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Comparative study of corrosion resistance of magnesium alloys in chloride environment

Daniel Kajánek[1], Jana Pastorková[1], Katarína Marušincová[2], Martina Jacková[1], Branislav Hadzima[1]

1 Research Centre, University of Žilina, Žilina, Slovak Republic

2 Faculty of Electrical Engineering and Information Technology, University of Žilina, Slovak Republic

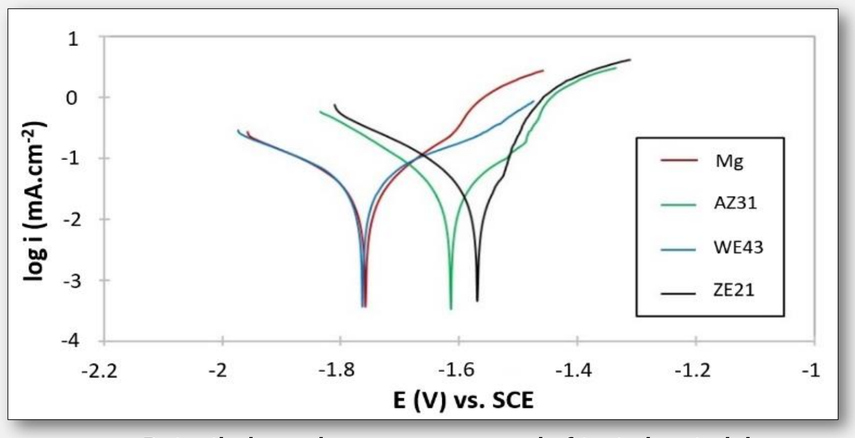
INTRODUCTION

- Magnesium and its alloys are materials suitable for the fabrication of lightweight constructions due to their favorable strength-to-density ratio (specific strength) and dimensional stability. Another important feature of magnesium is its biocompatibility and biodegradability.
- Using magnesium in practice is inhibited by its insufficient corrosion resistance in aggressive environments, which is typically lower compared to that of steel or aluminum alloys. Selection of alloying ellements and processing can improve mechanical and corrosion properties when comparing to pure Mg.
- Direct comparison of the corrosion resistance of various types of magnesium alloys remains challenging to the date. This study aims to directly compare the corrosion resistance of various types of magnesium alloys from chemically different groups and contrasting their properties with those of pure Mg.

MATERIALS, METHODS & IMPLEMENTATION

- Experimental materials: Mg-4Y-3RE-0.6Zr (WE43), Mg-2Zn-1RE (ZE21), Mg-3Al-1Zn (AZ31), pure Mg (99.9%).
- The short-term corrosion resistance of the materials was determined by potentiodynamic (PD) polarization tests in a 0.15 M NaCl solution.
- Long-term qualitative evaluation of corrosion resistance in an aggressive chloride environment was conducted via immersion exposure testing.
- The progression of corrosion was documented at various time points post-exposure using a stereomicroscope.
- The pH of the environment was measured during the exposure period using a waterproof pH – temp tester.
- To determine the corrosion rate during long-term exposure, weight loss was measured before and after the test.

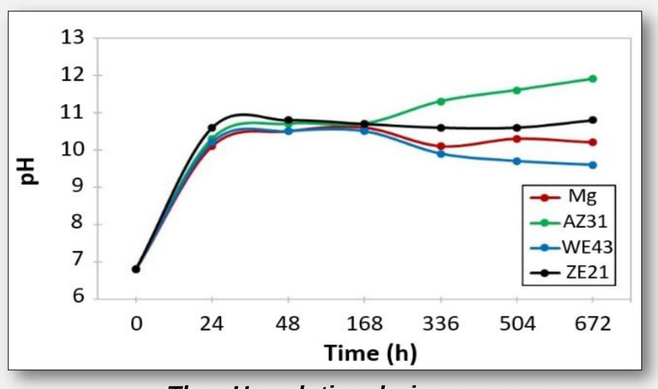
RESULTS



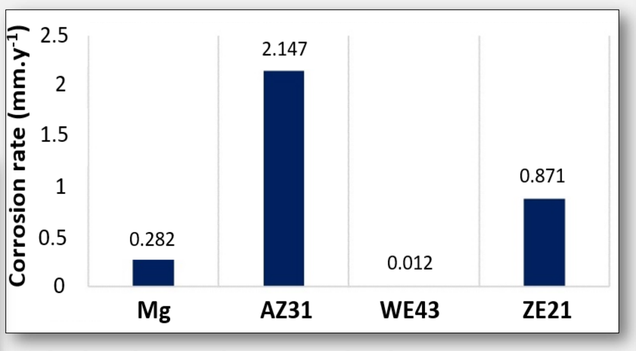
Potentiodynamic curves measured of tested materials measured in 0.15M NaCl

