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PERFORMANCE OF CORROSION BEHAVIOR OF COMMERCIAL MAGNESIUM ALLOY ANODE ELECTRODE IN SEAWATER-POWERED LAMPS

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ABSTRACT
The development of environmentally friendly alternative technologies, such as seawater batteries, is increasingly important in addressing energy needs. This study aims to analyze the corrosion behavior of a magnesium alloy anode electrode used in seawater batteries with varying salinity levels. Five commercial anode electrode samples were prepared, each immersed in a salt solution with different concentrations: 14g, 16g, 18g, 20g, and 22g in 380 ml of distilled water. Potentiodynamic testing was conducted to measure the corrosion potential (Ecorr), corrosion current (Icorr), and corrosion rate. The results showed that an increase in salt concentration significantly increased the corrosion rate. The sample with the highest salt concentration (22g) produced a corrosion potential of 1.5419 Volts, a corrosion current of 0.0010 Amps/cm², and a corrosion rate of 12.5850 mm/year. These findings indicate that the corrosion rate increases with higher salinity. The study concludes that there is a positive correlation between salinity and corrosion rate, with future research expected to focus on additional treatments to improve electrode performance.
Keywords : *Magnesium Alloy Anode, Seawater Batteries, Corrosion Behavior, Salinity Variation, Potentiodynamic Testing.*

1. Introduction

In the present era, research on environmentally friendly alternative technologies is becoming increasingly crucial in addressing the challenges of climate change and environmental sustainability. Technological advancements must always be accompanied by positive societal and environmental benefits. Progress in marine technology is particularly anticipated by communities involved in marine and fisheries activities, such as fishermen. These advancements can aid fishermen in catching fish more efficiently or simplifying their daily tasks. Alternative technologies may assist fishermen in employing more sustainable fishing practices, such as using eco-friendly nets and traps that do not harm coral reefs or other marine ecosystems. Moreover, fishermen can adopt renewable energy technologies, such as solar panels or wind turbines, to support their daily operations at sea. For instance, solar energy can be harnessed to power water pumps for drying fish or to operate electronic equipment on their vessels. In addition, the use of GPS and digital mapping technologies enables fishermen to locate fish more efficiently and navigate the seas more effectively. Lastly, technologies like RFID (Radio-Frequency Identification) or fish tracking systems can help fishermen monitor their catch more accurately and reduce the risk of illegal fishing. To realize these benefits, government policies are essential for proper regulation (P. Liu et al., 2021).

In the field of marine science, researchers continue to develop and innovate methods for generating electrical energy. Electrical energy sources refer to the various natural resources and technologies utilized to generate electricity. These sources form an integral part of modern infrastructure, enabling us to illuminate homes, power machinery, and meet other energy demands in daily life. Given the crucial role of energy sources in everyday life, several new

Renewable Energy Sources (RES) have been developed. In addition to fulfilling human energy requirements, the creation of these renewable energy sources has an environmental impact. Consequently, a few years ago, research was conducted on the environmental impact of RES-based power plants, which was analyzed through a comprehensive review that included solar thermal, solar photovoltaic, wind, biomass, geothermal, hydroelectric, tidal, marine current, ocean wave, ocean thermal energy, and osmotic effects (Rahman et al., 2022) Electrical energy sources are particularly vital for communities, especially fishermen residing in remote areas. Electricity can be derived from several sources, including Steam Power Plants (PLTU), where the process involves burning fossil fuels such as coal, oil, or gas to heat water and generate steam (Khaleel et al., 2022). Another source is Gas Power Plants (PLTG), which utilize natural gas as fuel to produce electricity (Ahmed et al., 2022). Furthermore, Nuclear Power Plants generate electricity through nuclear fusion or fission reactions within nuclear reactors, producing heat that is used to generate steam and, subsequently, electricity, similarly to PLTU and PLTG (Ong et al., 2022). Additionally, Hydropower Plants (PLTA) harness the energy of moving water to drive turbines and generate electricity (Yıldırım, 2021). Renewable energy from hydropower also utilizes turbines to convert the kinetic energy of flowing water into mechanical energy. In several countries, discussions are currently ongoing regarding the construction of turbine-based power plants. Various wind turbine designs have been proposed to maximize electricity generation, one of which is the floating vertical axis wind turbine (Ghigo et al., 2024). This design is highly suitable for meeting the needs of communities, particularly fishermen in remote areas, as Vertical Axis Wind Turbines (VAWT) are typically employed for small-scale applications, such as electricity generation in urban areas or isolated locations not connected to the power grid. Figure 1 illustrates the different types of Vertical Axis Wind Turbines (VAWT) commonly in use.

