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Study of Mixing Purple Sweet Potato and Turmeric Extract as Green Corrosion Inhibitor for API-5L in NaCl 3.5% Environment

Arie Wijaya[1], Johny Wahyuadi Soedarsono[2], Aldi Putra Laksana[3]
[1,2,3]Department of Metallurgy and Materials, Faculty of Engineering, Universitas Indonesia
[*]Corresponding author, e-mail: arie.wijaya@ui.ac.id

Abstract— Green inhibitors have become a major option for corrosion prevention since people are more aware of environmental damage. Chemical inhibitors are indeed more powerful at preventing corrosion, but its side effects are very harmful to the environment. Purple sweet potato (Ipomoea batatas L) in single use has been proven as an active inhibitor for certain applications. To improve this property, purple sweet potato is used as a mixed with other plants that contain antioxidant agents, such as ginger, melinjo, turmeric, jeera, etc. This paper discussed the effect of applying mixed extract of purple sweet potato with turmeric (Curcuma longa) as a green inhibitor to corrosion rate of API 5L steel in a 3.5% NaCl environment. Turmeric extract contains curcumin and kaempferol antioxidants while purple sweet potato extract contains antocyanin antioxidants. Corrosion rates were analyzed based on weight loss and polarization methods. The results showed the highest inhibitor efficiency was 82.54% achieved by 16 ml of turmeric mixed with 2 ml of purple sweet potato, and the optimum inhibitor efficiency was 74.2% achieved by 8 ml of turmeric mixed with 6 ml of purple sweet potato.

Keyword: corrosion inhibitor; corrosion rate; green inhibitor; inhibition efficiency; purple sweet potatoes extract; turmeric extract

INTRODUCTION

In the oil and gas industry, pipelines are critical equipment used in the distribution of liquid or gas. Pipelines shall be maintained to prevent failure during operation which contributes to environmental issues, safety, and incredibly expensive cost. The failures can be from internal corrosion due to corrosive fluids service in the pipe. It is well known that the effective way to control internal corrosion is by using an inhibitor. Presently, much research focus on development of efficient and echo environmental friendly corrosion inhibitors. Diversity in the source is one of the reasons that made green inhibitors are widely selected. Furthermore, their availability is guaranteed since green inhibitors are developed form antioxidant agents wherein contained in the natural plants.

Permana et.al. (2013) have studied the inhibition of corrosion at carbon steel material in 3.5% NaCl of Pluchea indica Less leaves extract (PILLE) using weight loss and polarization as an investigation methods. The study reveals percentage of inhibition increased as corrosion inhibitor increased. The corrosion test showed the Pluchea indica less leaves are classified as mixed type corrosion inhibitors. Fourier transform infrared (FTIR) spectroscopy results of adsorbed film on LCS surface containing PILLE show that in changes in the functional group frequencies of the organic component of the extract. Azmi et al. (2018) have studied inhibition of API 5L X42 carbon steel in 1M HCl of Bawang Dayak (Eleutherine Americanna Merr.). The results show that the molecule from green inhibitor Bawang dayak able to inhibits the hydrogen evolution and the anodic dissolution processes with highest inhibition efficiency at 1000 ppm was 84.5%. Kaban et al. (2018) have studied inhibition of carbon steel materials (API-5L gr.B) using Secang heartwood as corrosion inhibitor at 3.5% NaCl environment reveals the inhibitor adequate to reduce corrosion rate by 53.18% efficiency based on polarization measurement. Soedarsono et al. (2018) showed that Curcuma Xanthorriza extract is a good inhibitor for API 5L X42 carbon steel materials in 1M HCl solution. Curcuma xanthorrhiza acts as a mixed type inhibitor by absorbing the molecules on the metal surface. The highest inhibition efficiency 97% was obtained with the addition of 1000 ppm inhibitor in the potentiodynamic polarization. Subekti et al. (2020) investigations showed Areca flower extract