Electrochemical characteristics of tested materials in 0.15M NaCl

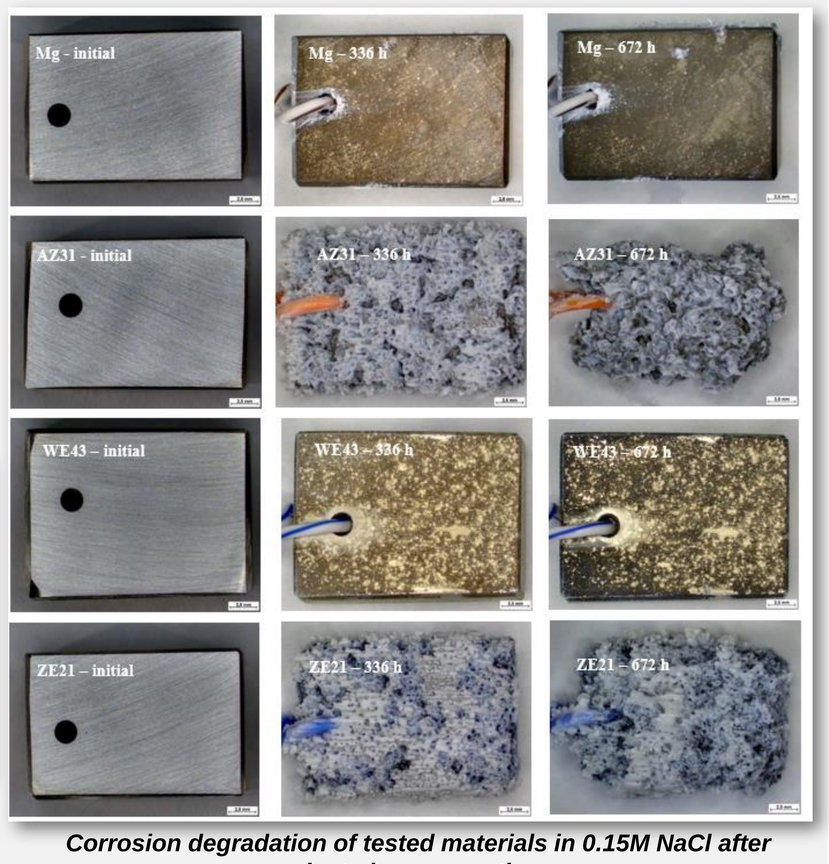
Material	E_{corr} (mV)	i_{corr} ($\mu A.cm^{-2}$)	r_{corr} ($mm.year^{-1}$)
Pure Mg	-1766±8	23.2±2.8	0.53±0.06
AZ31	-1594±20	20.9±1.2	0.48±0.03
WE43	-1757±8	33.2±1.2	0.76±0.03
ZE21	-1559±10	30.5±0.2	0.71±0.01



The pH evolution during exposure



Calculated corrosion rates after long term exposure



Corrosion degradation of tested materials in 0.15M NaCl after selected exposure times

CONCLUSION & IMPLEMENTATION PATH

Study compared the corrosion resistance of various types of magnesium-based materials utilizing potentiodynamic (PD) polarization tests and exposure testing in 0.15M NaCl. The results revealed that:

- The ZE21 alloy exhibited the highest thermodynamic stability, while the pure Mg alloy exhibited the lowest.
- The corrosion current density reached its lowest value in the case of AZ31 alloy, meaning that it exhibited less corrosion intensity compared to the other materials in short-term view.
- The long-term exposure testing indicated that the WE43 alloy exhibited the highest corrosion resistance after one month of exposure, with the pure Mg, ZE21, and AZ31 alloys following in succession.
- The photographic documentation of the corroded samples and the pH evolution confirmed that the WE43 alloy demonstrated a significantly reduced surface area affected by corrosion and the lowest pH value after 672 hours of exposure.
- Results confirmed that complex research on the corrosion stability of materials requires to consider not only the immediate electrochemical characteristics but also the indicators of corrosion resistance determined through long-term experiments.

ACKNOWLEDGEMENTS

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