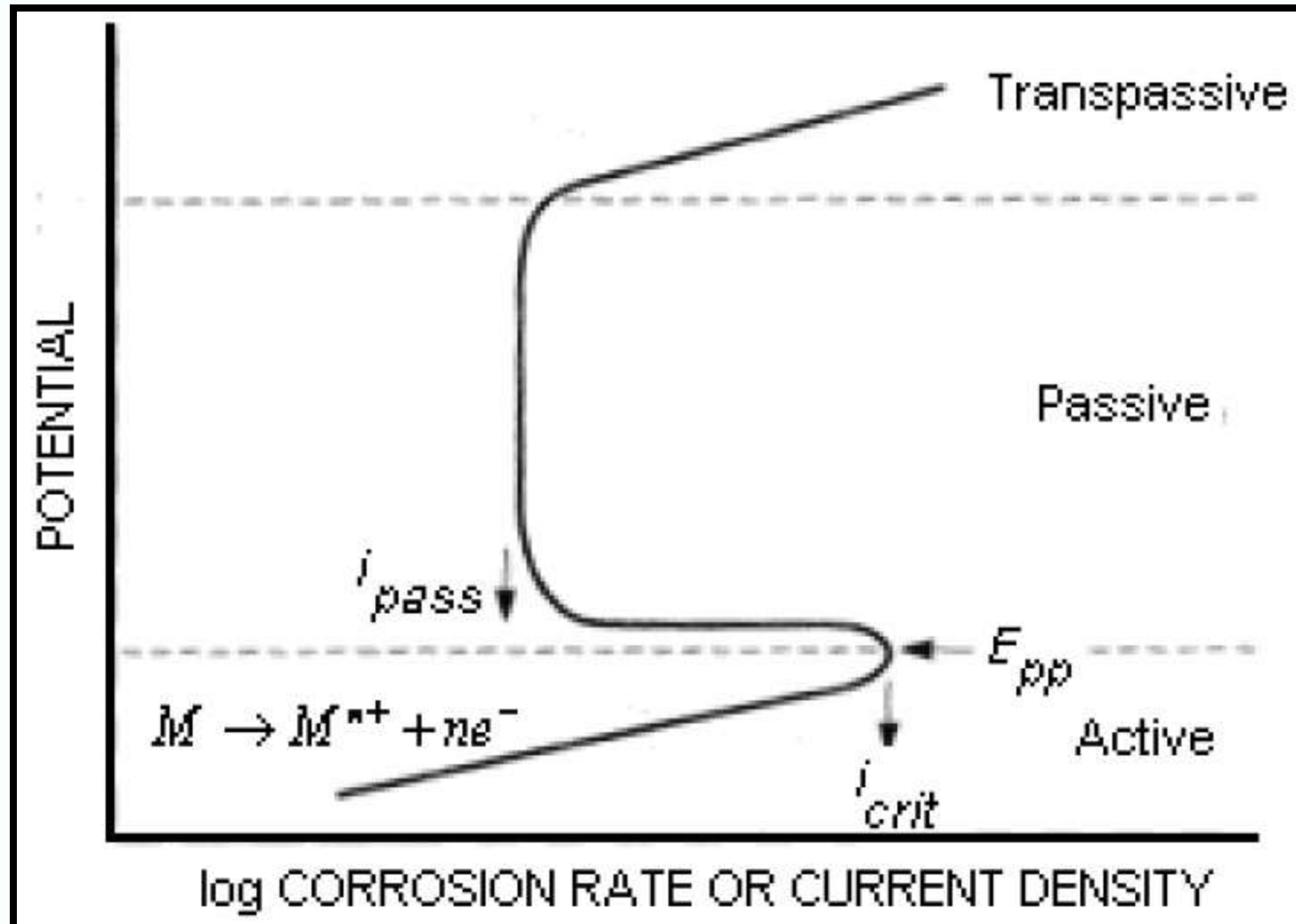




Potentiodynamic measuring

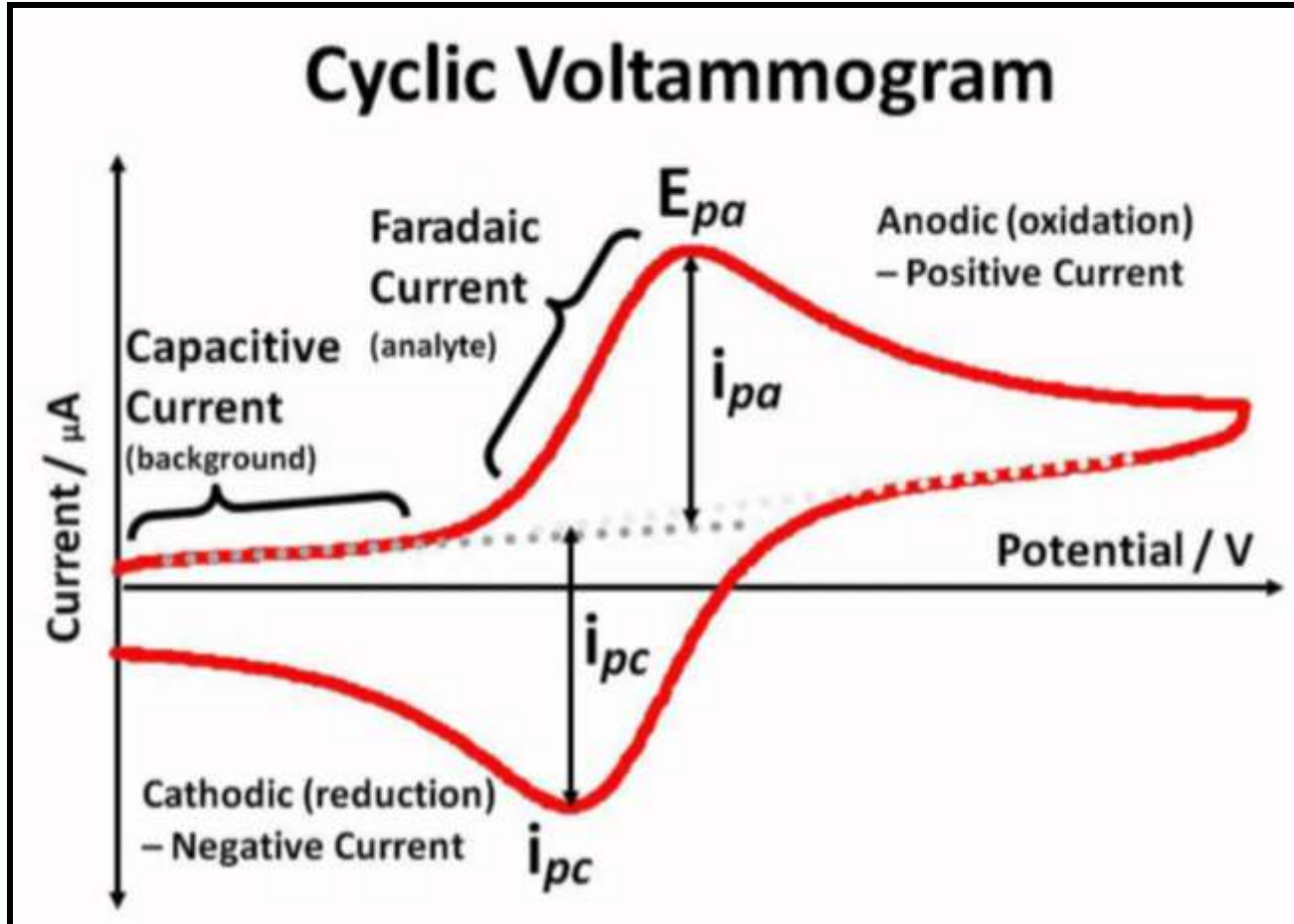








Cyclic Voltammetry

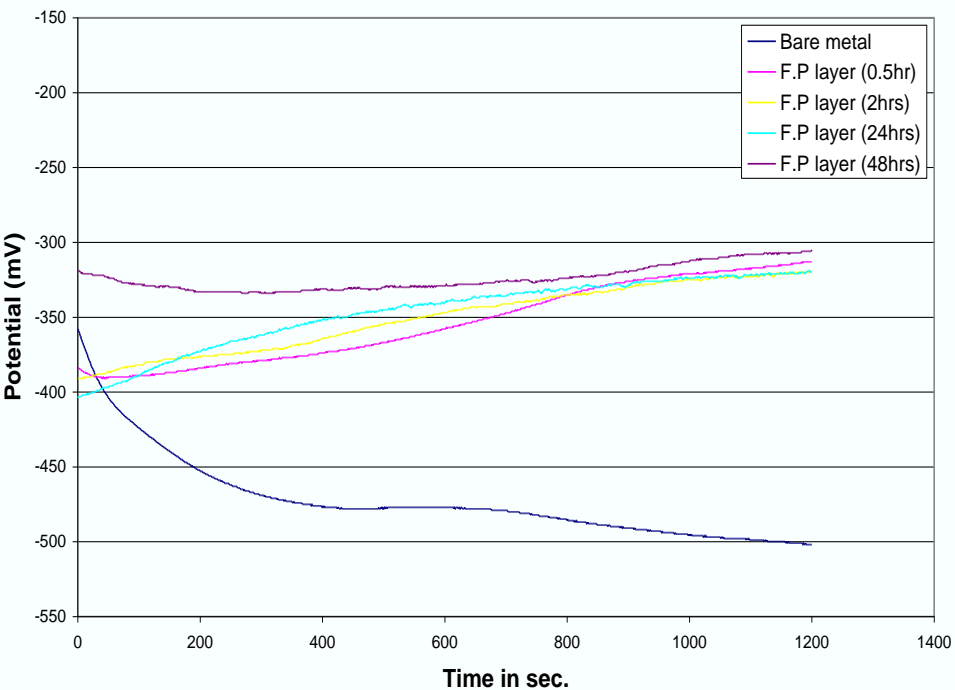




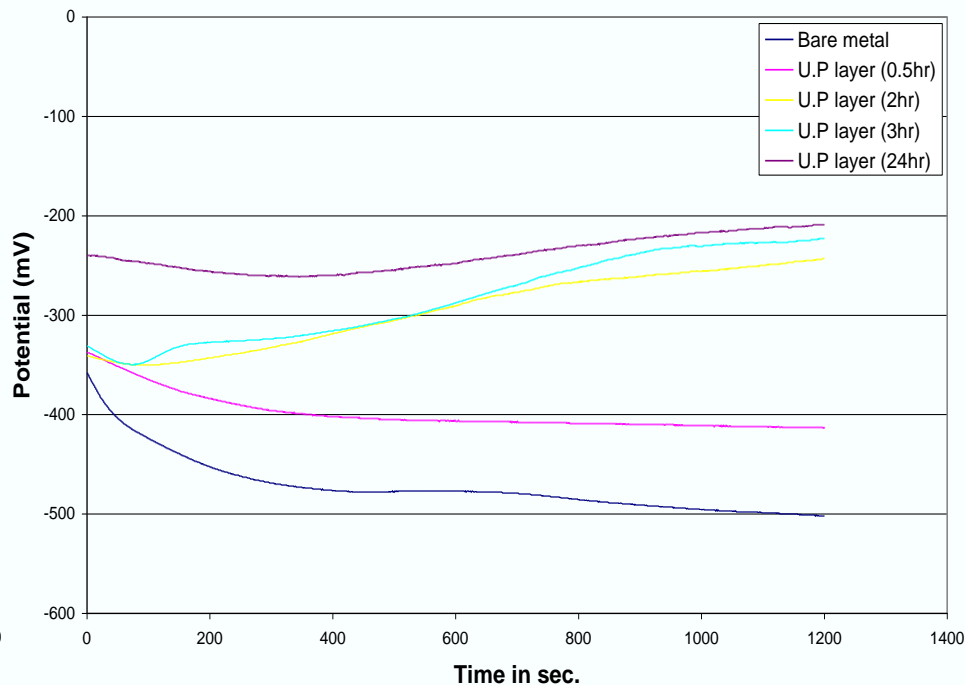
Test Results



Open circuit potential results