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able to decrease corrosion rate of API 5L Gr. B steel in 1 M HCl environment with optimum efficiency of linear polarization testing of 89.14%. The Areca flower extract adsorbed onto the metal surface as metal barrier between the steel surface and acidic environment by physical adsorption (physisorption). Kaban et al. (2021) have studied phenolic compounds in the white tea can be used as a green corrosion inhibitor and reduces the corrosion rate 85% of mild steel in 1 M Hydrochloric Acid Solutions. The thermodynamics calculations show phenolic compounds in white tea are chemisorption type inhibitors and adhere to Langmuir isotherm adsorption mode. Nugroho et al. (2011) found that applying purple sweet potato extract on a 3.5%NaCl environment lowers the corrosion rate of carbon steel to 79.4%. While Fachri et al. (2011) in their investigation found that the maximum efficiency of applying purple sweet potato in 60^0C saltwater environment in analyzing corrosion rate of carbon steel was 21.02%. Listanto et al. (2011) investigation showed that purple sweet potato tends to reduce the corrosion rate of SPCC steel in demineralization-water as the concentration increase. kbar et al. (2011) purple sweet potato lowers the corrosion rate of SPCC steel to 24.83% when carbon monoxide is injected into the demineralization water. Putra et al.(2011) studied inhibition efficiency of purple sweet potatoes as corrosion prevention for low carbon steel in a strong acid environment. The result showed the maximum inhibition efficiency is 84.88% with 12 days of submersion time. Ayende et al. (2013), Ayende et al. (2015) study concluded that among mangosteen skin extract, sapodilla skin extract, and purple sweet potato extract. The purple sweet potato had the highest inhibition efficiency. They also concluded that inhibition efficiency of purple sweet potato was the closest compared to inhibition efficiency of chemical inhibitors. All the research used purple sweet potato extract as a single source for the inhibitor.

Several researches have been conducted to observe the inhibition effect of purple sweet potato when it is applied together with other inhibitors. Ayende et al. (2015), Ayende at el. (2014) found the inhibition efficiency increased from 23.5 to 57.52% in a 3.5% NaCl environment by addition of 4 ml purple sweet potato and mixed with 10-4 M ascorbic acid due to formation of iron chelate. While Soedarsono et al. (2015) concluded that in the right combination of concentrations between purple sweet potato and melinjo have inhibitory efficiency of 78%.

If purple sweet potato contains anthocyanin, turmeric (Curcuma longa) is rich with curcumin and kaemferol. Johnsirani et al. (2013) in their research found that inhibition efficiency of 10 ml of turmeric in sea water environment is 79.5%. This research studied the effect of applying turmeric with purple sweet potato as mixed inhibitor for API 5L steel in 3.5%NaCl environment.

METHOD

Purple sweet potato extract and turmeric extract were applied as inhibitors to API 5L in a 3.5% NaCl environment. Both extracts are applied separately and mixed. Weight loss and polarization are used to investigate corrosion rate and mechanism of corrosion. The experiment was divided into 3 conditions in the first condition; both extracts were used separately. In the second condition, the concentration of turmeric was steady in 16 ml, while the concentration of purple sweet potato increased. This is also applied to the third condition except that turmeric concentration increases while purple sweet potato remains steady in 2 ml. The conditions of the experiment are presented in Table 1.

Table 1. Experimental Condition

Category	Sample Code	Extract Addition ml/100ml	
		Purple Sweet Potato	Turmeric
Group 1	1F	0	0
	1A	10	0
	2A	0	10
	3A	2	16
	4A	4	12
	5A	6	8
Group 2	6A	1	16
	7A	3	
	8A	4	
Group 3	9A	2	8
	10A		12
	11A		20

To avoid mistaking in data recording, abbreviations for each inhibitor are also listed in the sample coding. SW stands for purple sweet potato and T stands for turmeric. The concentration of each inhibitor is also attached

RESULT AND DISCUSSION

Experiment results from both weight loss and polarization methods for corrosion rate and inhibitor