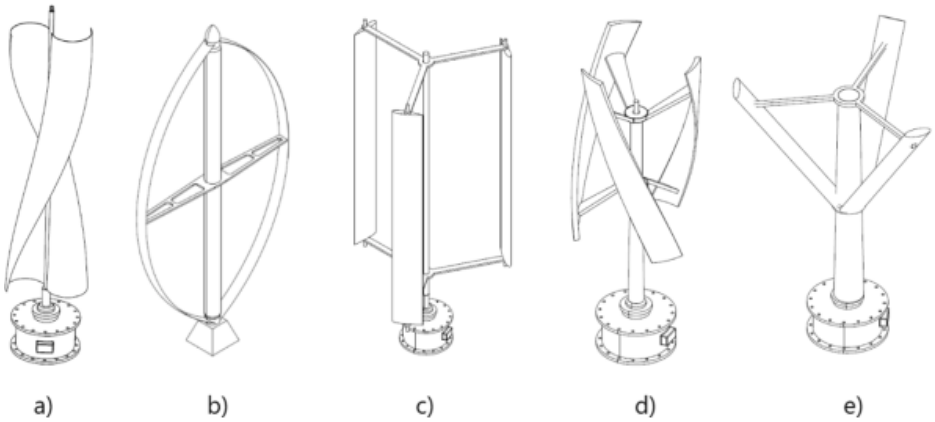

Fig. 1. Graphical representation of various types of Vertical Axis Wind Turbines (VAWT): (a) Savonius, (b) ϕ-Darrieus, (c) H-rotor Darrieus, (d) Helical bladed, (e) V-shaped

Electrical energy sources are not only derived from turbine power plants but can also be obtained from batteries. Batteries can store energy generated from renewable energy sources or from the power grid during low demand, to be used during peak demand or when primary resources are unavailable. A battery is a device composed of one or more electrochemical cells that can generate electrical energy. Currently, battery development is advancing rapidly, particularly with rechargeable batteries. Throughout this development, several issues and challenges in the advancement of rechargeable batteries have been successfully summarized, notably with lithium rechargeable batteries (Lee, 2020). Consequently, many researchers continue to strive to create higher-quality battery types focused on lithium (Xu et al., 2023). Table 1 presents several alternative materials that are being explored for battery electrodes. Various efforts have also been made, including the reaction between lithium (Li) and oxygen (O_2) to generate electricity, categorized as aprotic batteries, meaning that their electrolytes do not contain active protons, distinguishing them from water-based batteries (Ding et al., 2021). In addition to reactions with oxygen, to enhance performance and address high costs, scarcity, and environmental impacts, vanadate glass and glass-ceramics have been utilized as alternative cathode materials in rechargeable lithium-ion batteries (Kindle et al., 2021). Furthermore, the

development of lithium batteries involves the use of nanomaterials, based on the premise that nanotechnology has opened new possibilities in lithium rechargeable battery research, improving material properties and enabling new chemistry (AbdelHamid et al., 2022). Given that rechargeable lithium batteries exhibit superior performance compared to other types, efforts have been made to apply them in electric vehicles (Z. Wang et al., 2021; Nasri et al., 2023). To date, there are guidelines and trends for the development of the next generation of rechargeable lithium and lithium-ion batteries aimed at achieving enhanced performance (Wu et al., 2020).

Table 1 - Some alternative materials that are being developed for battery electrodes

Battery type	Features	Environmental impact
Ni–MH (established)	Low voltage, moderate energy density, high power density Applications: portable, large-scale	Nickel not green (difficult extraction/ unsustainable), toxic. Not rare but limited Recyclable
Lead–acid (established)	Poor energy density, moderate power rate, low cost Applications: large-scale, start-up power, stationary	High-temperature cyclability limited Lead is toxic but recycling is efficient to 95%
Lithium ion (established)	High energy density, power rate, cycle life, costly Applications: portable, possibly large-scale	Depletable elements (cobalt) in most applications; replacements manganese and iron are green (abundant and sustainable) Lithium chemistry relatively green (abundant but the chemistry needs to be improved) Recycling feasible but at an extra energy cost
Zinc–air (established)	Medium energy density, high power density Applications: large-scale	Mostly primary or mechanically rechargeable Zinc smelting not green, especially if primary Easily recyclable
Lithium– organic (future)	High capacity and energy density but limited power rate. Technology amenable to a low cost Applications: medium- and large-scale, with the exception of power tools	Rechargeable Excellent carbon footprint Renewable electrodes Easy recycling
Lithium–air (future)	High energy density but poor energy efficiency and rate capability Technology amenable to a low cost Applications: large-scale, preferably stationary	Rechargeability to be proven Excellent carbon footprint Renewable electrodes Easy recycling
Magnesium– sulphur (future)	Predicted: high energy density, power density unknown, cycle life unknown	Magnesium and Sulphur are green Recyclable Small carbon footprint
Al–CF *x* (future)	Predicted: moderate energy density, power density unknown	Aluminium and fluorine are green but industries are not Recyclable
Proton battery (future)	Predicted: all organic, low voltage, moderate energy density, power density unknown	Green, biodegradable

