Micro and nano- layers against material deterioration in aggressive environment

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Outline

- Aim of study
- Fulfillment of the third semester
- Background
- Experimental
- Results
- Conclusion
- Future Work

Aim of study:

- **Study of**:
  - **formation of self assembled molecular layers (SAM) on carbon steel, stainless steel, copper and aluminum**.
  - **influence of different variables** (solvent, oxide layer, working system (open or closed), temperature,pH) **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 fourth semester

- **Study of the effect of:**
  - Solvent type
  - Working system type (Open or closed)
  - Time of layer breakdown
  - Type of oxide layer(H_2O_2 or air)

  On precoated (**fluorophosphonic acid or undecenyl phosphonic acid surface layers)** carbon steel sample by leaner polarization technique.

- **Study of the effect of** surface roughness(400, 600, 800, 1200, 2000 and 4000 grit) on the layer formation of **fluorophosphonic acid and undecenyl phosphonic acid** on aluminum samples.

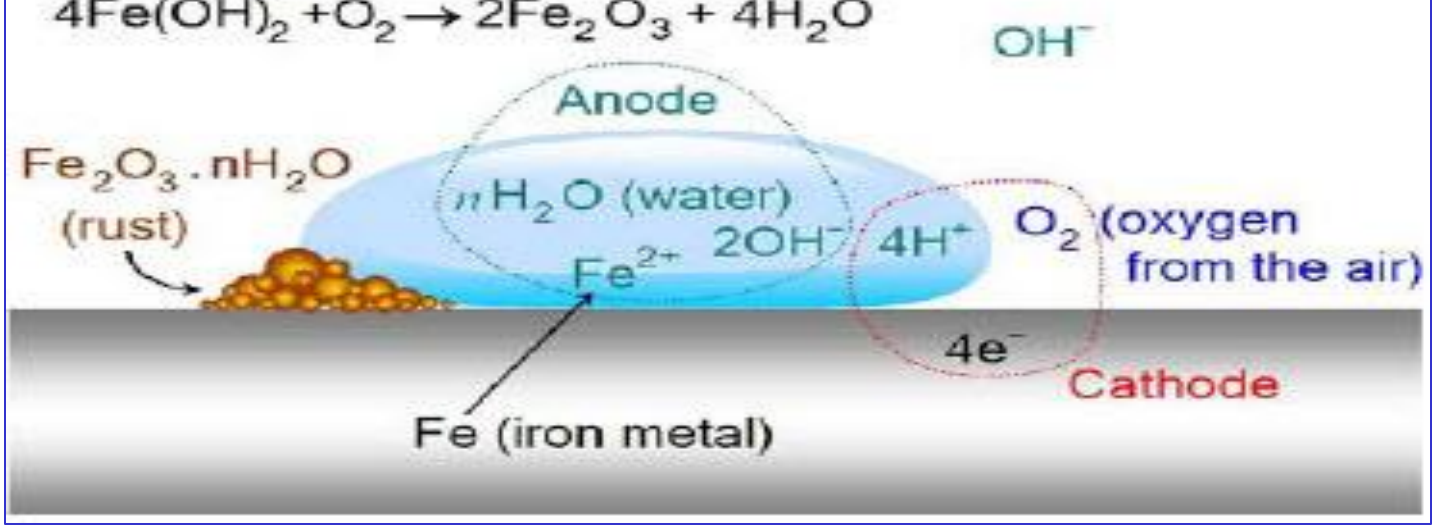
Corrosion process

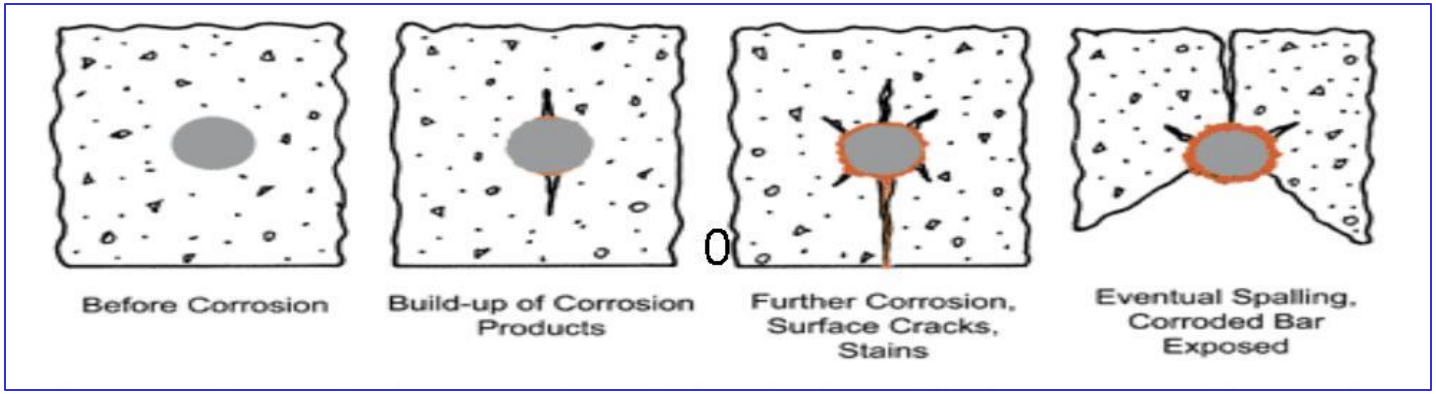
$Fe \rightarrow Fe^{2+} + 2e^-$

$O_2 + 4e^- + 2H_2O \rightarrow 4OH$

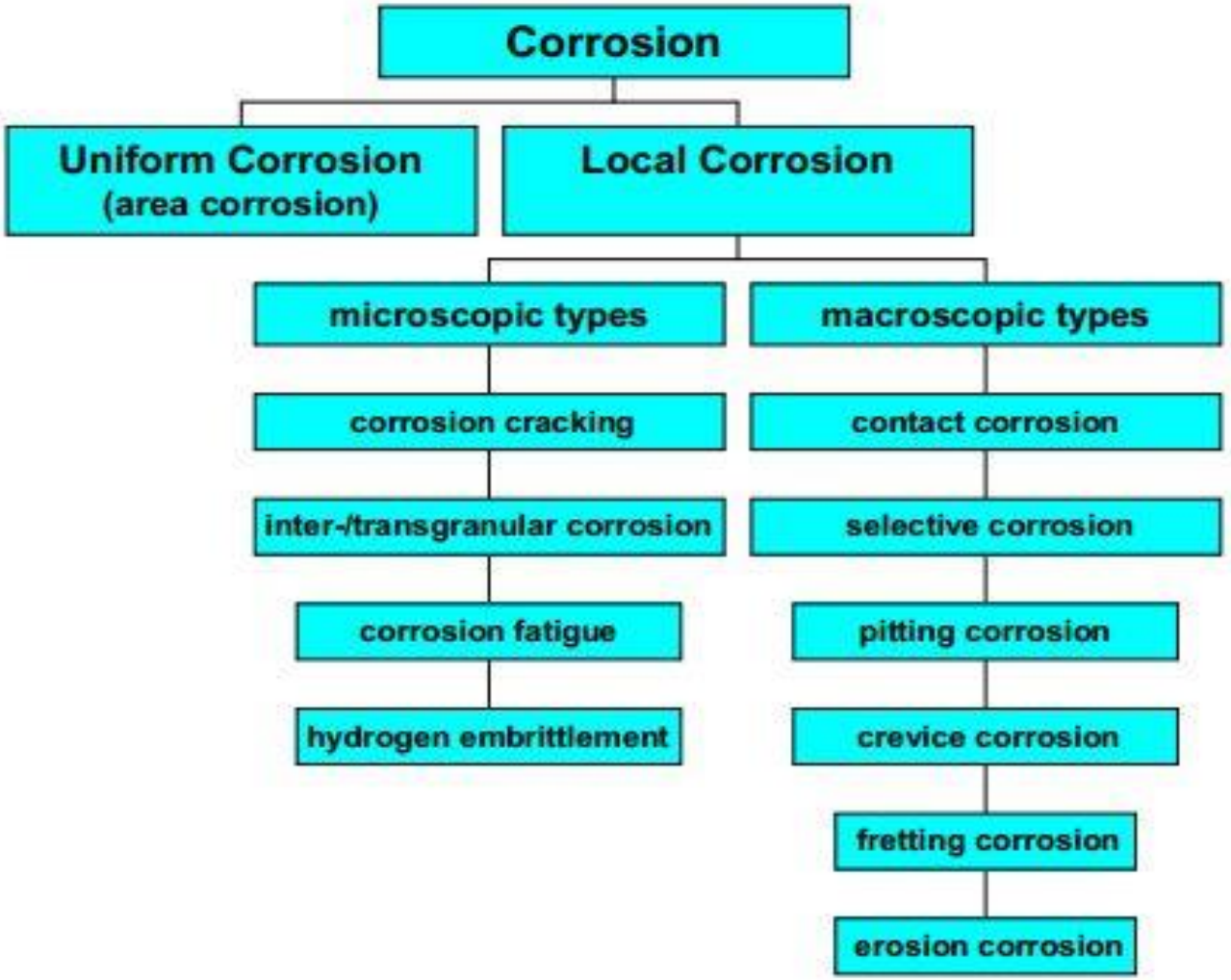
$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

$4Fe(OH)_2 + O_2 \rightarrow 2Fe_2O_3 + 4H_2O$





Outline of corrosion types

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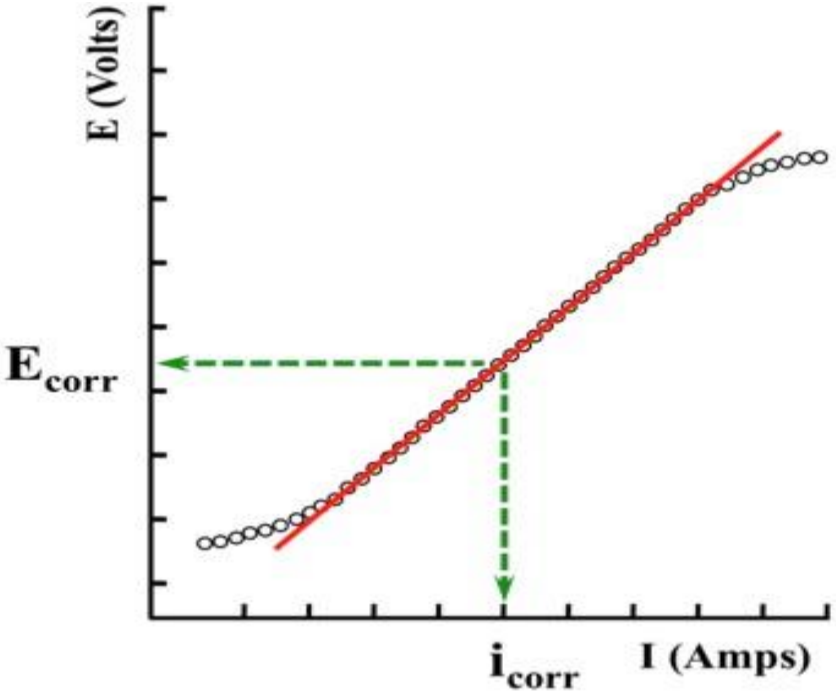
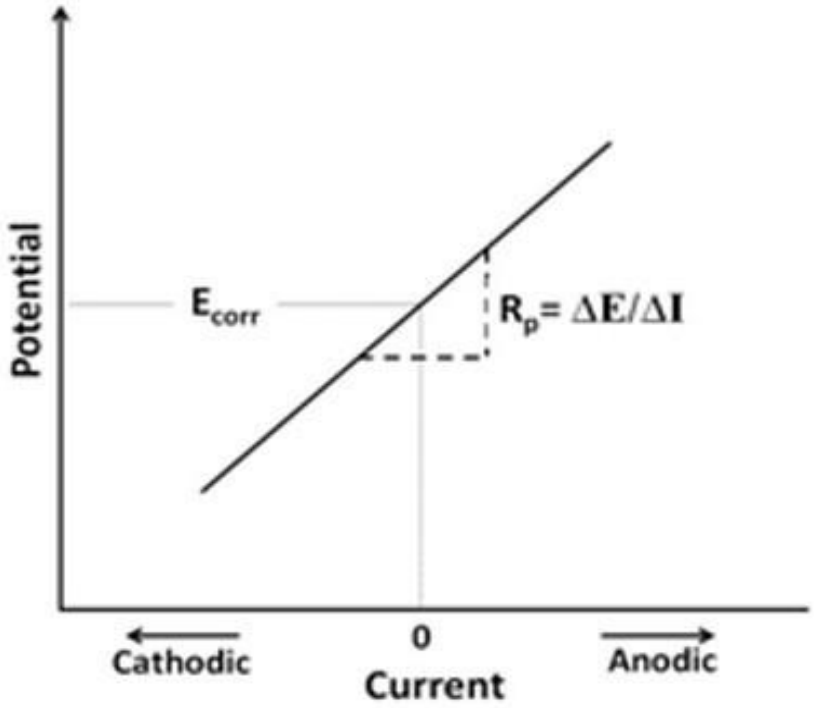
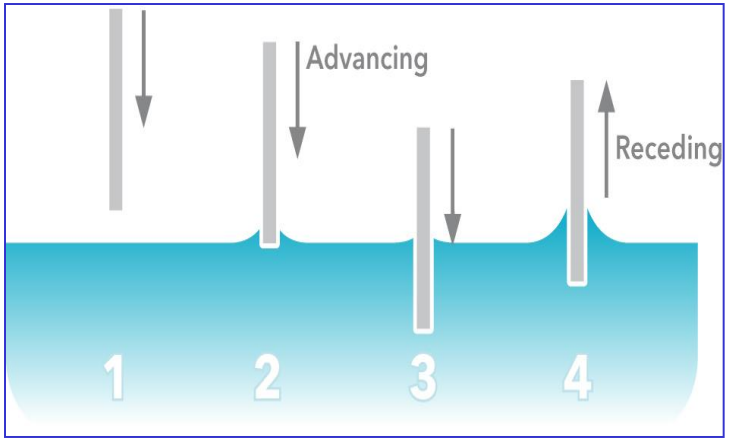
Introduction to the techniques

