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Extract of Cocor Bebek (*Kalanchoe pinnata*) as a Corrosion Inhibitor

Tri Reksa Saputra✉, **Agustinus Ngatin**

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Jurusan Teknik Kimia Politeknik Negeri Bandung Jl. Gegerkalong Hilir, Ds. Ciwaruga Kotak Pos 1234 Bandung 40012

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Abstract

In this study, Cocor Bebek leaves (*Kalanchoe pinnata*) extract is studied for metal corrosion inhibitor. 10.3 kg of *K. Pinnata* leaves produce concentrated extract of methanol, n-hexane and ethyl acetate as much as 65.7442, 36.1452, and 15.2711 g respectively. The concentrated extracts were then used to determine the rate of corrosion. Corrosion rate test showed that extract of ethyl acetate can reduce corrosion rate of carbon steel in NaCl 3.5% from 2.954 mpy to 0.963 and 0.923 mpy using 500 ppm and 1000 ppm of extract consecutively. Corrosion rate of Cocor Bebek extract at addition of 500 ppm ethyl acetate in the solution of NaCl 3.5% is decreasing immediately. It was found that the carbon steel corrosion rate decrease as much 4.857 for 6 hours and continuously shows sharp decline until 24 hours of corrosion time. Corrosion rate is slowly decreasing till reach 1.694 mpy at corrosion time of 168 hours.

INTRODUCTION

Corrosion is a material deterioration due to electrochemical processes between metal and its environment which involve electron transfer from anode to cathode (Jones, 1992). Damage on the corroded materials is shown by cracked on its surface also change of color signify its fragility and able to pollute the environment. Industrial activity also takes part in metal corrosion since it produce a corrosive exhaust gas.

Commonly used corrosion control methods are metal coating, cathode protection, additional of corrosion inhibitor and so on. Corrosion inhibitor is a substance that usually added in environment at small amount to retard metal corrosion process. Generally, corrosion inhibitor come from organic and inorganic compounds containing pair of free electron such as nitrite, chromate, phosphate, urea, phenylalanine, imidazoline and any other amine compounds. However, this synthetic chemical is hazardous to both living creatures and environments, and also expensive from the economical perspective. Due to these reasons, we need to provide a cheap, bio-degradable, non-toxic and environmentally friendly inhibitor. One of the solution is by utilizing organic materials such as extract of natural resources (Haryono et al., 2010).

There are so many natural resources are existed around us such as plants, animals and microorganisms. However, plants have been widely used as research material. Hence, numerous studies focuses on the various plants compounds especially secondary metabolite compounds. Secondary metabolites are used as poisonous compound to defend themselves, attractants for their own type or as a dying agent to attract another species (Dewick, 2009). This facts support that secondary metabolite products are potentially used as medicine, natural insecticide, science material and also many other industrial needs (Harbourne,

✉Corresponding author:
Jurusan Teknik Kimia Politeknik Negeri Bandung
Jl. Gegerkalong Hilir, Ds. Ciwaruga Kotak Pos 1234 Bandung 40012
E-mail: tri.reksa@polban.ac.id

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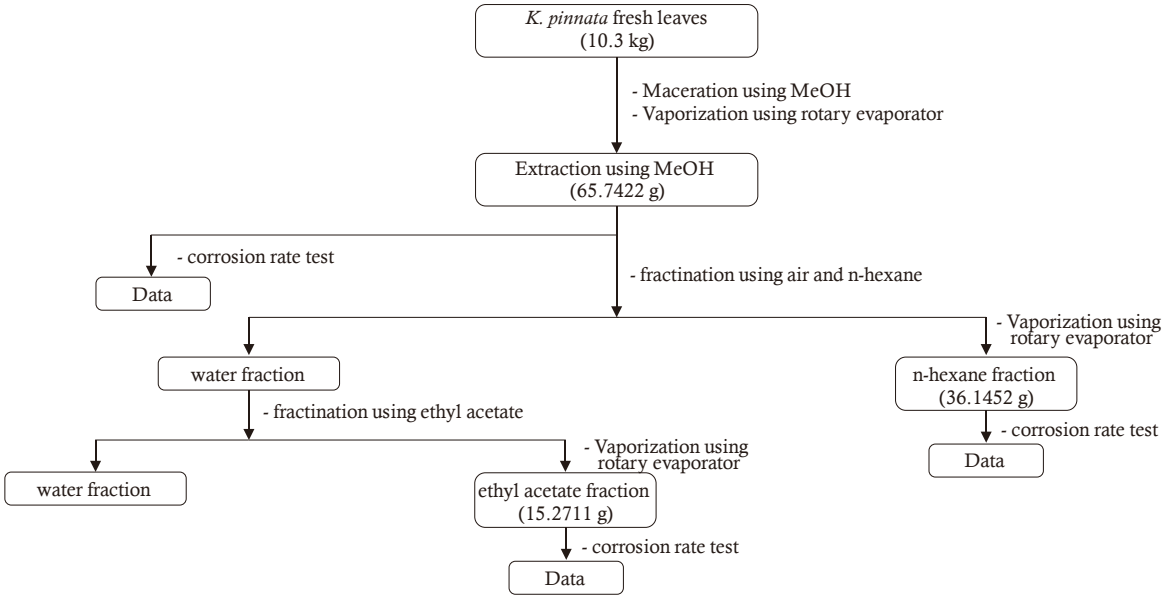