In addition to lithium-based or lithium-ion batteries, there is ongoing development of seawater-based magnesium batteries. The transition from lithium batteries to seawater as an energy storage solution represents an innovative approach to achieving sustainability in the field of energy storage. This technology was first introduced in 1968, based on research reports from 1959 that highlighted the potential of inert cathode/Mg-anode cells as an economical, durable, and low-power source (Wilson, 1968). The operating principle of this type of battery involves a chemical reaction occurring when the battery is in use. The anode is typically made of a metal such as zinc or magnesium, while the cathode is usually composed of metals like silver or gold oxide. The electrolyte solution consists of seawater or a salt solution containing free ions that facilitate the flow of electric current. The anode undergoes oxidation, releasing electrons, while the cathode undergoes reduction, receiving electrons. This reaction generates a flow of electric current through an external circuit that can be used to power electronic devices. This technology has advanced significantly, and seawater batteries are now being utilized in various fields, including marine exploration instruments, rescue equipment, and underwater weaponry (Chen et al., 2023). Figure 2 illustrates the development of the first seawater battery made from

Mg/AgCl, which was used as a power source for electric torpedoes during World War II and later expanded to power buoys, acoustic balloons, signal lights, rescue equipment, and autonomous underwater vehicles. Therefore, in recent years, research has been conducted on the first seawater battery (SWB) system in the world that operates effectively in real marine environments (Koo et al., 2020).

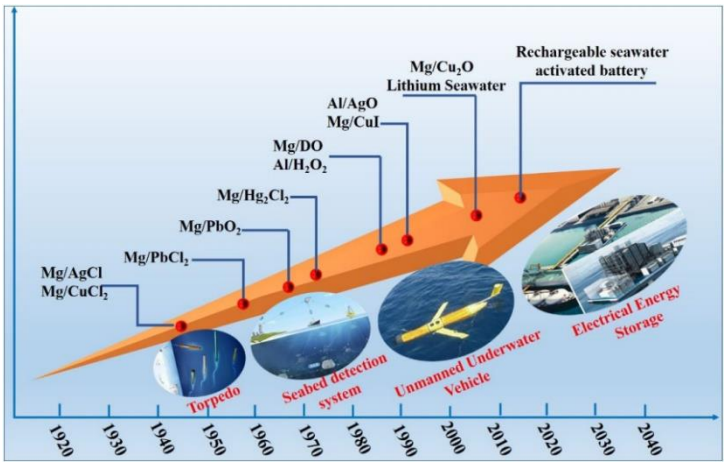

Fig. 2. Development of seawater-activated batteries and significant innovations and changes from primary to secondary systems

With the growing demand for seawater batteries, performance improvements are also being made. The performance of magnesium anode electrodes in seawater batteries can be enhanced through various approaches, such as applying catalysts on the magnesium anode surface, optimizing anode design by increasing the surface area involved in electrochemical reactions, adding certain chemicals to the electrolyte solution or using modified electrolytes, and developing magnesium anode materials that are more corrosion-resistant and exhibit better reactivity. Among these aspects, the most critical in improving battery performance is the development of magnesium anode materials with higher corrosion resistance and improved reactivity. This can be observed in the corrosion behavior of magnesium anode materials. There are several types of corrosion that can affect the performance of magnesium anodes, including general corrosion, self-corrosion, and the chunk effect (Deng et al., 2021). Recent corrosion behavior analyses have been conducted on magnesium anode materials by (Lu et al., 2021; Gao et al., 2024), highlighting the challenges faced by magnesium anodes in seawater battery applications, particularly in terms of corrosion behavior. One method for analyzing corrosion behavior is through the use of potentiodynamic polarization, an electrochemical technique used to study the corrosion behavior of a material by systematically applying varying voltage (potential) and measuring the resulting electric current. From this potentiodynamic polarization technique, polarization curves can be obtained, where the x-axis represents potential (usually in volts), and the y-axis represents current (in amperes or amperes per unit area of the electrode, A/cm²). This technique has recently been employed to assess the electrochemical performance of the Mg-8Li-0.5La and Mg-8Li-1La alloys as anodes for seawater batteries (Yu, Lv, et al., 2020). Figure 3 presents the potentiodynamic polarization curves for the electrodes: (a) Mg-8Li, (b) Mg-8Li-0.5La, and (c) Mg-8Li-1La. Previous analyses of corrosion behavior using potentiodynamic polarization techniques have also been conducted on magnesium anode materials (Supriyono et al., 2018; R. Wang et al., 2018).

