Control of aluminum corrosion in seawater environment by adding turmeric extract to the coating material

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Abstract. Turmeric is one of the plants that contains antioxidant compounds called curcumin. Antioxidants in curcumin include flavonoids and tannins. Antioxidants can be used as corrosion inhibitors and paint additives. This study aims to utilize turmeric extract as an inhibitor and additive coating agent for aluminum metal in the seawater environment. Turmeric is extracted using a methanol or acetone solvent with a sample: solvent ratio of 1: 8. Phytochemical and DPPH (1,1-Diphenyl-2-Picrylhydrazyl) analyzes were performed. Testing of extracts as inhibitors and coating additives was carried out by varying the concentration and time of corroding. The results showed that the extract produced contained flavonoids and tannins through qualitative tests using 1% FeCl3 and 10% NaOH, each of which gave a blackish green and a blackish red color. Antioxidant activity was tested by the DPPH method in acetone and methanol, which respectively showed 4509 ppm and 2057 ppm. The testing of turmeric extract as a coating additive was immersed for five days and obtained the best level of 1% which produced the lowest corrosion rate of 0.0228 mmpy with a protection efficiency of 68.60%. Turmeric extract corrosion test as a coating additive was achieved within eight days with a corrosion rate of 0.0011 mmpy and a protection efficiency of 88.89%.

1. Introduction
Aluminum metal mainly in the aviation industry is used because it is lightweight, safe and stable at neutral pH. However, Aluminium metals still experience corrosion in the seawater environment [1]. Aluminum and its alloys are widely used in aircraft and marine ship structures. Airplanes generally cross the surface of the sea water. Ships in the sea water environment. The atmosphere of the sea and the environment of the sea water contains a lot of chloride ions (Cl-). This ion is an aggressive ion against metals including aluminium metals and their alloys, which can cause pitting corrosion.

A method of controlling corrosion is to use coatings. The selection of turmeric extract is based because it contains secondary metabolites which have antioxidant properties [2-5]. These secondary metabolites are rich in free electrons which will bond with metals to form complex compounds and coat the metal surface so that they are protective. Based on this, turmeric extract can be used as an additive coating to protect metals from corrosion.

Turmeric extract was obtained by maceration extraction method using acetone and methanol [4]. The choice of solvent is based on the polarity of the antioxidants contained in the polar turmeric extract. In the study of curcumin extraction regarding the extraction of turmeric extract using ethanol solvent with variations in temperature, turmeric particle size, stirring time, and solvent-sample ratio. Optimum results
in turmeric extraction were obtained at 60 °C, solid particle size of 0.42 mm, stirring time of 30 minutes, and solvent-sample ratio of 50, resulting turmeric extract with a yield of 12.89% [6].

This research focuses on the model of taking turmeric extract based on this method, namely acetone and methanol. The extract is used as an additive coating for aluminum metal in seawater environments. It will be investigated how much the yield of turmeric extract containing antioxidants using acetone and methanol. Also what is the ability of turmeric extract as an additive coating to protect corrosion of aluminum metal in an isolated seawater media. And finally, the efficiency of protection of turmeric extract as an additive coating to protect corrosion of aluminum metal in the seawater environment will be determined.

2. Method
Research methods through experiments in the Corrosion Laboratory, Chemical Engineering Department, POLBAN.

2.1. Materials
Turmeric is taken from the Bandung regional market. Extraction by maceration using acetone or methanol with a ratio of sample: solvent 1: 8 which is done in two cycles. Aluminum metal with a thickness of 0.33 mm; length 2 cm; and 4 cm wide. Seawater used comes from the sea water of Pelabuhan Ratu, Sukabumi.

2.2. Procedure
Turmeric is cleaned and shredded into small particles. Pre-treatment of aluminum metal is carried out by sanding using 1000 grit sandpaper. The extraction method used is maceration. Turmeric is soaked in acetone or methanol in a ratio of 1: 4 each at room temperature for two hours, accompanied by stirring at 100 rpm. Rafinat is macerated again with a ratio of 1: 4 so that the total ratio of samples to solvents is 1: 8. The resulting second extract is mixed with the first extract. Concentration is done by rotary evaporator at 50-60°C, speed of 100 rpm and time of 20 minutes.

2.3. Turmeric extract test
The flavonoid content test is carried out by taking as much as 5 mL and adding 10% NaOH as much as three drops, if yellow, orange or red color is formed, indicating the presence of flavonoids. The tannin test is carried out by taking 5 mL of sample added 1-2 drops of reagent Iron (III) Chloride, if a blackish blue or blackish green color indicates the presence of tannin.