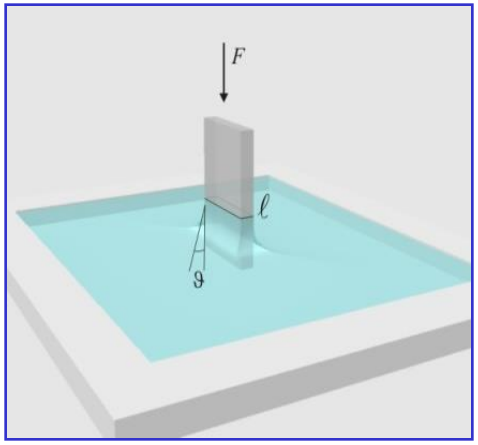
- **Leaner polarization measurments**

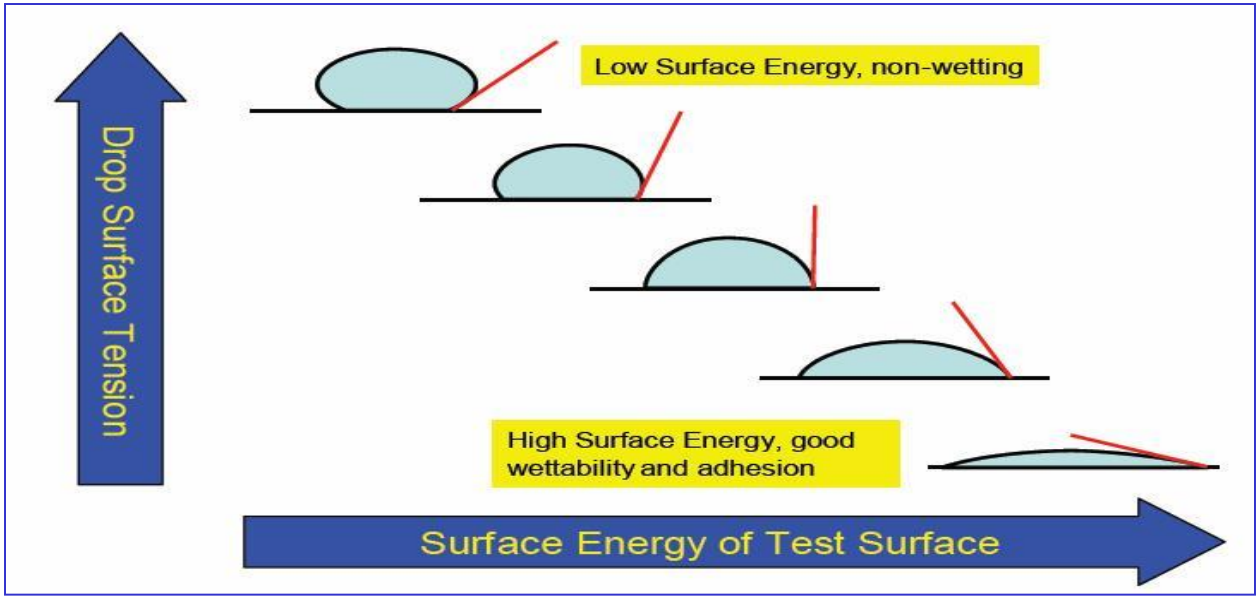




Dynamic contact angle measurments



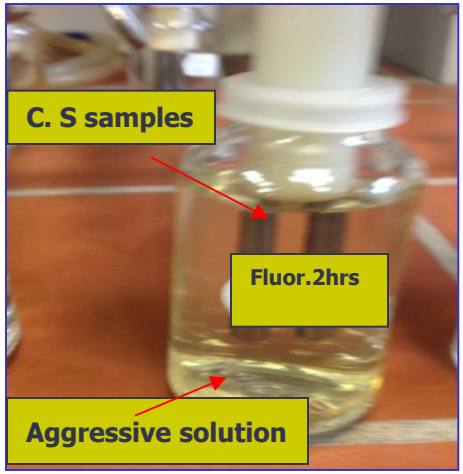




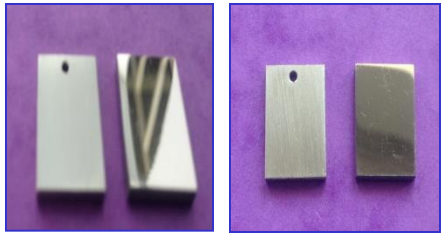
Experimental Work

Leaner polarization measurements

- Carbon steel metal samples: used as the working electrodes.
- SAM layers: formed at 24hrs.
- Electrolyte solution:
  - containing chloride and sulfate ions
  - tap water.
- Measurement were taken at 0min, 30min, 1hr, 2hr, 3hr,4hr, 5hr, 6hr, 24h, 48hr, and up to 10 days