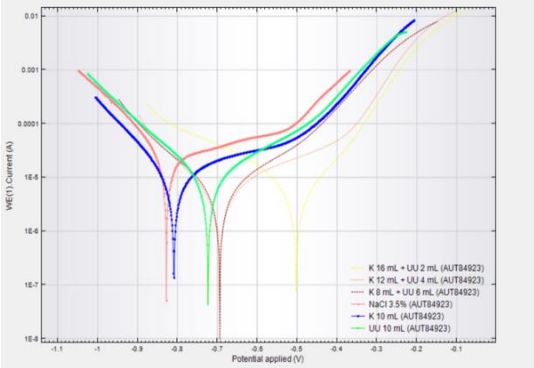

Figure 1a. Polarization Curve of Mixed Inhibitor

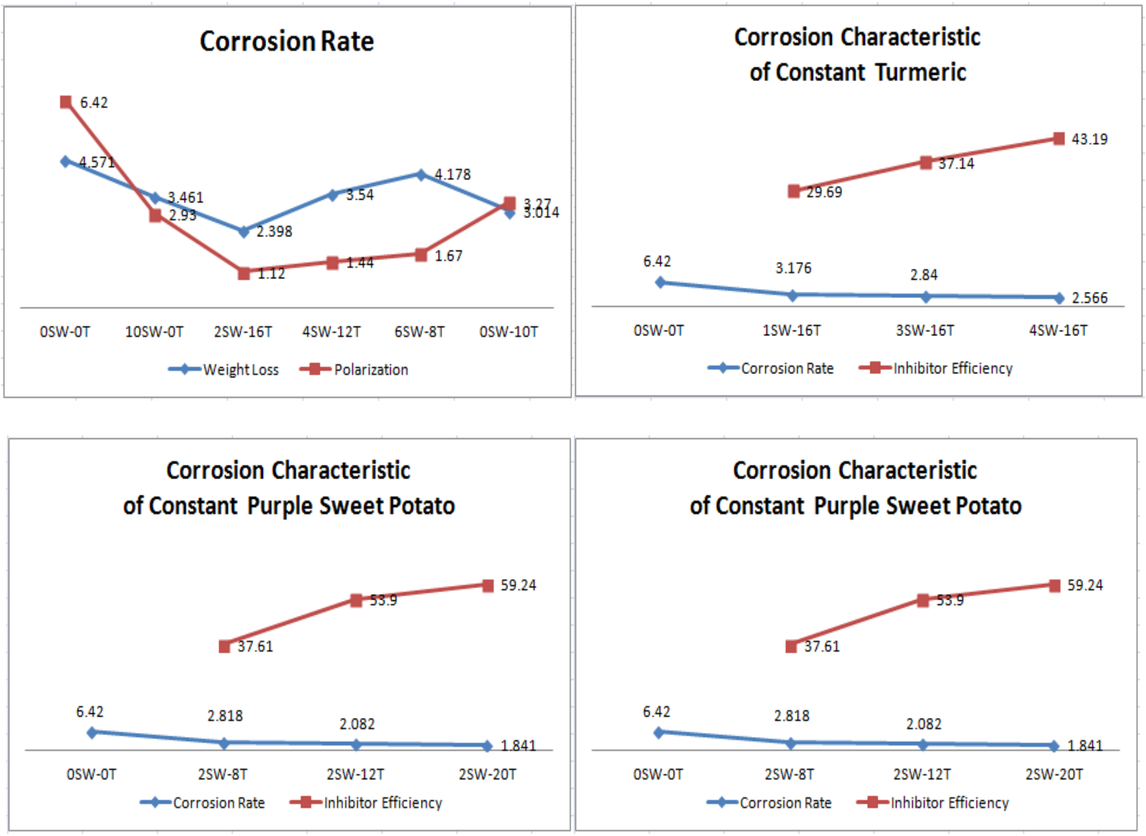

Figure 1b. Corrosion Characteristics

efficiency are presented in Fig. 1a and Fig 1b. Applying 10 ml of purple sweet potato reduces corrosion rate to 24% based on weight loss analysis and 54% based on polarization analysis. While applying 10 ml of turmeric reduces corrosion until 34% (weight loss analysis) and 49% (polarization analysis). While the inhibitor efficiency of each inhibitor is 23% based on weight loss analysis and 54% based on polarization analysis for 10 ml of purple sweet potato and 33% based on weight loss analysis and 49% based on polarization analysis for 10 ml of turmeric. Both analyses show a similar trend that is corrosion rate increases as both inhibitors concentration increases.