Open circuit potential results for layers formed by fluorophosphonic acid.



Open circuit potential results of layers formed by udecenyl phosphonic acid.



Steady-state values of bare carbon steel + SAM nanolayer of fluorophosphonic acid

| SAM layer formation time (hr) | E (mV) |
|--------------------------------------|---------------|
| ∅ | -505 |
| 0,5 | -312 |
| 2 | -318 |
| 24 | -318 |
| 48 | -303 |

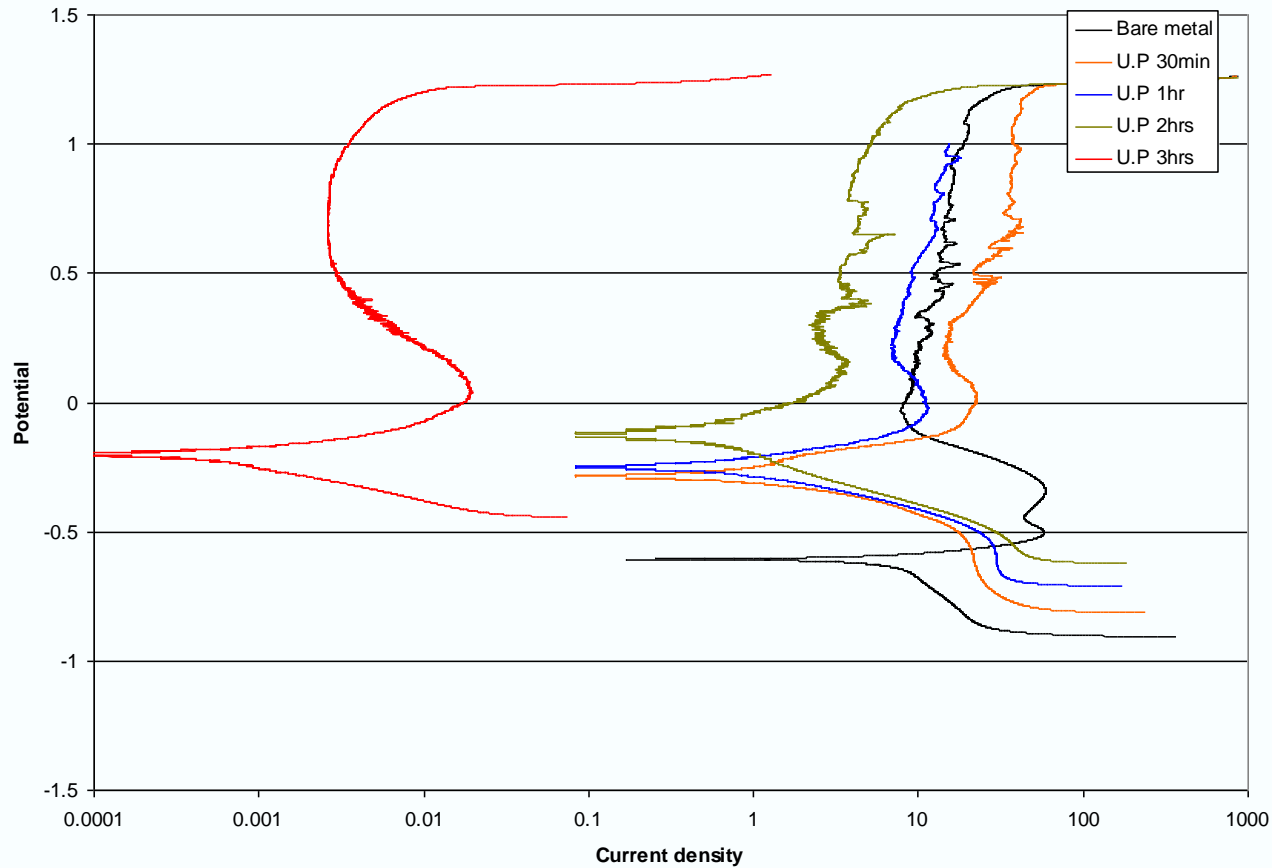
Steady-state values of bare carbon steel + SAM nanolayer of undecenyl phosphonic acid