- Electrodes were polarized with 10mV and the instrument gave immediately the real corrosion rate value in mpy (milinches per year).



Surface roughness effect



- Aluminium samples as the working metal.

- Different surface finish roughness were used (400, 600, 800, 1200, 2000 and 4000 grit).

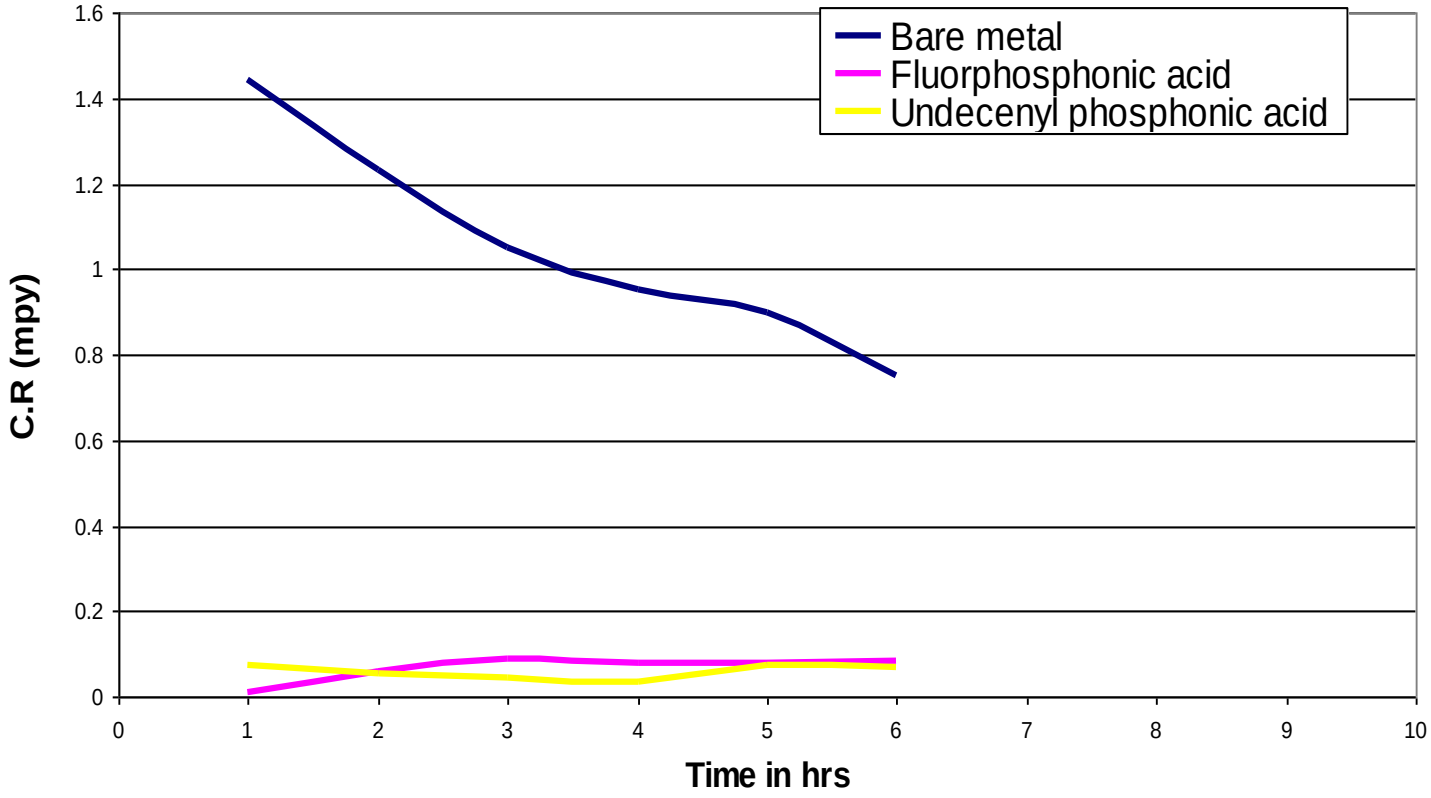
- SAM were formed on the metal surface by **fluorophosphonic acid or undecenyl phosphonic acid** chemicals at 24hrs.

- The influence of the different surface roughness was characterized by dynamic contact angle measurements.