Based on polarization analysis, corrosion rate of 10 ml purple sweet potato is 11% lower than 10 ml of turmeric; but the result with weight loss analysis is reversed. In weight loss analysis corrosion rate of 10 ml purple sweet potato is 13% higher than 10 ml of turmeric. When the purple sweet potato was mixed with turmeric, corrosion rate increased as concentrations of purple sweet potato increased while concentrations of turmeric decreased for both analysis methods. Based on polarization analysis, all corrosion rates of mixed inhibitors are lower than the corrosion rates of the single inhibitors, but different results are shown by weight loss analysis. In weight loss analysis, two concentration of mixed inhibitor have higher corrosion rate than purple sweet potato and turmeric.

Corrosion rates decreased as purple sweet potato concentrations increased in a steady turmeric concentration. While inhibitor efficiency is increased as purple sweet potato concentration increases in a steady turmeric concentration. A similar trend also happened in conditions of steady purple sweet potato concentrations. Comparing both results showed that turmeric gives more effect than purple sweet potato in mixing condition. The highest inhibition efficiency was found in the mixing of 2 ml purple sweet potato with 16 ml of turmeric, clarified with EIS examination was conducted to find alteration in surface resistance of API 5L steel in a 3.5% NaCl environment (Fig. 2).

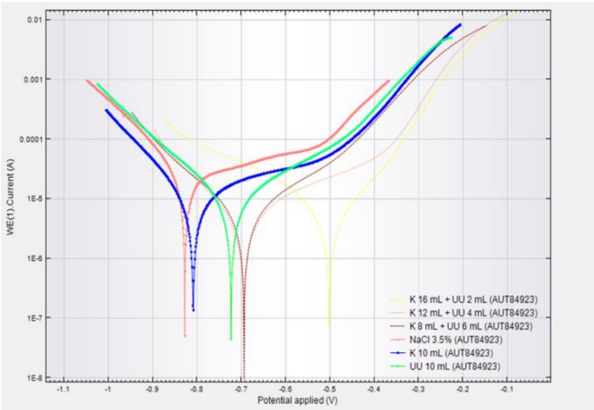

Figure 2: EIS Curve of Mixed Inhibitor

Comparing this research with the work of Ayende et al. (2015), Ayende et al. (2014) shows that mixing purple sweet potato with turmeric gives higher inhibitor efficiency (29.69 to 82.54%) than mixing purple sweet potato with ascorbic acid (23.50 to 57.52%). When compared to the results of Soedarsono et al. (2015) then mixing purple sweet potato with turmeric still gives higher inhibitor efficiency than mixing purple sweet potato with melinjo (31.29 to 78.12%). Mixing sweet purple potato with turmeric is more effective compared to mixing purple sweet potato with melinjo because in all mixing concentrations the inhibitor ability are higher than the single used. This is also confirmed that purple sweet potato and turmeric support each other. As for the kind of steel being protected by purple sweet potato, the efficiency for low carbon steel (79.4%) is higher than with API 5L steel (54.36%) (Nugroho et al., 2011). Higher inhibitor efficiency (84.88%) is gained in the work of Putra for low carbon steel in strong acid environments (Putra et al.,2011).

The mixed inhibitor efficiency of purple sweet potato with turmeric is higher compared to rosella (13.2%) Saputra et al. (2011), red spinach (73.30%) Darmawan et al. (2012), banana peel (71%) Sangeetha M et al. (2012), false daisy, or eclipta alba (65%) Johnsirani V et al. (2013), asafetida (71%) Sangeetha et al. (2012). But lower when compared with mangoosten skin (92.68%) Rachmanda et al. (2013) and jeera (93%) Sribharathy et al. (2013). The inhibitor efficiency of mixed purple sweet potato with turmeric is similar to ginger (84%) (Fouda et al.(2013)

CONCLUSION

The weight loss analysis method gave different results than polarization. In weight loss analysis, inhibitor efficiency of turmeric was 42% higher than purple sweet potato. While based on polarization analysis methods inhibitor efficiency of purple sweet potato is 10% higher than turmeric. Generally, the inhibitor efficiencies of mixed inhibitors are higher than the single use of each inhibitor. This shows that turmeric and purple sweet potato support one another. The highest inhibitor efficiency was 82% reached in the concentration of 2 ml purple sweet potato with 16 ml turmeric. The optimum inhibitor efficiency is 74.2% achieved by 8 ml turmeric mixed with 6 ml purple sweet potato. The influence of turmeric in steady purple sweet potato is more powerful compared to the influence or purple sweet potato in steady turmeric.