| SAM layer formation time (hr) | E (mV) |
|--------------------------------------|---------------|
| ∅ | -505 |
| 0,5 | -410 |
| 2 | -257 |
| 3 | -232 |
| 24 | -208 |



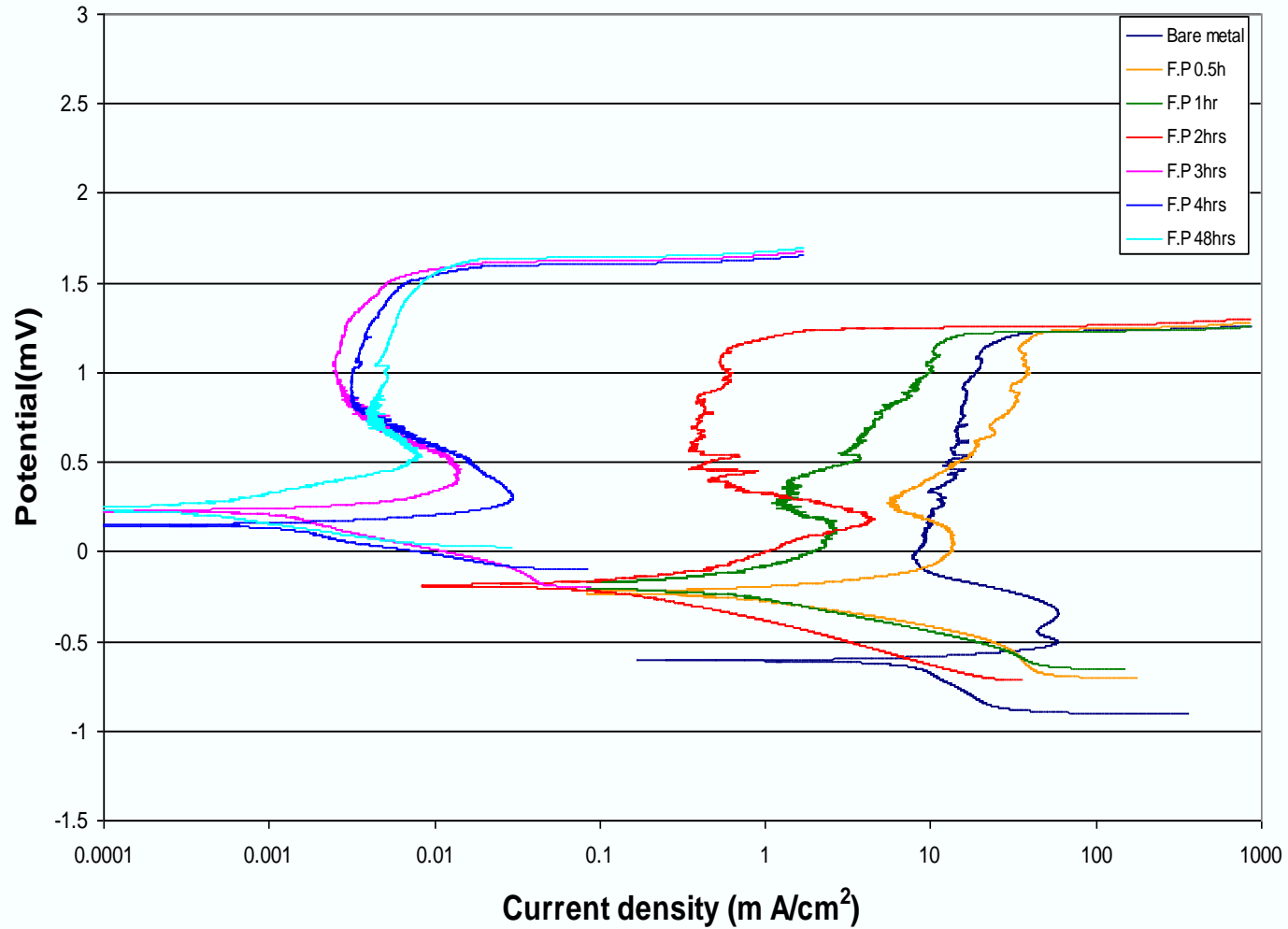
