**MODULE:**

Chemistry in transportation: Corrosion of aluminium and aluminium alloys (their inhibition)

**DESCRIPTION OF PRACTICAL:**

The purpose is to investigate the influence of the structure of aluminium and aluminium alloys used in the transport industry on corrosion resistance in chloride medium and present the influence of the inhibition with cerium acetate - $Ce(CH_3COO)_3$.

Aluminium is very corrosion-resistant in environmental conditions, because of the formation of a protective oxide layer on the surface - passivation. But exposing aluminium to more aggressive media, such as a solution of chloride salts, passivation loses efficiency. Chloride ions penetrate through the oxide pores, react with the aluminium, and form corrosion. The same applies to aluminium alloys, which additionally include intermetallic consisting of copper, zinc, iron, or magnesium. Intermetallic in alloys improve the mechanical properties of the alloy, but they are often more anodic than the aluminium. Consequently, the inclusions reduce corrosion resistance and present an incisal part of the corrosion process. Corrosion protection can be improved, e.g. by inhibition of these metal inclusions. One of the possibilities is the addition of cerium ions into the corrosive media. The cerium precipitates to the aluminium or aluminium surface, thereby improving corrosion resistance.

**MATERIAL:**

- 4 x 100 mL cups
- 300 ml flask
- Aluminium, aluminium alloys 2024-T3 and 7075-T6 sheets size of 2 × 3 cm
- NaCl
- $Ce(CH_3COO)_3$
- Emery paper
- Distilled water

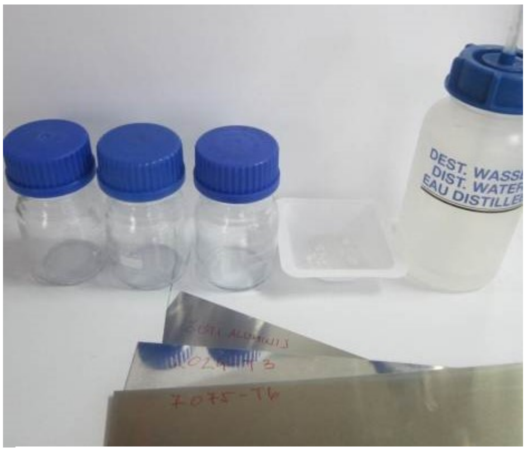


Figure 1: Basic supplies for experiment.

**METHODS OF WORK:**

1. Prepare a 3.5% NaCl solution and pour it into cups. In one of the glasses, where AA7075-T6 will be immersed, add also 3mM $Ce(CH_3COO)_3$. Ground the metals with emery paper and ring the surface with water. Then immerse the pieces of aluminium/aluminium alloy. At different periods, evaluate the course of corrosion on the surface.

2. After the end of the exercise, pour the solution into the drain, rinse the metals, and return them to the assistant.

**RESULTS:**

Enter the changes in the table.

| | **0 h** | **6h** | **1 day** | **2 days** | **1 week** |
|---|---|---|---|---|---|
| **Aluminium** | | | | | |
| **AA2024-T3** | | | | | |
| **AA7075-T6** | | | | | |
| **AA7075-T6 + inhibitor** | | | | | |

**REPORT:**

Observe the experiment and answer the questions.

**TEST:**

1. What is passive and what is the immune region?
2. Describe the importance of anodising the aluminium?
3. From the Pourbaix diagram, consider the conditions under which the aluminium is stable/corroded.

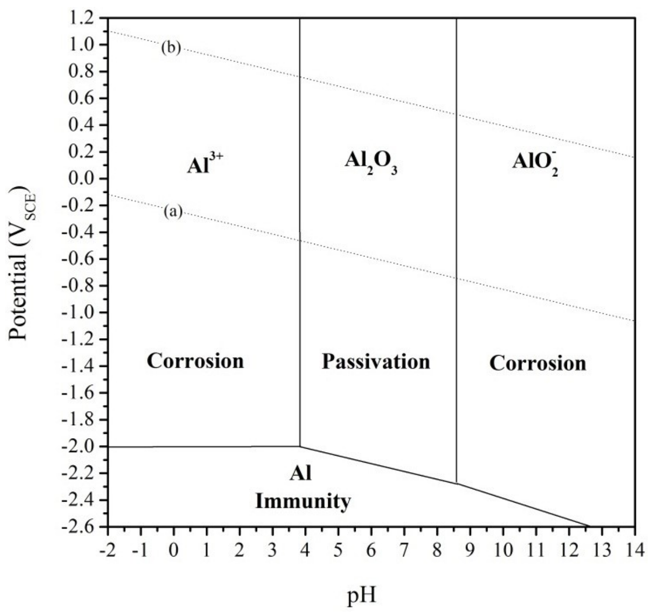


Figure 2: Aluminium *E*-pH (Pourbaix) diagram.

4. Why are chloride ions so highly corrosive to aluminium? Detail the reaction that takes place.
5. Explain why metal inserts affect the corrosion resistance of aluminium alloy in the chloride medium?
6. Propose a method for effective metal protection?
7. Describe the potentiometric measurement procedure.
8. In the figure: the current density - $j_{corr}$, the corrosion potential - $E_{corr}$, the breakthrough potential - $E_{pit}$ and the change in the corrosion potential – $\Delta E_{corr}$.