Compared with another purple sweet potato mixed inhibitor, the mixed between purple sweet potato with turmeric gives the highest inhibitor efficiency.

REFERENCES

Akbar, M.I., & Soedarsono, J.W. (2011). Studi pengaruh waktu rendam ekstrak ubi ungu sebagai Green Corrosion Inhibitor untuk material baja karbon rendah (SPCC) pada lingkungan air demineralisasi yang diinjeksikan karbon dioksida (CO2). Thesis, Depok, Departement of Metallurgy and Material, Fac. Eng. Univ. of Indonesia.

Ayende, Rachmanda. F., Soedarsono, J.W., Priadi, D., and Sulistijono, S. (2013). "Corrosion Behaviour of API-5L in Various Green Inhibitors", *Advanced Materials Research*, vol. 634-638, pp. 689-695.

Ayende, Rustandi, A., Soedarsono, J.W., Priadi, D., Sulistijono, Suprapta, D.N., Priyotomo, G., & Bakri, R. (2015). "Effect of Purple Sweet

Potato Extract Addition in Ascorbic Acid Inhibitor to Corrosion Rate of API 5L Steel in 3.5% NaCl Environment", *Applied Mechanics and Materials*, vol. 709), pp. 384-389.

Ayende, Rustandi, A., Soedarsono, J.W., Priadi, D., Sulistijono, Suprapta, D.N., Priyotomo, G., & Bakri, R. (2015). "Effect of Purple Sweet Potato Extract Addition in Ascorbic Acid Inhibitor to Corrosion Rate of API 5L Steel in 3.5% NaCl Environment", *Applied Mechanics and Materials*, vol. 709), pp. 384-389.

Ayende, Rustandi, A., Soedarsono, J.W., Priadi, D., and Sulistijono. (2014). "Interaction of Purple Sweet Potato Extract with Ascorbic Acid in $FeCl_3$ Solution," *Applied Mechanics and Material*, vol. 680, pp. 32-37, 2014.

Azmi, M. F., & Soedarsono, J. W. (2018). Study of Corrosion Resistrance of Pipeline API 5L X42 using Green Inhibitor Bawang Dayak (eleutherine americanna Merr.) in 1M HCL. *IOP Conference Series: Earth and Environmental Science*, *105*, 012061.

Azmi, M. F., & Soedarsono, J. W. (2018). Study of Corrosion Resistrance of Pipeline API 5L X42 using Green Inhibitor Bawang Dayak (eleutherine americanna Merr.) in 1M HCL. *IOP Conference Series: Earth and Environmental Science*, *105*, 012061.

Darmawan, O., & Soedarsono, J.W. (2012). Studi Green Corrosion Inhibitor Ekstrak daun Bayam merah amaranthus gangeticus) pada baja karbon rendah dalam larutan 1M HCl dengan metode polarisasi dan EIS. Thesis, Depok, Departement of Metallurgy and Material, Fac. Eng. Univ. of Indonesia.

Fachri, A., & Soedarsono, J.W. (2011). Studi pengaruh konsentrasi ubi ungu sebagai green inhibitor pada material baja karbon rendah di lingkungan air laut pada temperatur 60^0C. Thesis, Depok, Departement of Metallurgy and Material, Fac. Eng. Univ. of Indonesia.

Fouda, A. E.-A., Nazeer, A. A., Ibrahim, M., & Fakih, M. (2013). Ginger extract as green corrosion inhibitor for steel in sulfide polluted salt water. *Journal of the Korean Chemical Society*, *57*(2), 272–278.

Johnsirani,V., Sathiyabama.J., Rajendran, S., Christy, S.M.L., and J. Jeyasundari, J. (2013) "The Effect of Eclipta Alba Leaves on the Corrosion Inhibition Process of Carbon Steel in Sea Water," *Portugaliae Electrochimica Acta*, vol. 31 No. 2, pp. 95-106.

Kaban, A. P., Ridhova, A., Priyotomo, G., Elya, B., Maksum, A., Sadeli, Y., Sutopo, S., Aditiyawarman, T., Riastuti, R., & Soedarsono, J. W. (2021). Development of white tea extract as green corrosion inhibitor in mild steel under 1 m hydrochloric acid solution. *Eastern-European Journal of Enterprise Technologies*, *2*(6 (110), 6–20.