Potentiodynamic measuring

➤ Undecenyl phosphonic acid



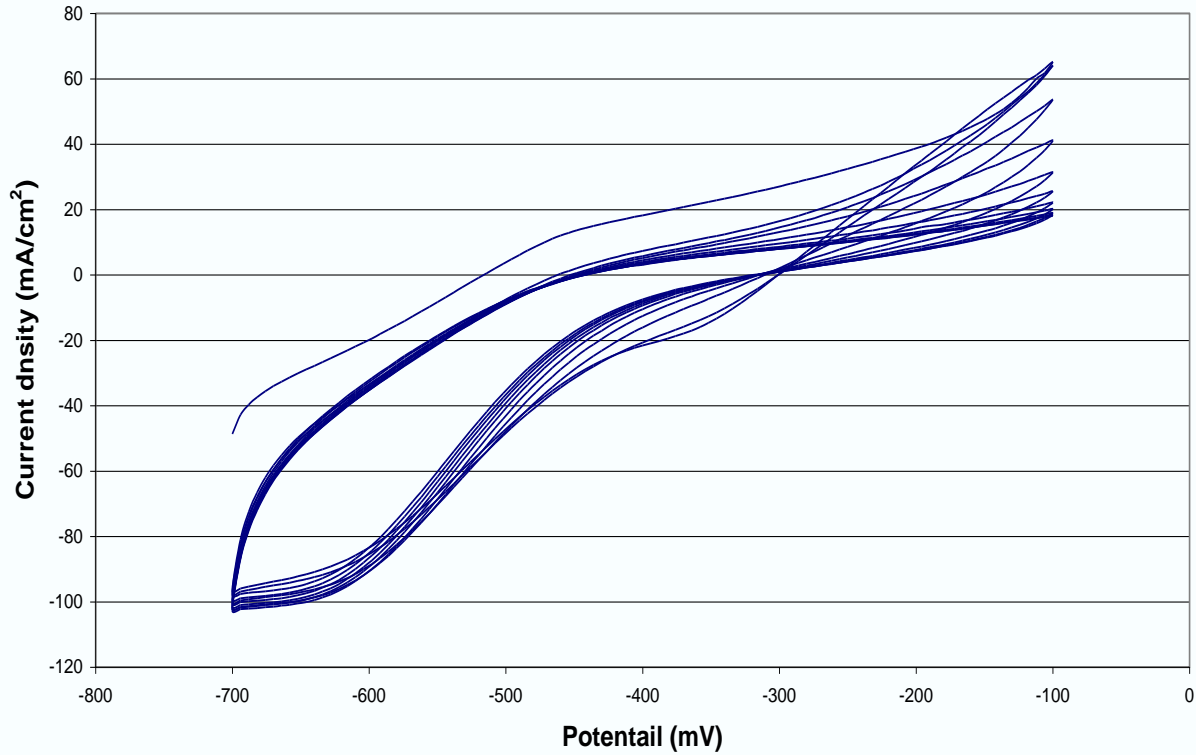


Fluorophosphonic acid





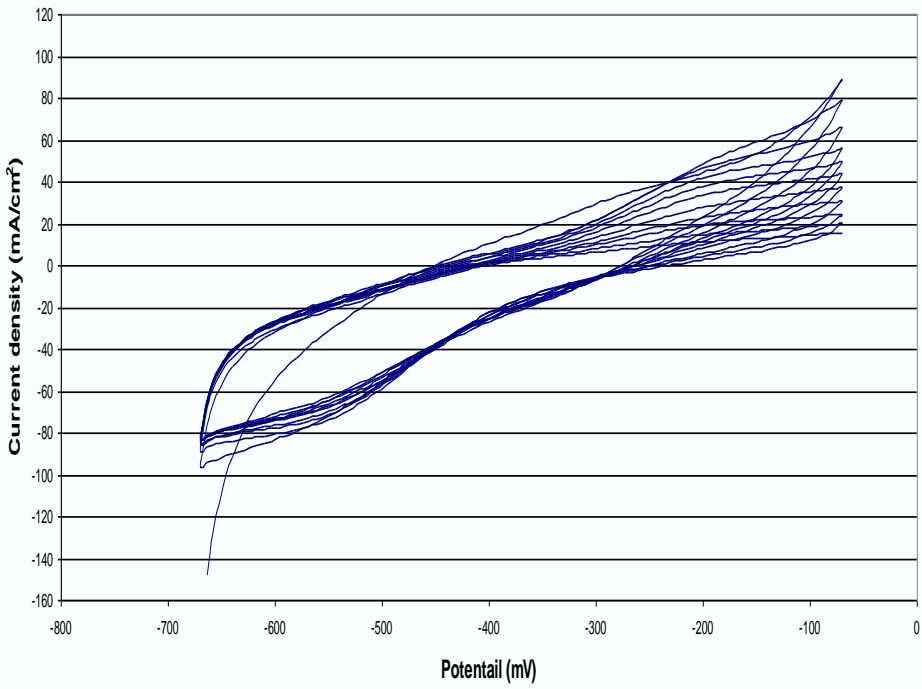
Cyclic Voltammetry results



