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THE ANALYSIS OF PANDAN LEAF (*Pandanus amaryllifolius Roxb*) EXTRACT AS INHIBITOR ON CORROSION RATE OF STAINLESS STEEL ORTHODONTIC WIRE

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ABSTRACT

Background*: Corrosion is a physical phenomenon that occurs due to electrochemical reactions between the metal and its environment which can lead to decreased quality of the metal so it becomes rough, fragile and easily wrecked. The cause of corrosion is the release of ion that occur due to the interaction of the wire to the environment with acid pH and friction between one component with other components.* ***Purpose:*** *This research aims to analyze pandan leaf extract as an inhibitor in reducing the corrosion rate of stainless steel wire.* ***Methods****: This type of research includes true experimental design with post test only control group design. The subject of this research consisted of three group: one control group and two treatment groups. The stainless steel wire control group was immersed in a saline solution, the stainless steel wire treatment group was immersed in the extract of 600 ppm and 1000 ppm pandan leaf. Each group consisted of 10 samples of scratched stainless steel wire along the wire, which is was cut 5 cm long and immersed in a solution od saline along with the extract of pandan.* ***Results:*** *The results showed that the average rate of corrosion of stainless steel wire immersed in the extract of 1000 ppm pandanleaf is was equal to 2,70419x10^{-5} mm/y, the average rate of corrosion of stainless steel wire immersed in the extract of 600 ppm pandan leaf was equal to 6,77152x10^{-5} mm/y and the average rate of corrosion of stainless steel wire immersed in a solution of saline was equal to 1,26262x10^{-5} mm/y.* ***Conclusion****: Based on the results of the research, it can be concluded that the corrosion rate of orthodontic stainless steel wire immersed in the extract of 1000 ppm pandan leaf is lower than the extract of 600 ppm pandan leaf.*

Keywords : *corrosion, pandan leaf extract, stainless steel*

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INTRODUCTION

Malocclusion is an abnormal form of occlusion.[1,2,3] Orthodontic treatment is one of the measures used to treat malocclusion cases, improve phonetic function, mastication and aesthetic function.[4] Generally, the type of device used as orthodontic treatment is divided into orthodontic appliances fixed and removable orthodontic devices. Fixed orthodontic appliances are used for more complex malocclusions. The removable orthodontic appliance is an ortho wire designed to be installed and removed by the patient.[5,6,7]

One type of wire that can be used is stainless steel wire, because it has good mechanical

properties, good strength and flexibility, and also corrosion resistance.[8] The stainless steel orthodontic wire contains of 71% iron, 18% chromium, 8% nickel and 0.2% carbon. Chromium and nickel ions are stainless steel orthodontic wire components which can provide corrosion-resistant effect and increase the strength of the wire. The use of orthodontic wire in the oral cavity may allow the occurrence of corrosion.[9,10]

One effective way that can be done to inhibit the rate of corrosion is the use of inhibitors because of the affordable cost and simple process.[12,13] Corrosion inhibitor is a substance that can inhibit the rate of corrosion of metal structures by adding a small amount of substances into the environment.[14,15] The corrosion inhibitor is divided into two parts, that is organic inhibitor and inorganic inhibitor. Organic inhibitor are the type of environmentally inhibitors and can be obtained from parts of the plant that contains tannin. It forms complex compound that precipitate as a thin protective layer on the metal surface which can inhibit the reaction of metal to its environment.[15,16,17]Organic inhibitor is made from plant extracts that contains atoms, free electron pairs.[17,18]

An example of the organic inhibitors that can inhibit the corrosion rate is pandan leaf. Pandan leaf grow in the tropics, especially in the Asia Pacific region and pandan plants have many benefits for life.[19,21,22] Phytochemical test results on chemical compounds in pandan leaf have been reported by Prameswari and Widjanarko (2014) that positive ethanol extract contains of alkaloids, tannins, flavonoids and polyphenols.[19] Organic compounds in the extract pandan leaf can be used as corrosion inhibitors because they fulfill the characteristics of organic inhibitors such as the presence of heteroatoms, polar groups and π bonds.[18]