Figure 1. Flow diagram of the research.

1987). These secondary metabolites also usually used as research material either in eco-friendly industrial field or pharmaceutical industry.

Cocor Bebek (*Kalanchoe pinnata*) is one of commonly used plant as a research material. This plat is popularly used as traditional medicine and ornamental plant. Previous studies focused on secondary metabolites isolation as model compounds, bioactivity test result showed the existence of nitrogen, oxygen and any other atoms with pairs of free electron (Biswas et al., 2011). The elements with pairs of free electron are served as ligand to form complex compound with metal. The effectivity of organic inhibitor from Cocor Bebek leaves in decreasing metal corrosion rate is studied in this research.

RESEARCH METHODOLOGY

This research uses true experimental methods which consist of leaves collection, maceration using methanol (MeOH), evaporation, fractionation using n-hexane and ethyl acetate (EA) eluents to produce concentrated extract from those three fractions. All these fractions were then tested on carbon steel for corrosion rate test. The steps involved in this research is shown in Figure 1.

10.3 g of Cocor Bebek fresh leaves were macerated and extracted with methanol for 3x24 hours at room temperature and then evaporated using a rotary evaporator at ± 40 °C, which resulted in 65.7442 g leaves extract. These extracts were then fractionated using n-hexane and water resulting n-hexane and water fraction. Water fraction was subsequently separated using ethyl acetate into ethyl acetate and water fraction. Final fractionation products were then evaporated using rotary evaporator to obtained 36.1452 of n-hexane extract and 15.2711 ethyl acetate extract.

Concentrated extract of methanol, ethyl acetate and n-hexane were then tested its corrosion rate at carbon steel plate using NaCl 3.5% medium. NaCl 3.5% was chosen as a medium to obtain similar salinity condition of seawater. Corrosion test parameters used in this study were extract concentration (100, 250, 500, 750 and 1000 ppm) and corrosion time (6 hours, 1, 2, 3, 4 and 7 days). The results were then compared to the blank sample (carbon steel without extract addition at the same parameter) to obtain optimum condition from extraction and corrosion process.

RESULTS AND DISCUSSIONS

Concentrated Cocor Bebek leaves extract (methanol, ethyl acetate and n-hexane) have been tested as carbon steel inhibitor in 3.5% NaCl medium. Corrosion rates of carbon steel at different extract type and concentration are shown in Figure 2.

Figure 2 shows that carbon steel corrosion rate in NaCl 3.5% medium is decreasing as a function of inhibitor concentration. Corrosion rate (MPY) of carbon steel was calculated using weight loss measurement method as shown in Equation 1