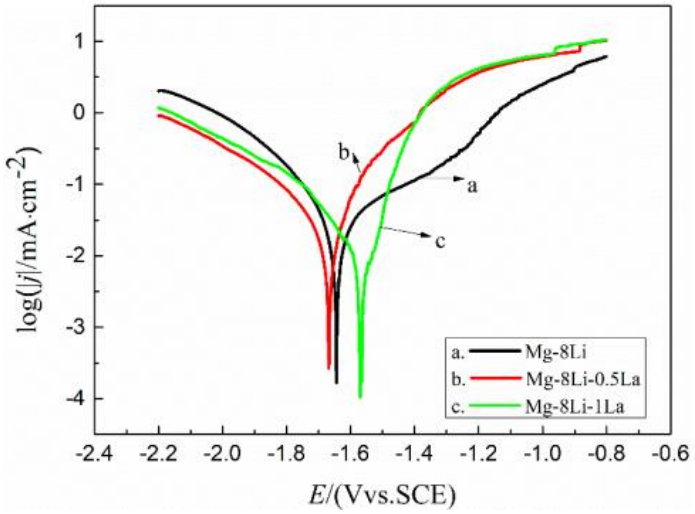

Fig. 3. Potentiodynamic polarization curves for the electrodes: (a) Mg-8Li, (b) Mg-8Li-0.5La, and (c) Mg-8Li-1La

In its application as a seawater battery, magnesium materials inevitably undergo corrosion caused by the reaction between the magnesium anode and chloride ions present in the seawater electrolyte solution. This reaction triggers the formation of corrosion products such as magnesium hydroxide ($Mg(OH)_2$) and an oxide layer on the surface of the anode, which can reduce the battery's efficiency. Therefore, various development strategies, such as the addition of corrosion inhibitors or the use of magnesium alloys, are being pursued to slow down the corrosion rate and enhance the performance and longevity of the battery. The incorporation of inhibitors such as sodium phosphate and sodium dodecylbenzenesulfonate (Y. Li et al., 2018), as well as Trisodium Phosphate (TSP) (Karudesh et al., 2024), into sodium chloride solution has been explored. The results obtained indicate that both materials have the potential to improve the performance and durability of the battery.

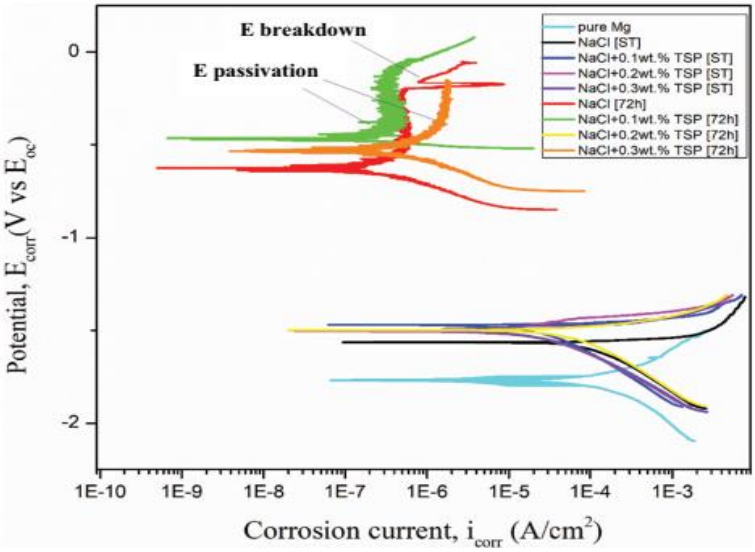

Fig. 4. Tafel curves for Mg-5Sn-0.2Ca-0.2Mn at various immersion periods across different electrolyte concentrations.

In general, the focus of performance development in batteries over the past few decades has been on the advancement of magnesium anode materials for seawater batteries (Shrestha et al., 2019; C. Wang et al., 2020; Ma et al., 2020; Tong et al., 2021; Q. Li et al., 2022; N. Wang et al., 2021). Table 1 presents several electrodes that have been tested to evaluate their performance. In addition to adding inhibitors to the magnesium anode, the use of magnesium-aluminum eutectic alloys as anodes in magnesium-air batteries has proven to enhance corrosion performance, which can extend the battery's lifespan and improve its operational efficiency (Ma et al., 2020). Recent advancements in magnesium anodes for seawater batteries continue to emerge, with the AZ63 alloy being recognized as the best candidate for long-term applications

due to its more controlled corrosion behavior and superior anodic efficiency compared to AZ101 (Abedini, Valmoozi, et al., 2023) Additionally, the development of magnesium anodes for seawater batteries has involved heat treatment through solutionizing and aging of the AZ63-1.5RE alloy, significantly enhancing corrosion resistance and anodic efficiency, thus making it a promising candidate for anodes in low-power seawater batteries (Abedini, Shamskhani, et al., 2023).