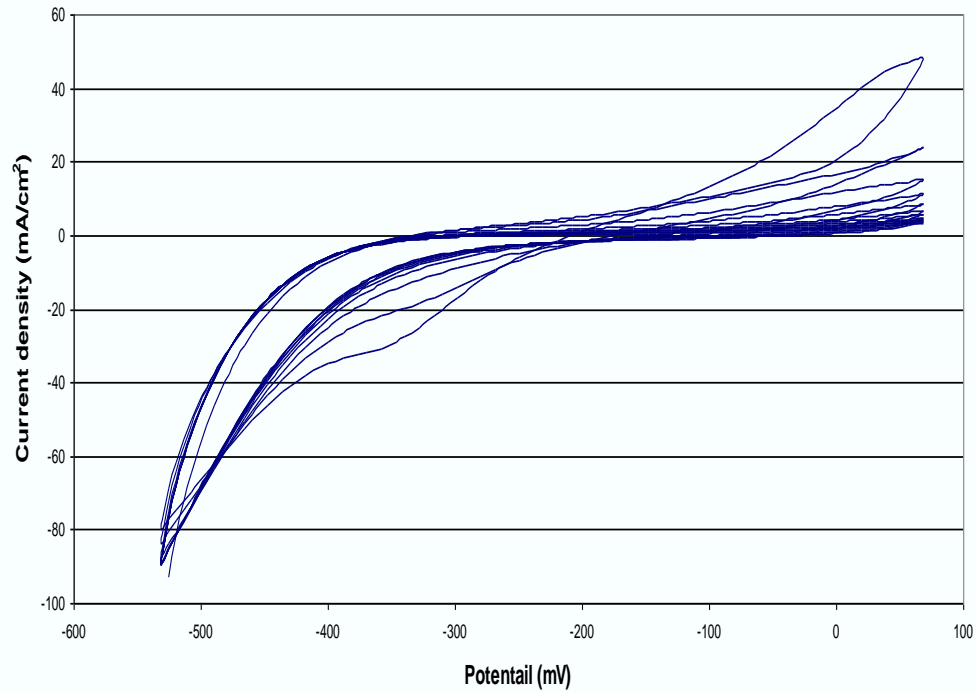
Cyclic voltammetry results for bare metal.



Udecenyl phosphonic acid



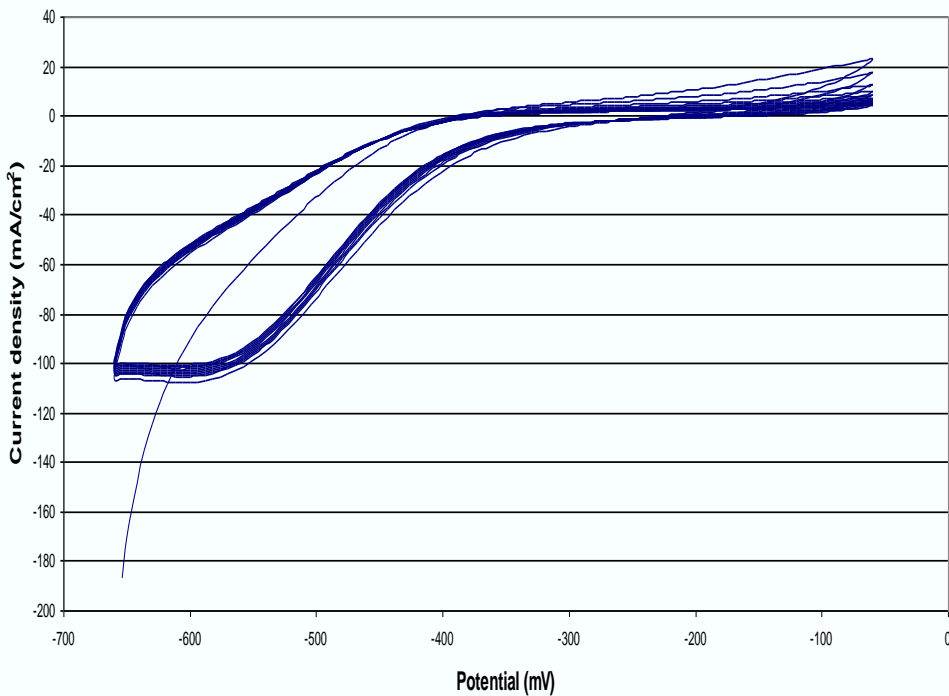
Cyclic voltammetry results for undecenyl phosphonic acid formed at 30min.