Experimental Results

The anticorrosion effect of SAM layers

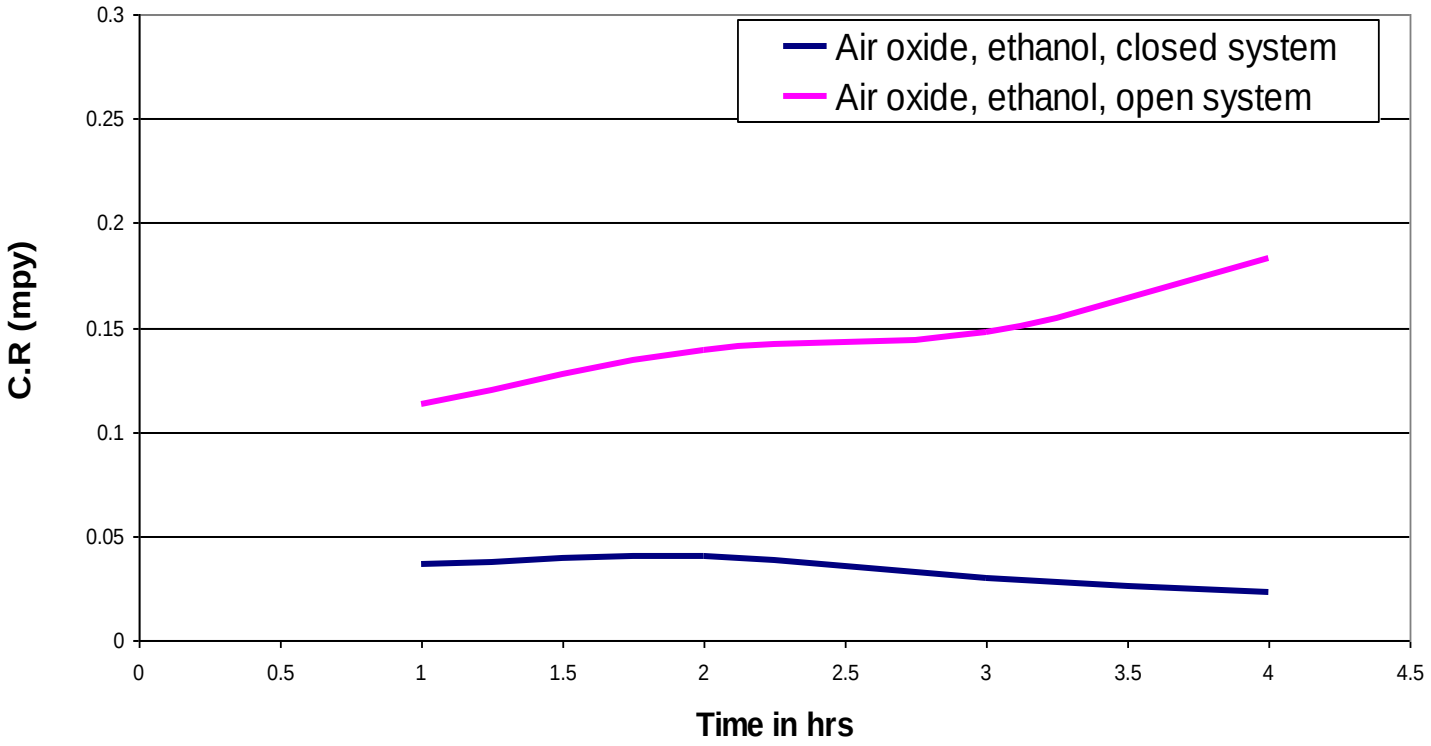
SAM layers formed by different chemicals at 24hrs on carbon steel surface in tap water



❖Time of layer breakdown was 7 days for the undecenyl phosphonic acid while it was 9 days for the fluorophosphonic acid at the same working conditions(24hrs layer forming and air formed oxide)

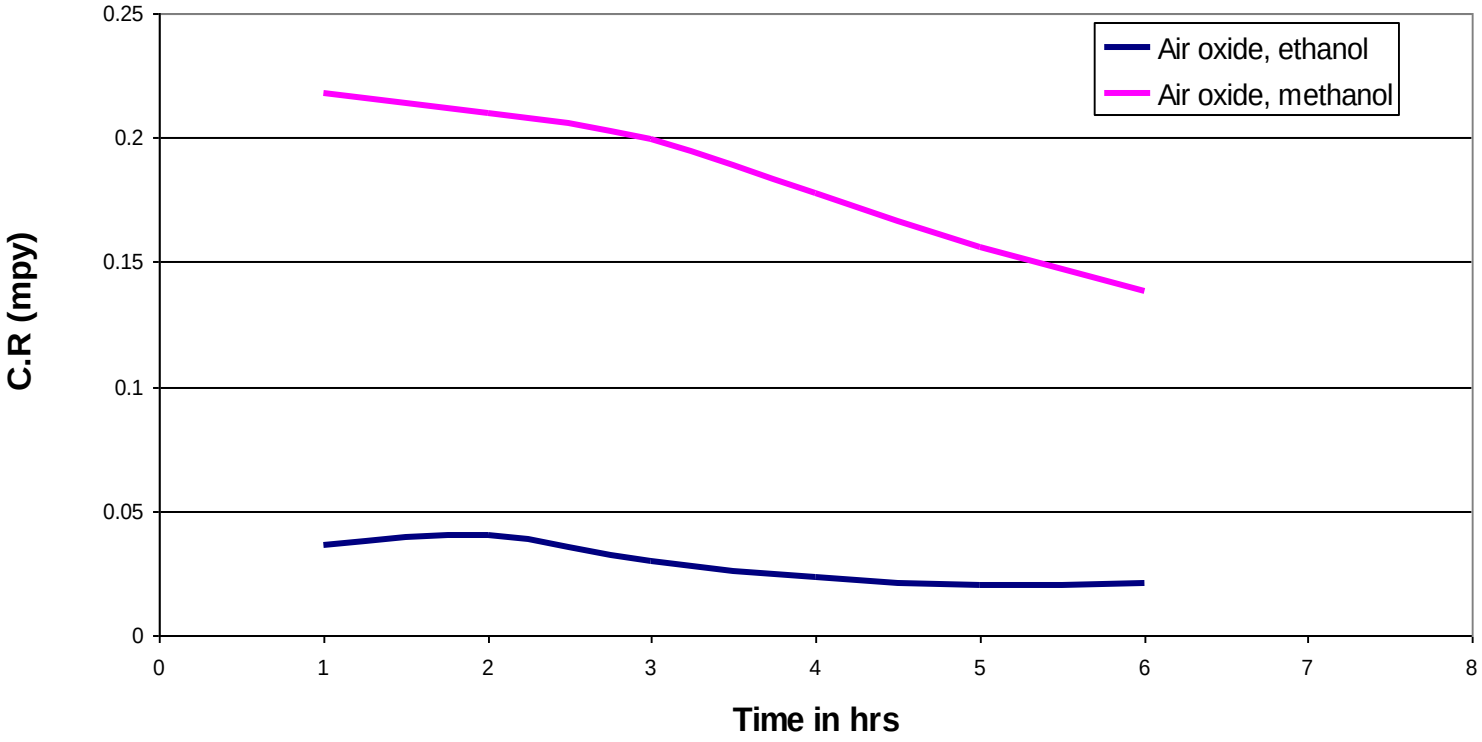
Effect of working system

Fluorophosphonic acid layers on air formed oxide layers in different working systems and tap water