Table 2 - Several electrodes that have been tested to determine performance

Item	AZ61	ZK60	AZ31
Current (mA)	50	85	75
Voltage (V)	0.41	0.60	0.51

Furthermore, as developments progress, it is crucial to address the performance demands for the widespread adoption of magnesium-based seawater batteries as a sustainable energy storage solution. Continuous research and development efforts are necessary to optimize the performance of these batteries and make them an economical and environmentally friendly alternative. Consequently, various materials have been added to enhance their performance, including aluminum (Ma et al., 2020), manganese (D. Zhang et al., 2021), aluminum-zinc (X. Liu et al., 2019), zinc-tin (Tong et al., 2021), aluminum-zinc-manganese (Q. Li et al., 2022; N. Wang et al., 2021), aluminum-zinc-manganese-cerium (Q. Li et al., 2022), and others. The diversity of materials added significantly affects battery performance. For instance, High Entropy Alloys (HEAs) are metal materials composed of five or more elements. Compared to conventional alloys, HEAs possess a greater number of active catalytic sites due to their unique structural characteristics, such as high entropy effects and lattice distortion, providing promising potential applications in hydrolysis catalysis. The addition of these supplementary elements is expected not only to enhance the performance of seawater battery electrodes but also to yield affordable materials. Table 3 and Table 4 illustrate the discharge performance of Mg anodes made from the Mg-6 mass% Al-0.3 mass% Mn-2 mass% Ca (AMX602) alloy and the Mg-6 mass% Al-0.3 mass% Mn (AM60) alloy, as well as the corrosion parameters of the AMX602 and AM60 alloys obtained from the polarization curves. Additionally, elements such as MgFexMn2-xO4 (x = 0.67; 1; 1.33; 1.6) have been introduced to enhance performance at a low cost (Y. Zhang et al., 2020). Recently, the addition of elements like the NiSe2-CoSe2@TiVCTx (NCSe@TiVC) heterostructure has been explored. By leveraging the synergistic effects of the TiVCTx MXene and NCSe, the NCSe@TiVC heterostructure electrode demonstrates a specific discharge capacity of 136 mAh g−1 at 0.05 A g−1 and high cycle stability of over 500 cycles, indicating promising practicality (Y. Zhang et al., 2022).

Table 3 - Discharge performance of anode Mg batteries made of AMX602 and AM60 alloys

Current density (mA/cm^2)	Specimen	Discharge capacity (mAh/g)	Operating voltage (V)	Anodic efficiency (%)
2.5	AMX602	1156	1.163	52.4
	AM60	872	1.148	39.5
5	AMX602	1221	0.952	55.3
	AM60	861	1.117	39.1
10	AMX602	1331	0.651	60.4
	AM60	1098	0.739	49.8

Table 4. Corrosion parameters of AMX602 and AM60 alloys obtained from polarisation curves

Specimen	Immersion time (h)	E_{corr} V/SCE	Icorr ($A\ cm^{-2}$)
AMX602	0.5	-1.452	2.190×10^{-6}
AM60	2	-1.418	2.370×10^{-6}
AMX602	8	-1.488	83.77×10^{-6}
AM60	0.5	-1.547	111.6×10^{-6}
AMX602	2	-1.564	95.08×10^{-6}
AM60	8	-1.566	41.35×10^{-6}

Furthermore, in addition to adding various supplementary materials to enhance the performance of seawater batteries, it is essential to gain a deep understanding of the concepts related to seawater-based metal-air batteries, as well as a comprehensive analysis of the crucial air electrode reactions from both thermodynamic and kinetic perspectives. A rational design strategy for the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER)

electrocatalysts compatible with chloride-containing and seawater-based electrolytes also warrants detailed discussion (Yu et al., 2020). Moreover, foundational knowledge regarding the properties of batteries is crucial. One such property is Prelithiation, which involves the process of inserting lithium ions (Li) into the material prior to its use. This is done to achieve outstanding performance in magnesium batteries (F. Liu et al., 2020).

Considering the importance of understanding corrosion behavior in the effort to enhance the performance of magnesium alloy anode electrodes in batteries, preliminary analysis of the commercial magnesium alloy anode electrodes is essential. This step is crucial for gathering initial information regarding corrosion behavior, which will provide insights into the actions needed for improvement. In this study, the anode electrodes will be sourced from commercial products and reacted with salt solutions of varying salinities. The technique of potentiodynamic polarization will be employed to determine the corrosion rate, susceptibility to pitting, passivation, and cathodic behavior within the electrochemical systems derived from magnesium-based anodes, which will ultimately be applied to seawater-powered lamps.

2. Research Methods

2.1 Material

In this study, the material used is a commercially available magnesium alloy anode electrode branded as LED Green Lantern, manufactured in Indonesia. This product is relatively new to the market and, as a result, not yet widely recognized by the public. Currently, the exact composition of the materials used in this product has not been identified, though the packaging specifies it as a "magnesium rod." The product also features compact dimensions, with a height of 97.95 mm, a diameter of 20.60 mm, and a mass of 78 g. Figure 3 shows the packaging and product specifications.