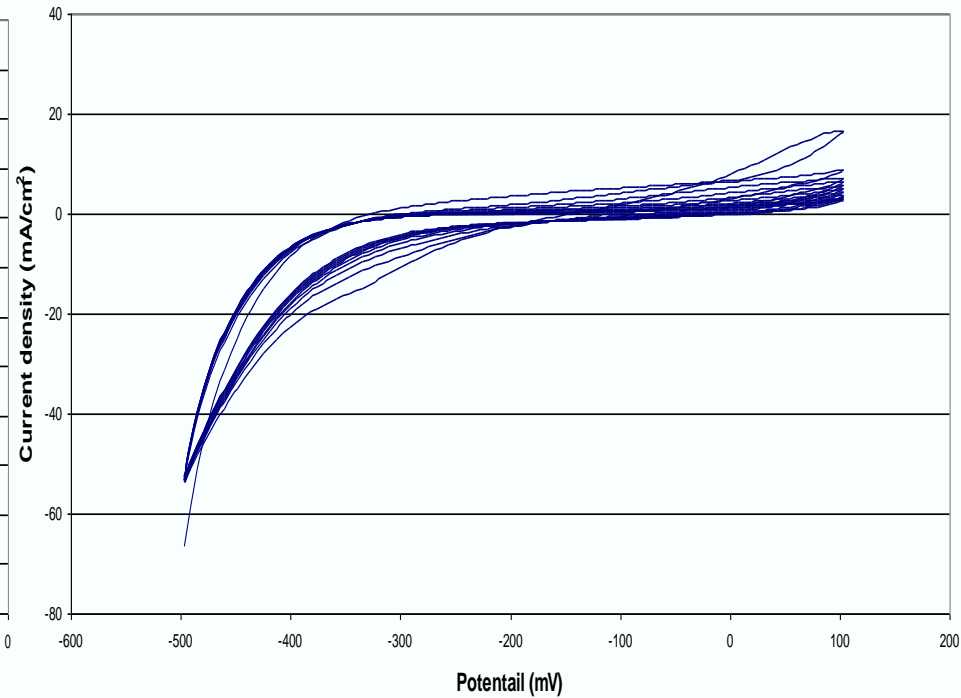
Cyclic voltammetry results for undecenyl phosphonic acid formed at 24hrs.



Fluorophosphonic acid



Cyclic voltammetry results for fluorophosphonic formed at 30min.

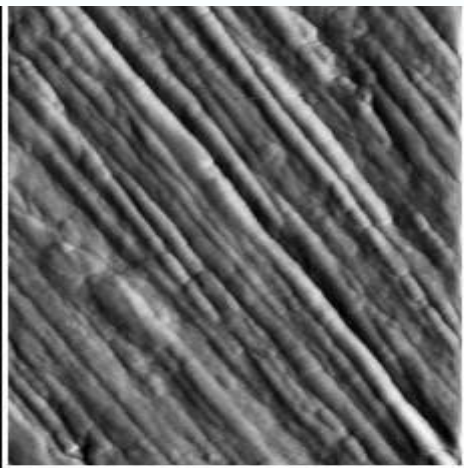


Cyclic voltammetry results for fluorophosphonic formed at 1hr.