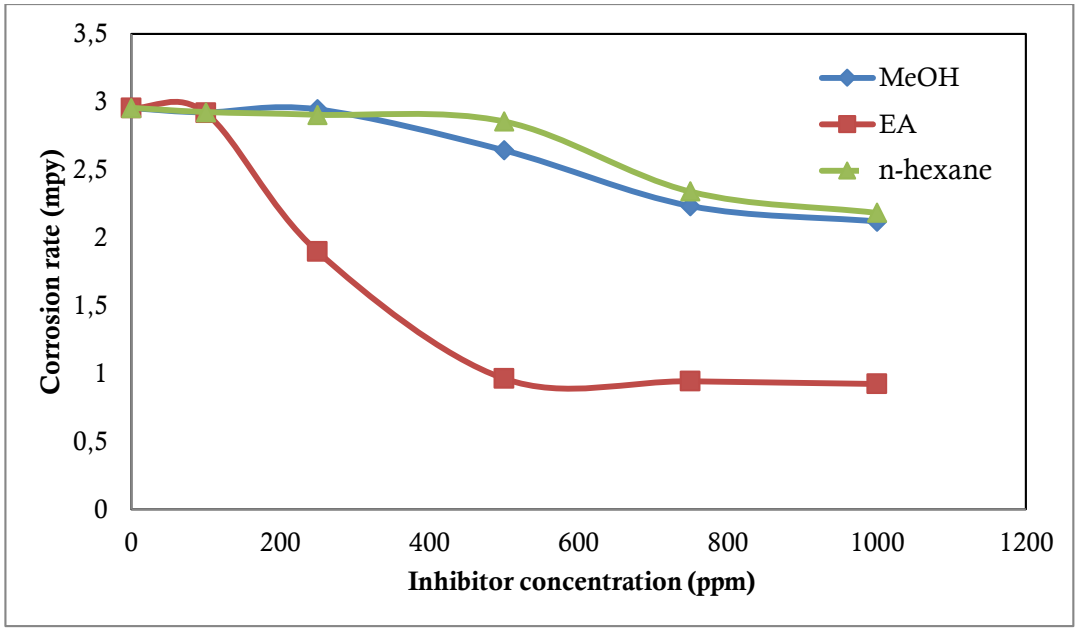

Figure 2. Effect of inhibitor concentration on the carbon steel corrosion rate

$$MPY = (534\ w)/ (DAT) \quad (1)$$

Where w is weight difference/weight loss (g), D is density (g/cm^3), A is corroded metal surface area (in^2) and T is corrosion time (hour). From Figure 2 it can be seen that extract with ethyl acetate solvent able to decrease corrosion rate of carbon steel compared to extract from methanol and n-hexane. This is caused by the polarity characteristic difference of those three solvents. Ethyl acetate has medium polarity (semi polar), while n-hexane is non-polar solvent and methanol is polar. Solvent polarity will influence polarity of compound in the extract. Since polar solvent will dissolve polar compound while non-polar solvent dissolve non-polar compound inside Cocor bebek leaves.

This results are supported by previous research results on the isolation of Cocor bebek leaves compounds. Compounds with bioactivity mostly found at extract with medium polarity in this case is extract which use ethyl acetate solvent (Biswas et al., 2011; Okwu & Nnamdi, 2011). The results show that extracts in ethyl acetate was easily dissolved with NaCl solution compared to extract in methanol and n-hexane. The extract in ethyl acetate can decrease carbon steel corrosion rate in NaCl 3.5% medium from 2.954 mpy to 0.963 mpy at 500 ppm of extract addition. While, addition of 1000 ppm Cocor bebek extract reduce corrosion rate into 0.923 mpy. Relationship between Cocor bebek leaves extract from three different solvents (ethyl acetate, methanol and n-hexane) efficiency as carbon steel inhibitor in NaCl 3.5% to extract concentration is shown in Figure 3.

Figure 3 shows that Cocor bebek extract which used ethyl acetate has higher efficiency rather than methanol and n-hexane extract efficiency. It shows that extract with ethyl acetate solvent contains strong electrolyte compounds which easily mixed with NaCl solution. Compounds in this extract will be able to inhibit or protect carbon steel from corrosion. The inhibition process will reduce corrosion rate and increase extract efficiency. As shown in Figure 3, inhibitor efficiency of Cocor bebek leaves extract is around 68% at extract concentration of 500 ppm to 1000 ppm.

Previous studies with cocor bebek leaves focused on the isolation of secondary metabolite compound as model compound and bioactivity test such as flavonoid, alkaloid and steroid. Cocor bebek extract compounds are an organic compound which is containing mixed compound. Generally, it has pairs of free electron inside the molecule. In the presence of free electron pair, organic compound will be adsorbed chemically on the carbon steel surface effectively (Jones, 1992). Chemical adsorption process of organic molecule is a polar group from molecule structure that attacks carbon steel surface and reacts with Fe^{2+} ion to form coordinate covalent bond which later on become a film or thin layer that protects carbon steel from corrosive environment (Asdim, 2008). This will decrease the carbon steel rate of corrosion. The most effective polar group is a polar group that