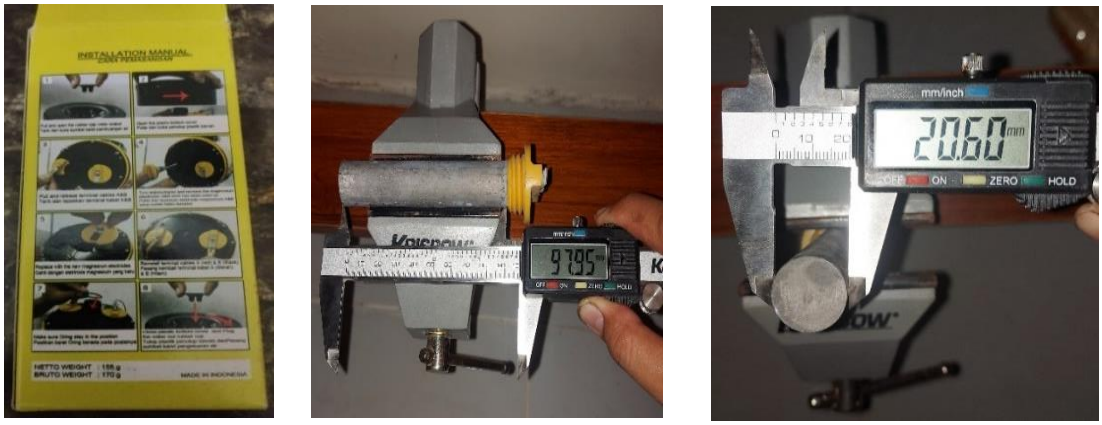

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Fig. 3. Product packaging and specifications: a) product packaging; b) height; c) diameter

2.2 Specimen preparation

In the specimen preparation stage of this study, salt solutions with different variations were used. These solutions were mixtures of distilled water (aquades) and various salt concentrations, consisting of five different variations, each repeated three times. The salt concentration used in this study follows the standard provided on the lamp's packaging, which indicates a solution composed of 18 g of salt dissolved in 380 ml of distilled water. This composition serves as a reference for evaluating the corrosion behavior of magnesium alloy anode electrodes. Table 5 presents the experimental design for preparing salt solutions with varying salt concentrations used in this study.

Table 5 - Experimental design for the preparation of saline solution of varying salt content

Sample	Water volume (ml)	Salt mass (g)
A1	380	14
A2	380	16
A3	380	18

A4	380	20
A5	380	22

The next step is to explain the technique used in preparing the salt solutions. The preparation process involves weighing the salt and measuring the required volume of water as outlined in Table 5. Once all components are ready, each sample is stirred at a speed of 400 rpm at room temperature for 5 minutes. After completing these steps, the prepared salt solutions are transferred into separate bottles and labeled according to their respective variations. Figure 4 illustrates the steps involved in the preparation of the salt solutions.