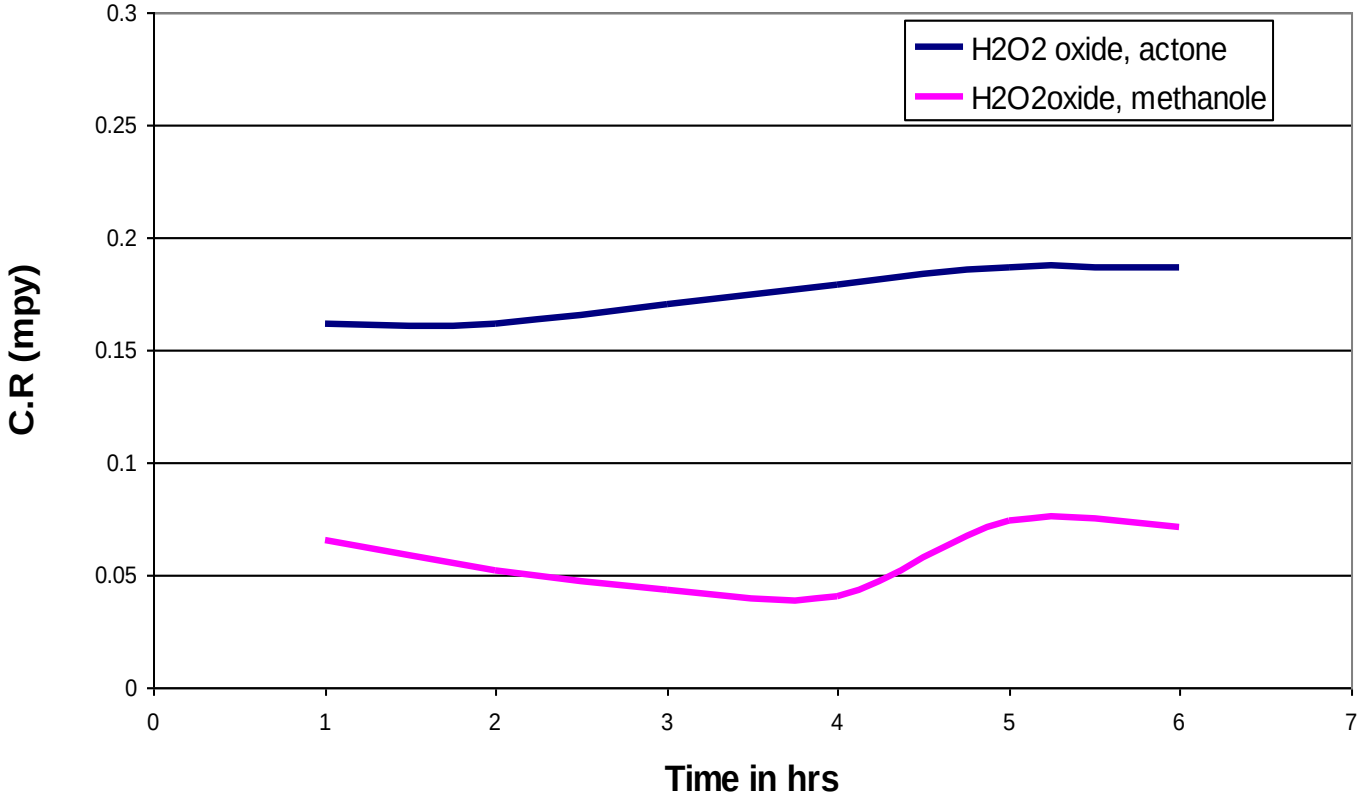


Effect of solvent

Fluorophosphonic acid layers formed at 24hrs in different solvents and tap water

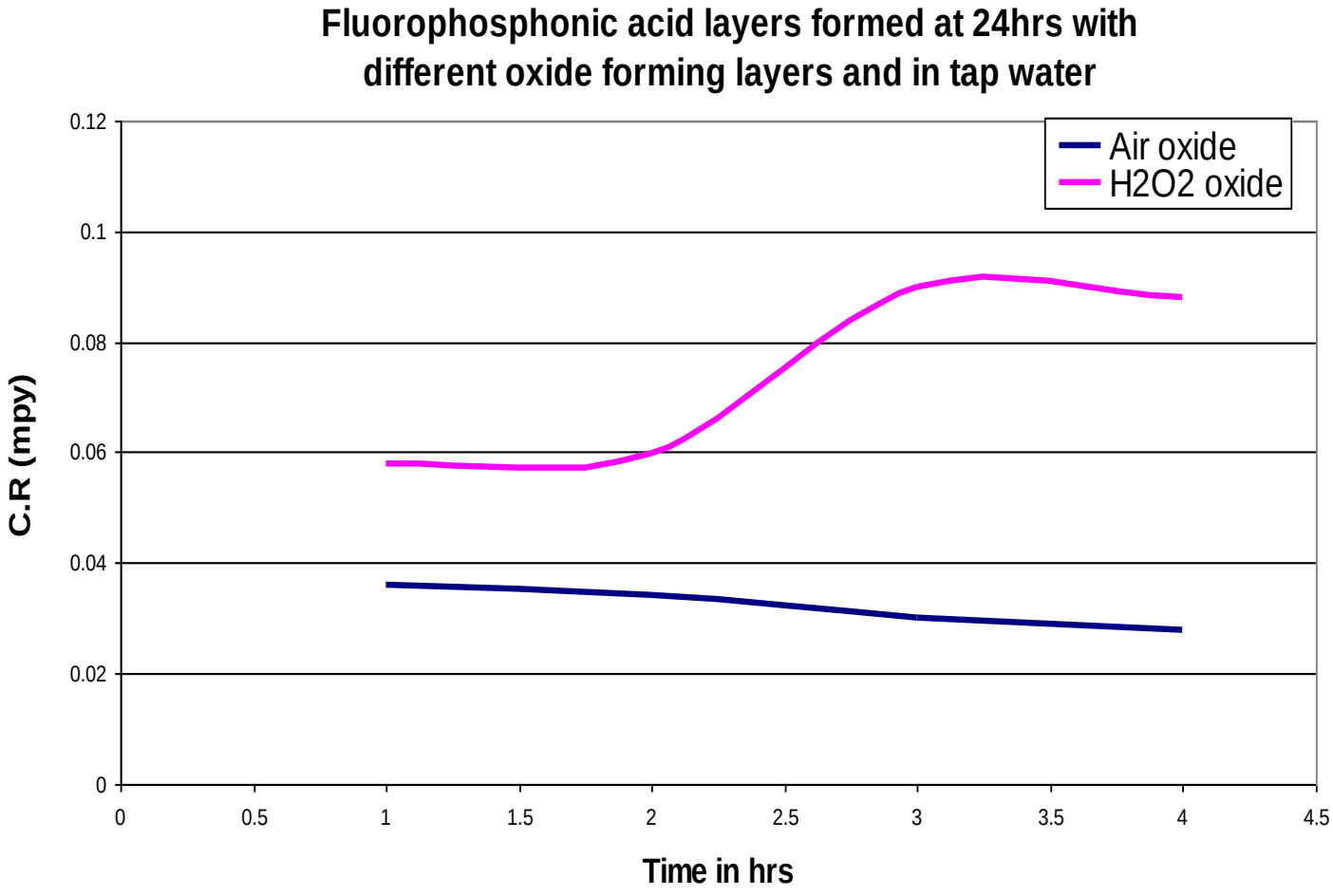


Undecenyl phosphonic acid layers formed at 