Antioxidant levels were carried out using the DPPH method. All control solutions, turmeric extract solution and positive standard solution (vitamin C) were shaken using a waterbath shaker and incubated at 37 °C for 30 minutes in the dark (covered in aluminum foil). This is because DPPH radicals are easily degraded by light. This test was carried out at a wavelength of 517 nm using a UV-Vis spectrophotometer [7].

The testing of turmeric extract as a coating additive was tested with a concentration of 0.5; 1; 2; 4; 8; and 12% for 5 days. Dilution is carried out from 12% mother liquor to obtain varying concentrations of additive coatings. Corrosion rate testing is calculated based on weight loss method. Photomicrobial analysis of metal surfaces is used to see the coating mechanism on metals.

3. Results and discussion

3.1. Extraction of turmeric
The results of maceration were filtrated and concentrated using a rotary evaporator so that the concentrated extracts are shown in table 1.
Table 1. Extracted data.

| Parameter                | Solvent  |
|--------------------------|----------|
|                          | Methanol | Acetone |
| Mass of Turmeric (g)     | 500      |         |
| Volume (mL)              | 243      | 340     |
| Density (g/mL)           | 0.94     | 0.92    |
| Massa of Extract (g)     | 228.42   | 312.8   |
| Yield (%)                | 52.7     | 87.66   |

Table 1 shows yields, densities, and volumes obtained from operating conditions at temperatures of 50-600°C with the same speed of 100 rpm in 20 minutes. The temperature selection of 600°C is used for the separation of methanol solvents which have a boiling point of 65.70°C. The temperature selection of 500°C is used for separating the solvent which has a boiling point of 560°C. This operating temperature is below the boiling point of each solvent under pressure in the rotary evaporator is vacuum.

3.2. Antioxidant content in the extract

Phytochemical test results showed a change in color to blackish red with the addition of 10% NaOH solution and a change in color to blackish green with the addition of a 1% FeCl3 solution. The addition of 10% NaOH solution into the extract changes color to blackish red which indicates the presence of flavonoids and the addition of a 1% FeCl3 solution to the extract changes color to blackish green which indicates the presence of tannins.

![Figure 1. Graph of antioxidant concentration.](image)

The quantitative antioxidant activity (flavonoids and tannins) was tested by DPPH. Tests show that turmeric extract contains antioxidants. DPPH test is performed based on IC50 values. IC50 value is the concentration of antioxidants to inhibit 50% of free radical activity. DPPH test results obtained based on the value of IC50 shown in figure 1 which identifies that the smaller the IC50 value indicates the higher antioxidant content.

3.3. Additives coating

The results of testing the turmeric extract additive coating in seawater media with variations in concentration are shown in figure 2.
Figure 2. Graph for determining the concentration of the best additive coating.

From figure 2, the best concentration of the addition of additive coating at 1% using a methanol solvent can be seen from the lowest corrosion rate with a protection efficiency of 68.60% shown in figure 3.

Figure 3. The graph of the protection efficiency of determining the concentration of additive coatings. Corrosion time affects the rate of corrosion of aluminum metal in seawater shown in figure 4.

Figure 4. Graph of corrosion rate of additives coating.
In figure 4 the data produced tends to be fluctuating. The highest protection efficiency was found on the 8th day of 88.89%, as shown in figure 5. This shows that the protective ability of turmeric extract additive coating at 1% concentration was effective for 8 days.

3.4. Photomicro test analysis results
The metal is cut transversely then analyzed using a microscope with a 50x lens magnification as shown in figure 6.

Figure 6. Photomicrobial metal additive coating.

Figure 6 compare the metal protected by extract as an inhibitor and the metal protected by extract as an additive coating. Metals protected by additives coating have a smaller overdraft. The thin layer that coats the metal looks more evenly distributed. At 50x magnification for the two metals, corrosion is not too severe. Corrosion time of 3 days for aluminum metal looks more corrosion resistant than ferrous metal. Aluminum metal in neutral conditions (pH 6-8) forms a passive layer of Al(OH)$_3$ or Al$_2$O$_3$.xH$_2$O.

4. Conclusions and suggestions

4.1. Conclusions
Turmeric extract with antioxidant content in methanol solvent produces higher antioxidant levels than the extract results in acetone solvent in the ratio of 2: 1. The use of turmeric extract as an Al metal additive coating in seawater media showed that the addition of 1% extract showed the lowest corrosion rate of 0.0011 mmpy with 88.89% protection efficiency and was able to last for 8 days.

4.2. Suggestions
The following research can be continued with the maceration process using a solvent that is more dissolving turmeric extract. The product of turmeric extract obtained can be converted into powder form for ergonomics using corrosion control. Corrosion control media can be done on other media variations to obtain more corrosion data and find out the best inhibitor efficiency and protection efficiency, for example in freshwater conditions.
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