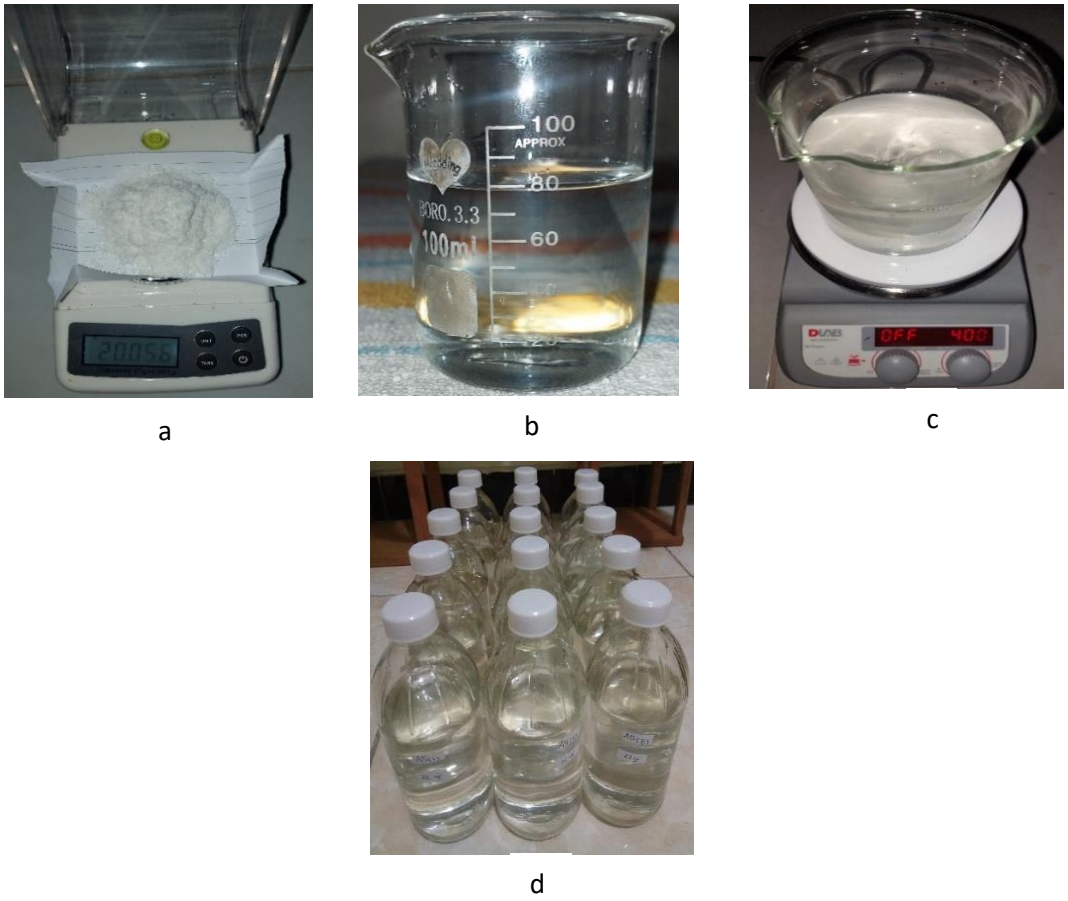

Fig. 4. Steps for making salt solution: a) weighing salt; b) measuring the volume of water; c) stirring; d) salt solution ready for use

2.3 Test Method

After completing the preparation of all test samples, testing is conducted using potentiodynamic equipment. The potentiodynamic method is an experimental approach in electrochemical chemistry that utilizes a potentiostat to control the electrode potential of an electrochemical system while monitoring the electric current response over time or potential changes. In this method, the electrode potential is adjusted to a specific level (typically by varying the voltage at the reference electrode), and the resulting electric current response is recorded. This technique provides direct control over the overpotential, enabling the observation of corrosion rates through readings of the potential polarization curve. Dynamic potential polarization graphs are visual representations of the data obtained from the potentiodynamic technique. These graphs are employed to assess the corrosion properties of metal materials, such as magnesium alloy, in specific environments. Additionally, this method is used to analyze the effects of anodizing concentration and electrical potential on the corrosion behavior of magnesium (Zheng et al., 2018; Supriyono et al., 2018).

Metal corrosion occurs when the anodic current equals the cathodic current, even in the absence of an external current applied to the system. The anodic current arises from the

oxidation reaction of the metal, while the cathodic current results from the reduction reactions of species in the environment, such as oxygen or hydrogen ions. This equilibrium establishes a closed electrochemical circuit within the metal, facilitating the continuous progression of corrosion. The potentiodynamic system used in this study was assembled in accordance with applicable testing standards before the experiments were conducted. The potentiodynamic equipment utilized in this research is from the CorrTest brand. Figure 5 illustrates the testing process, including the equipment and the setup of the potentiodynamic system used in this study.

A B

Fig. 5. Potentiodynamic testing process: a) equipment; b) equipment circuit

3. Results and Discussions

3.1 Results

Based on the results of the potentiodynamic testing, a polarization curve was obtained for the magnesium rod in the commercial product, showing good linearity across a broad voltage range, with the slope of the cathodic branch being quite consistent. This indicates that the magnesium rod in the commercial product maintains a relatively stable potential difference. However, the slope of the anodic branch varies, reflecting the corrosion mechanism of the magnesium alloy and indicating differences in corrosion rates due to variations in salt concentration. This observation is consistent with findings reported in the (Zheng et al., 2018; Supriyono et al., 2018). Overall, the commercial product demonstrates favorable performance. Figure 6 presents the potentiodynamic polarization curves for each sample.

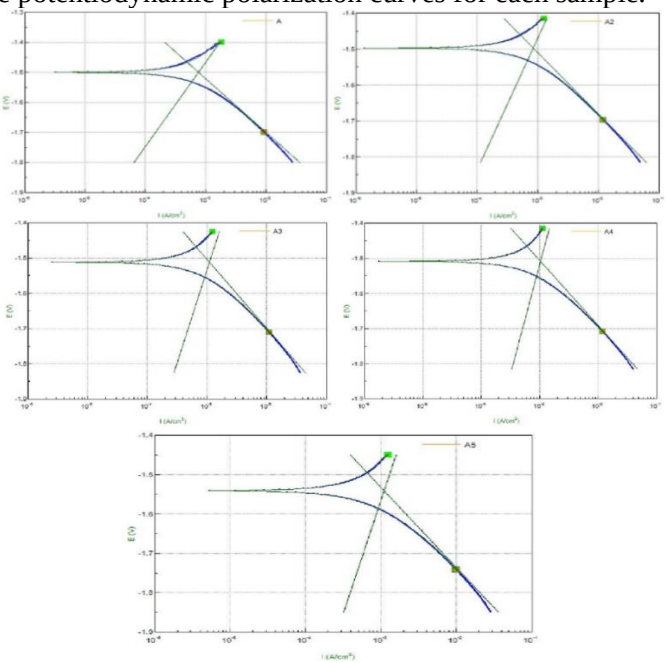

Fig. 6. Potentiodynamic polarization curves of each sample

The polarization curves reveal varying values for each sample. The electrical potential measurements for the magnesium alloy anode electrodes under the tested environmental conditions show minimal variation among samples. Specifically, the electrical potentials for