24hrs in different solvents and tap water

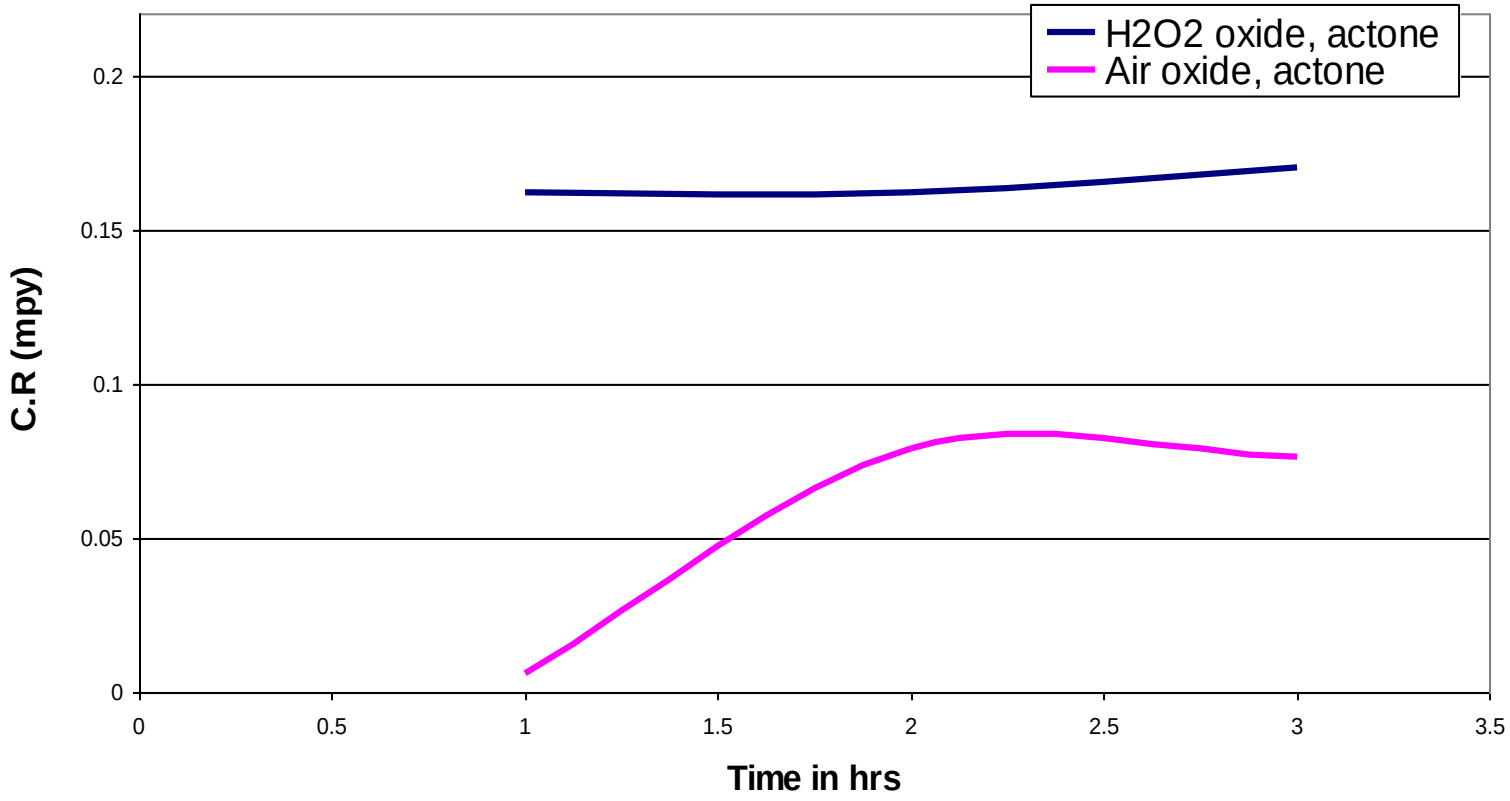


❖ **In case of methanol as a solvent for undecenyl phosphonic acid layers with air oxide, the corrosion rate was very low (less than 0.001 mpy).**