Kaban, E. E., Maksum, A., Permana, S., & Soedarsono, J. W. (2018). Utilization of secang heartwood (Caesalpinia sappan l) as a green corrosion inhibitor on carbon steel (API 5L GR. b) in 3.5% nacl environment. *IOP Conference Series: Earth and Environmental Science*, *105*, 012062.

Listanto, C., & Soedarsono, J.W. (2011). Studi pengaruh konsentrasi penambahan sirup ubi ungu sebagai inhibitor organik untuk material baja SPCC pada air demineralisasiI dengan injeksi CO2, Thesis. Depok, Departement of Metallurgy and Material Fac. Eng. Univ. of Indonesia.

Nugroho, A., & Soedarsono, J.W. (2011). Study of potato peel (Solanum tuberosum L.) extract as green corrosion inhibitor on low carbon steel in 3,5% NaCl environment. Thesis. Depok, Departement of Metallurgy dan Material, Fac. Eng. Univ. of Indonesia.

Putra, R.A., & J.W. Soedarsono. (2011) Study of combination between purple sweet potato and turmeric extract as corrosion inhibitor for API 5L steel pipe in NaCl 3.5 % environment, Thesis, Depok, Departement of Metallurgy and Material, Fac. Eng. Univ. of Indonesia.

Pramana, R. I., Kusumastuti, R., Soedarsono, J. W., & Rustandi, A. (2013). Corrosion inhibition of low carbon steel by Pluchea indica less. in 3.5% NaCL solution. *Advanced Materials Research*, *785-786*, 20–24.

Sangeetha, M., Rajendran, S., Sathiyabama, J., & Prabhakar, P. (2012). Eco Friendly Extract of Banana Peel as Corrosion Inhibitor for Carbon Steel in Sea Water. *J. Nat. Prod. Plant Resour., vol. 2, No. 5, pp. 601-610.*

Sangeetha, M., Rajendran.S., Sathiyabama. J., & Prabhakar. P. (2012). Asafoetida Extract (ASF) as Green Corrosion Inhbitor for Mild Steel in Sea Water, I*nt. Res. J. Environment Sci*., *vol. 1, No. 5, pp. 14-21*.

Saputra, R., & Soedarsono, J.W. (2011). Studi pengaruh konsentrasi ekstrak teh rosella (Hibiscus Sabdariffa) sebagai Green Corrosion Inhibitor untuk material baja karbon rendah di lingkungan NaCl 3,5% pada temperatur 40 derajat celsius. *Thesis, Depok, Department of Metallurgy dan Material, Fac. Eng. Univ. of Indonesia*.

Sangeetha, M., Rajendran.S., Sathiyabama. J., & Prabhakar. P. (2012). Asafoetida Extract (ASF) as Green Corrosion Inhbitor for Mild Steel in Sea Water, I*nt. Res. J. Environment Sci*., *vol. 1, No. 5, pp. 14-21*.

Rachmanda, F., & J.W. Soedarsono, J.W. (2013). Study of effect of pericarp of mangoosten (Garcinia mangostana) extract as a corrosion inhibitor for API-5L pipe steel in produced water environment, Thesis, Depok, Departement of Metallurgy and Material, Fac. Eng. Univ. of Indonesia.

Soedarsono, J.W., & Felix. (2015). "Study of the mixing concentration of melinjo Gnetum gnemon extract and purple sweet potato Ipomoea batatas extract as corrosion inhibitors for API 5L steel in NaCl 3.5% solutions." Thesis, Depok, Departement of Metallurgy and Material, Fac. Eng. Univ. of Indonesia.

Subekti, N., Soedarsono, J. W., Riastuti, R., & Sianipar, F. D. (2020). Development of environmental friendly corrosion inhibitor from the extract of areca flower for mild steel in acidic media. *Eastern-European Journal of Enterprise Technologies*, *2*(6 (104), 34–45.

Sribharathy, V., & Rajendran, S. (2013). Cuminum cyminum extracts as eco-friendly corrosion inhibitor for mild steel in seawater. *ISRN Corrosion*, *2013*, 1–7.