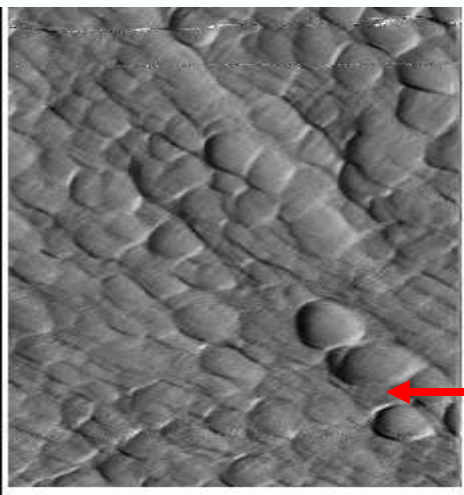


AFM result

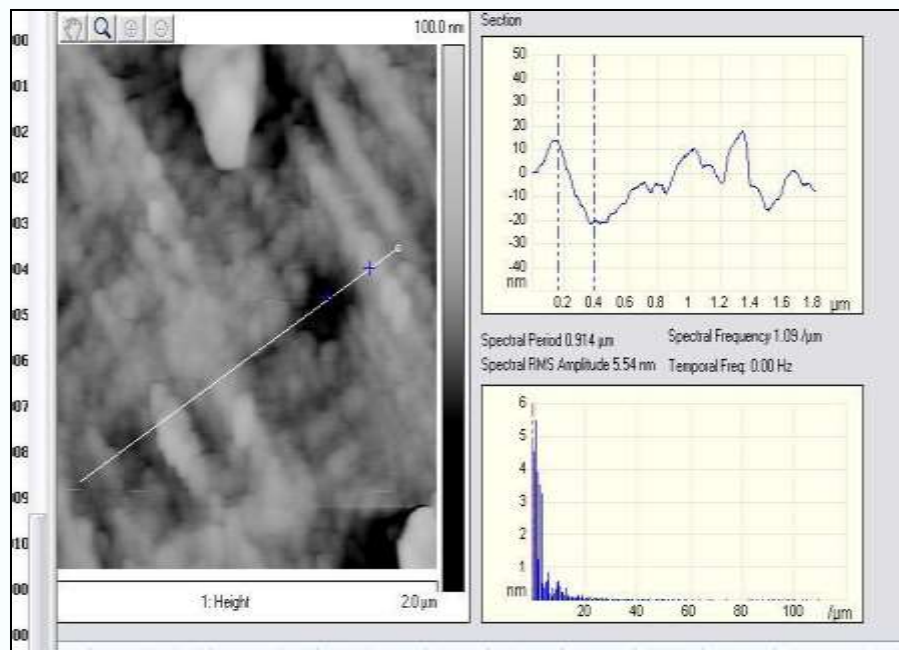
Udecenyl phosphonic acid



undecenyl phosphonic acid layer formed at 30min



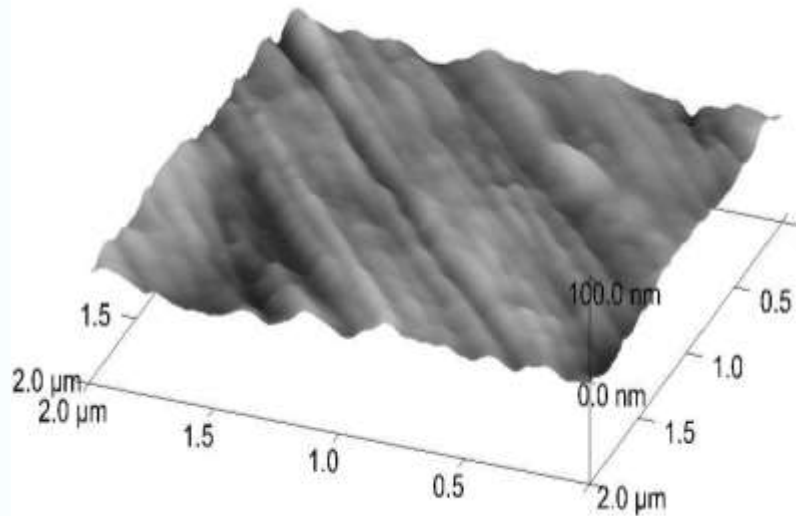
undecenyl phosphonic acid layer formed at 30min and treated with NaClO4 for 2hrs.



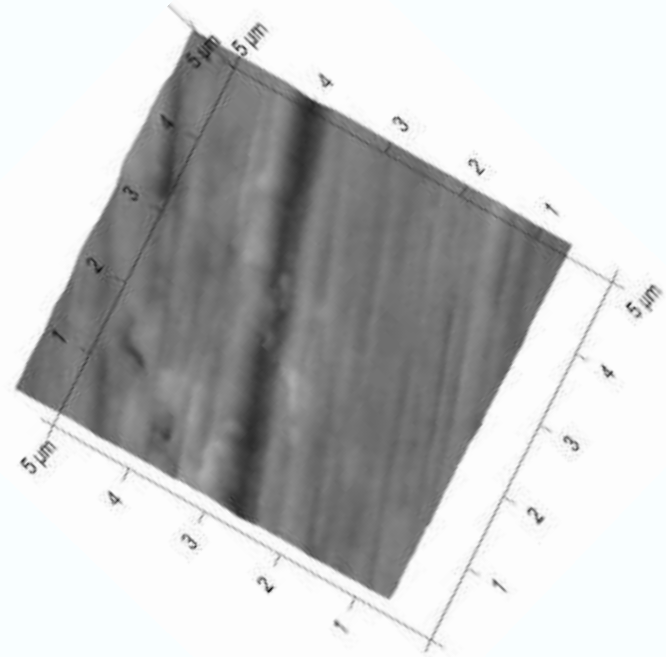
undecenyl phosphonic acid layer formed at 30min and treated with NaCl for 2hrs.



Fluorophosphonic acid



fluorophosphonic layer formed at 30min.



fluorophosphonic layer formed at 30min and treated with NaCl for 1hr.



Conclusion

- 1 Potentiodynamic results showed that the best layer formation time (with the least corrosion current density) for both fluorophosphonic acid and undecenyl phosphonic acid was that formed at 48hrs.
- 2 Fluorophosphonic acid and undecenyl phosphonic acid performed as anodic anticorrosion inhibitors according to the OCP results.
- 3 Cyclic voltammetry results showed that layers formed by undecenyl phosphonic acid at 30min and 1hr gave similar results as those of no layer on the metal surface. While fluorophosphonic acid layers showed good results at all different time of formation..
- 4 In case of fluorophosphonic acid, increasing the layer formation time led to decreasing the corrosion rate.
- 5 AFM showed that the effect of sodium chloride was more savior than that of sodium perchloride where pitting corrosion occurred.



Plan for the sixth semester

- Characterization of the formed layers by fluorophosphonic acid and undecyl phosphonic acid on aluminum and carbon steel surfaces with the use of AFM. Following the corrosion process by AFM on solid surface covered by nanolayers while effected by aggressive ions.
- Applying further EIS measurements and the practical data will be converted into theoretical values by application of equivalent electrical circuits .
- After comparison of results got by complementary techniques, publication in international will be sent.



Thank you for your attention