Effect of oxide layer forming

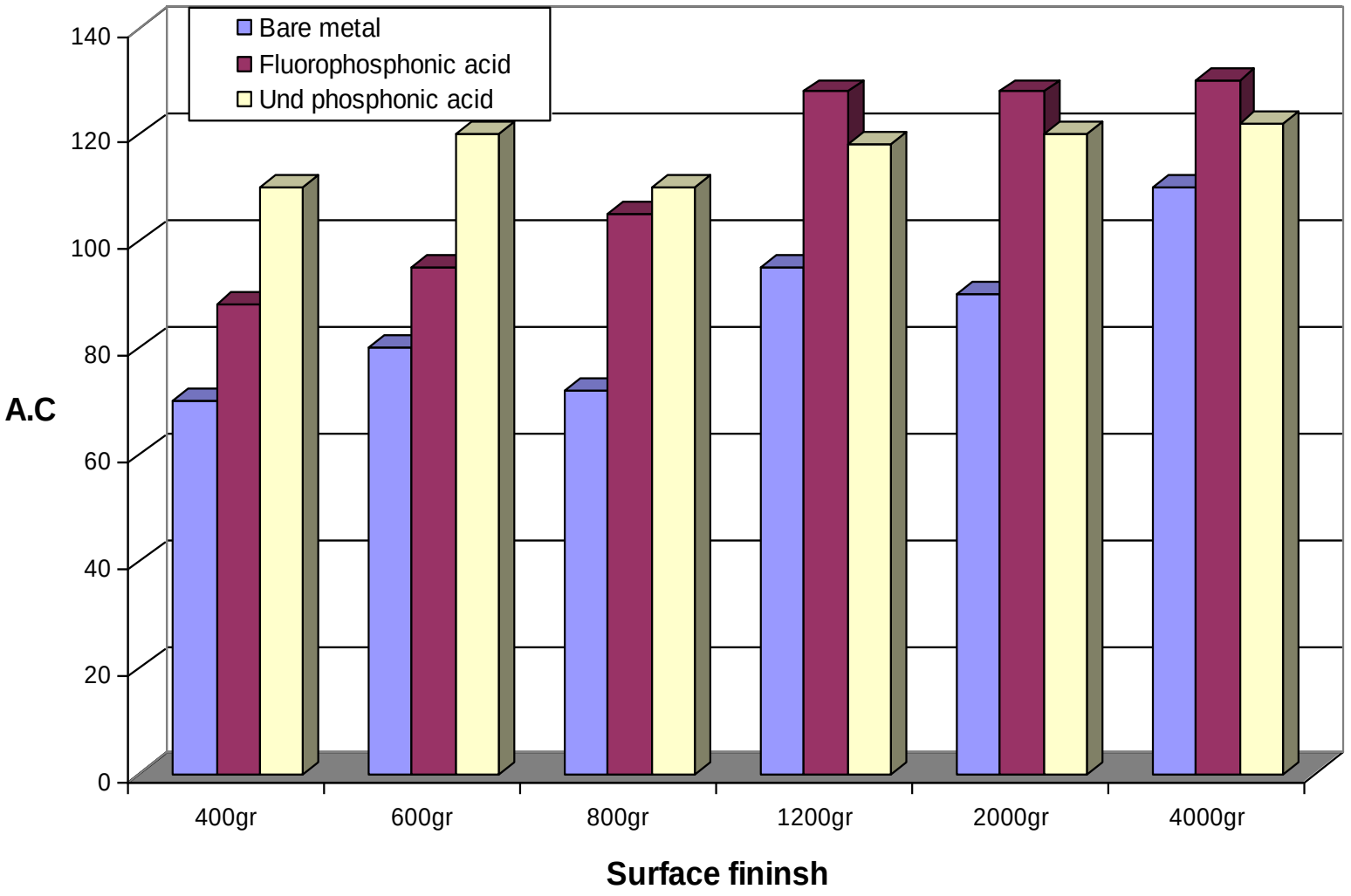


Undecenyl phosphonic acid layers formed at 24hrs with different oxide layers in tap water



Effect of surface roughness

Diffrent surface finish for Al samples with and without precoating.



Conclusion

- **The leaner polarization results show:**

1. The undecenyl phosphonic acid and fluorophosphonic acid layers performed protection of the metal surface against corrosion.

1. The fluorophosphonic acid layers deposited on oxide layers formed in air showed better corrosion protection in closed system than in an open system.

2. Type of solvent had an effect on the layer quality: the SAM formed by fluorophosphonic acid dissolved in ethanole gave better results than in a methanole solution, while methanol was better in the case of undecenyl phosphonic acid layers than with acetone.

3. Generally: SAM layers developed on air -formed- oxide layers of the metal surface showed better results than on that of formed by H_2O_2 layers.

4. The addition of aggressive ions (chloride and sulfate) increased the corrosion rate more that the use of tap water.

- **Dynamic contact angle results show:**

In general, as the surface roughness decreased the contact angel values increased although in the case of undecenyl phosphonic acid there was only a small difference.

Plan for the fifth semester

- Characterization of the formed layers by fluorophosphonic acid and undeceyl phosphonic acid on aluminum and carbon steel surfaces with the use of AFM.

- Appling further the EIS measurments and the practical data will be converted into theoretical values by application of equivalent electrical circuits .

- Cyclic voltammetry measurements will be carried out in order to study the durability of the surface layer in aggressive solutions.

- Potential − Time curves will be measured for identification of the type of inhibition (whether the chemicals work as anodic or cathodic inhibitors).

- Publication of results achived by the characterization of the formed layers and electrochemical measurements will be summarized in a full paper.

Thank you for your attention