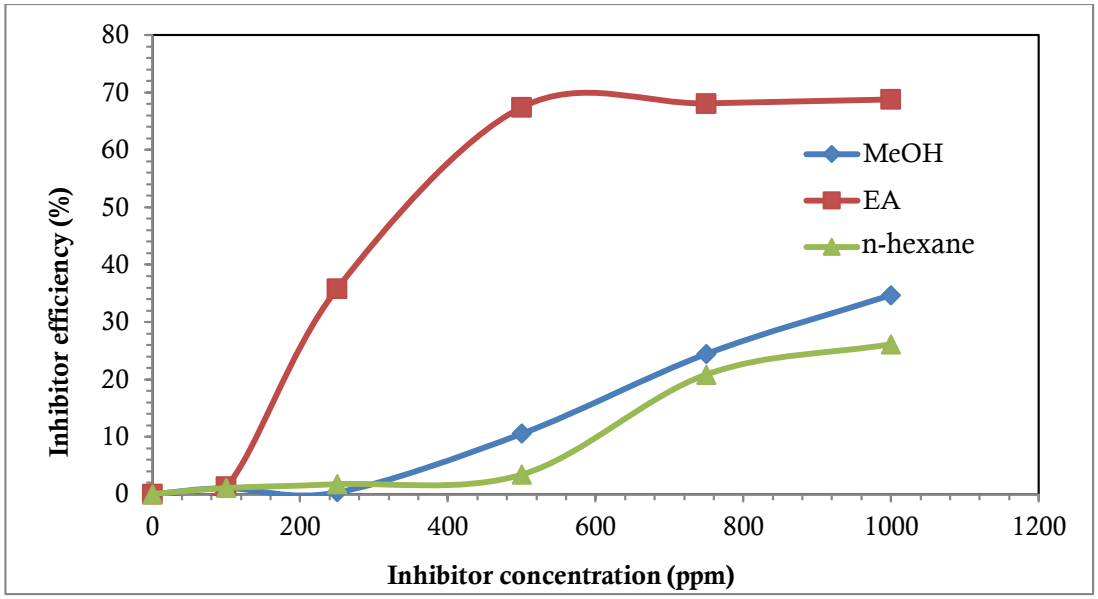

Figure 3. Effect of inhibitor concentration on the inhibitor efficiency.

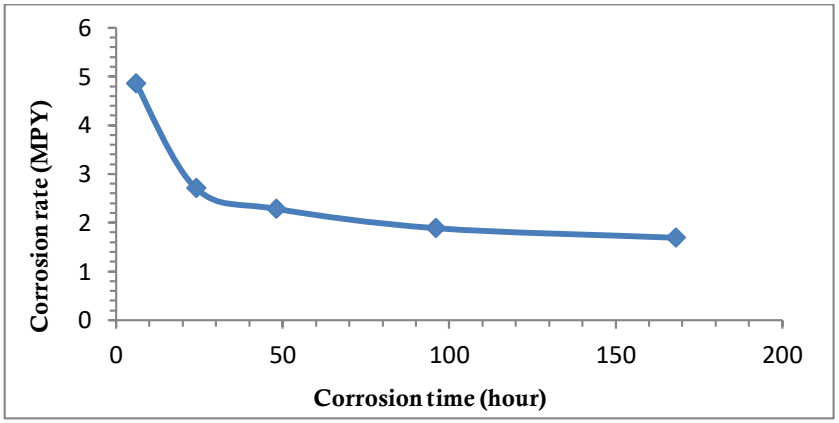

Figure 4. Carbon steel corrosion rate as a function of corrosion time.

involves sulfur, nitrogen, hydroxyl (such as pyridine, imidazoline). Inhibiting character of organic molecule effectivity due to the bigger size of the molecule, symmetry, higher molecular weight and higher electron density (Jones, 1992).

Based on the results shown in Figure 3, Cocor bebek extract with ethyl acetate solvent has the highest extract efficiency. This extract was then further studied for its application in inhibiting carbon steel in NaCl 3.5% medium. Figure 4 shows the relationship between rates of corrosion to corrosion time.

Figure 4 shows that corrosion rate of carbon steel with addition cocor bebek extract in NaCl 3.5% medium will decrease as a function of corrosion time. It proofs that cocor bebek extract contain chemical substance as carbon steel corrosion inhibitor. At corrosion time of 6 hours, carbon steel corrosion rate is very high around 4.857 mpy and decrease sharply until corrosion time of 24 hours. As a function of corrosion time, corrosion time is slowly decreasing until it reach 1.694 mpy at 168 hours of corrosion time. In the beginning of corrosion process, Fe (carbon steel) is dissolved in the anode and cathode to become Fe^{2+}. The longer corrosion time, Fe^{2+} will react with hydroxyl ion to form passive molecule of $Fe(OH)_2$ (Fitria, 2013). Chemical substances inside cocor bebek extract also going to be adsorbed and form a covalent coordinate that will coat carbon steel surface with passive layer. This explained the reason for slowly decreased of corrosion rate in carbon steel corrosion process (Harrop, 1990).

CONCLUSION

Cocor bebek extract with ethyl acetate as solvent able to reduce carbon steel corrosion rate in the NaCl 3.5% medium from 2.954 mpy to 0.963 and 0.923 mpy using 500 ppm and 1000 ppm of

extract consecutively. Corrosion rate of carbon steel with addition of 500 ppm cocor bebek extract decreases over corrosion time.

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