samples A1, A2, A3, A4, and A5 are -1.5006 V, -1.4980 V, -1.5128 V, -1.5096 V, and -1.5419 V, respectively. Similarly, the electrical current measurements also exhibit minimal differences among the magnesium alloys under the tested conditions, with values of 0.0008 Amps/cm² for samples A1 and A2, 0.0011 Amps/cm² for samples A3 and A5, and 0.0010 Amps/cm² for sample A4. In contrast, the corrosion rate measurements show more pronounced differences. The corrosion rates for samples A1, A2, A3, A4, and A5 are 8.673 mm/a, 9.619 mm/a, 12.581 mm/a, 11.815 mm/a, and 12.585 mm/a, respectively. These results indicate that, relative to the recommended salinity levels provided on the packaging, lower salinity levels correspond to lower potential differences and corrosion rates, while higher salinity levels correlate with higher corrosion rates. Table 6 presents the detailed results obtained from the potentiodynamic polarization of the commercial magnesium rod products.

Table 6 - The value of the potentiodynamic polarization results on commercial magnesium rods

Sample	Salt mass variation (g)	E_{Corr} (Volts)	I_{Corr} (Amps/cm^2)	Corrosion Rate (mm/a)
A1	14	-1.5006	0.0008	8.6727
A2	16	-1.4980	0.0008	9.6189
A3	18	-1.5128	0.0011	12.5810
A4	20	-1.5096	0.0010	11.8150
A5	22	-1.5419	0.0011	12.5850

3.2. Discussion

Potentiodynamic techniques are commonly employed to assess the active-passive behavior of metals. This method provides valuable information about corrosion rate, pitting susceptibility, passivation, and cathodic behavior of the electrochemical system. From the results obtained, several key aspects can be elucidated, including the electrochemical characteristics of the magnesium alloy anode electrode. These characteristics are illustrated by the relationship between electrode potential (on the vertical axis) and electric current (on the horizontal axis) under varying salinity conditions. Additionally, the inflection point on the potentiodynamic curve, where a sharp change in slope occurs, signifies a significant shift in the metal's electrochemical response to the applied potential. Finally, the corrosion rate, observable from the dynamic potential polarization graph of the magnesium alloy anode electrode, can be evaluated.

Based on the test results, the electrochemical characteristics of the samples are relatively similar. This similarity may arise from the series of chemical processes that occur when the magnesium alloy interacts with the same corrosive environment, namely the salt solution, despite variations in salinity levels. Additionally, the potentiodynamic inflection points for each sample exhibit a similar sharp change in slope. While the initial electrochemical response of the metal to the applied potential might seem different, closer examination reveals that the results are relatively consistent across samples. However, although the corrosion rates observed from the dynamic potential polarization graphs appear similar, further analysis indicates that there are differences in the corrosion rates among the samples.

Further analysis based on the test results is presented in Table 6, which details the magnitude of values obtained from the potentiodynamic polarization of commercial magnesium rods. The results indicate that salinity, as a measure of salt content resulting from acid-base reactions, significantly influences the corrosion rate. Specifically, the chemical reaction occurring in this study involves the interaction between sodium in the salt solution and the magnesium rod. As the concentration of salt in parts per thousand (ppt) increases, the amount of salt formed also increases, which correlates with the corrosion rate. Higher salinity values enhance the corrosion rate of the magnesium alloy. To improve the corrosion behavior of the magnesium alloy anode electrode, the addition of inhibitors such as a combination of sodium alginate (SA) and sodium phosphate (SP) is recommended. These inhibitors have been shown to enhance the corrosion resistance of magnesium alloy anode electrodes (Hou et al., 2016).

4. Conclusion

Based on the results obtained from the five prepared samples, the corrosion behavior of commercial magnesium rods varies with salinity levels. The highest values recorded were for

corrosion potential (Ecorr = -1.5419 Volts), electric current (Icorr = 0.0010 Amps/cm²), and corrosion rate (12.5850 mm/a). These results demonstrate that corrosion performance increases with higher salinity. To ensure optimal corrosion behavior and maintain the integrity of magnesium rods in various industrial applications and corrosive environments, the use of inhibitors is recommended. Future research is anticipated to focus on improving the performance of seawater-based battery electrodes.

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