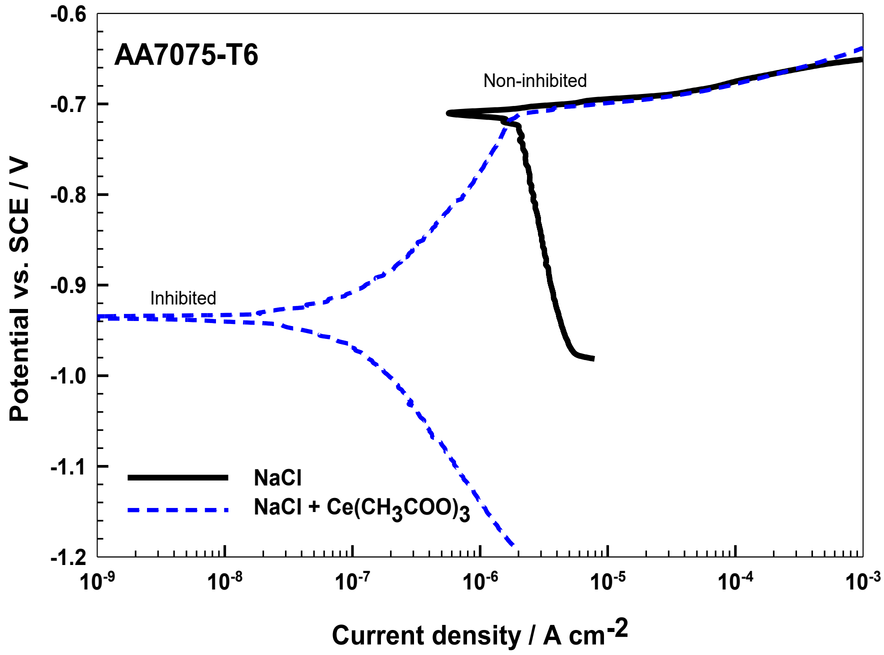


Figure 3: Result of potentiodynamic measurements for AA7075-T6 in 0.1 M NaCl solution without and with inhibitor.

9. Calculate missing values according to equation in Table 1:

$\Delta E_{corr} = \Delta E_{corr(inhibited)} - \Delta E_{corr\ (non\text{-}inhibited)}$

Inhibition efficiency = $((i_{corr\ (non\text{-}inhibited)} - i_{corr\ (inhibited)}) / i_{corr\ (non\text{-}inhibited)}) \times 100$

Table 1: Corrosion parameters determinate from potentiodynamic measurements.

| | $R_p$ [kΩ/cm²] | $i_{corr}$ [nA/cm²] | $E_{corr}$ [V] | $E_{pit}$ [V] | $\Delta E_{corr}$ [mV] | *Inhibition efficiency [%]* |
|---|---|---|---|---|---|---|
| **AA7075-T6** | 1.576 | 1859.9 | −0.71 | −0.70 | | |
| **AA7075-T6 + $Ce(CH_3COO)_3$** | 1450 | 8.0 | −0.44 | −0.70 | _____ | _______________ |

10. Compare the surface appearance of AA7075-T6 without and with the addition of corrosion inhibitor, Figure 4.

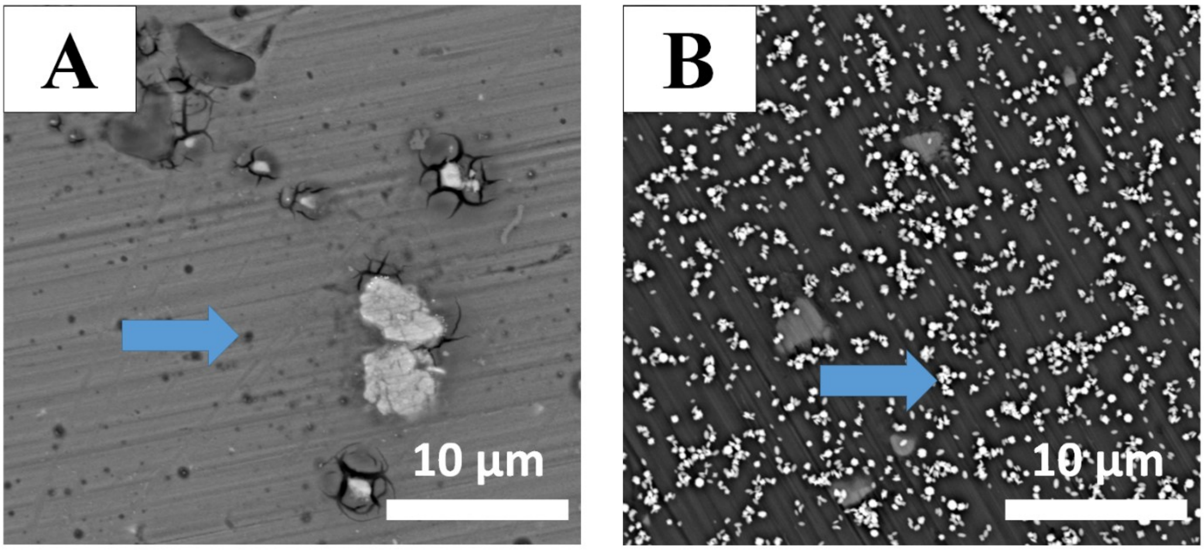


Figure 4: Surface appearance of AA7075-T6 after immersion for 24 h in 0.1 M NaCl solution A) without and B) with the addition of $Ce(CH_3COO)_3$.

- Where does the corrosion process start in Fig. A?
- What present small dark holes in the structure marked with an arrow in Fig. A?
- What present the white spots marked with an arrow on Fig. B

**EVALUATION OF THE PRACTICAL**:

| | | | |
|---|---|---|---|
| Knowledge for practical | | | |
| Experimental Exercise | | | |
| Results and answers | | | |
| Compliance with security rules: | | | |
| | | | |
| Review date: | | Supervisor signature: | |