Pandan leaf extract was so potential to inhibit the corrosion process of a metal in steel.[18] In a previous study conducted by Saputri et al (2015), the corrosion rate of orthodontic NiTi wire in the group without the addition of wuluh starfruit leaf extract had the highest average corrosion rate, then decreased in the treatment group which had been given the extract at concentration of 600 ppm and 1000 ppm.[20] Based on those background and the absence of research on the analysis of pandan leaf extract as an inhibitor to the corrosion rate of stainless steel orthodontic wire, the researchers is interested to do research about whether pandan leaf extract can reduce the corrosion rate of orthodontic wire made from stainless steel in saline solution with the addition of pandan leaf extract at concentration of 600 ppm and 1000 ppm.

MATERIAL AND METHODS

This research began by making research permit and certificate of Ethical Benefit that made by Faculty of Dentistry, Lambung Mangkurat University no. 002 / KEPKG-FKGULM / EC / VIII / 2017. This research was a pure experimental research with posttest only control group design. Sample in this research was stainless steel orthodontic wire with brand Dentaurum Germany, hard spring type.

The number of samples in this study was calculated by using unpaired numerical analytical formulas, with total of 10 samples of stainless steel orthodontic wire.[31] Sample of stainless steel wire with a length of 5 cm and a diameter of 0.7 mm wire were scratched along the wire, then the wire sample was immersed in a saline solution and soaked in pandan leaf extract with concentration of 600 ppm and 1000 ppm.

The Production of pandan leaf extract (*Pandanus amaryllifolius Roxb)*

The process of extracting began by selecting the appropriate pandan leaves and weighed as much as 1 kg. Pandan leaves that have been cut into small pieces washed with running water and then be aerated until the pandan leaves became semi-dried and put into the oven with a temperature of 40^{o}C. Leaves that had been dried were blended until crushed and sifted to obtain smooth results. The process of maceration of pandan leaves was using 96% ethanol. The sample was soaked, stirred 3 times a day and closed tightly. This maceration process lasted for 3 x 24 hours, then performed filtration to obtain pandan leaf liquid extract and residual pulp that has been filtered by doing the maceration process again. Liquid extract of pandan leaves was evaporated using a rotary evaporator

with a temperature of 50°C and followed by evaporation using waterbath with a temperature of 50°C until obtained viscous extract.

The Dilution of Pandan Leaf Extract (*Pandanus amaryllifolius Roxb*)

The thick **p**andan leaf extract was weighed according to the required concentration that was 600 ppm for 6 g and 1000 ppm for 10 g. Thick pandan leaf extracts were diluted between the saline solution and the viscous the pandan leaves extract. Pandan leaf extract was dissolved in 1L saline solution at a concentration of 600 ppm and 1000 ppm.

Treatment of orthodontic wire

Stainless steel orthodontic wire with a length of 50 cm was scratched along the wire using a diamond fissure bur of 500 rpm speed with a support tool. Stainless steel orthodontic wire had been scratched as deep as 0.03 mm cut along 5 cm.

Corrosion Rate Measurement

Preparation of stainless steel orthodontic wire sample, saline solution, leaf extract and a set of potentiostat tool sets was done. The non-blending saline solution of pandan leaf extract was poured into a 100 ml glass glass and then covered with a three-hole cover as the site of the supporting electrode, the reference electrode and the working electrode. The black port cable was connected to the Pt (platinum) electrode as the supporting electrode and inserted into the glass, then the red port cable was connected to the Ag / AgCl electrode used as the reference electrode and inserted into the glass, then the red port cable was connected to the wire orthodontics that have had been scratched as working electrodes and put into a glass. The potential range was set to be used and the measurement speed to be performed. The measurement of stainless steel orthodontic wire was from the start to complete. The step was repeated again for measurement of corrosion rate with pandan leaf extract.

RESULT

Data of this research shows that the mean value of corrosion rate measurement from stainless steel orthodontic wire is as follow:

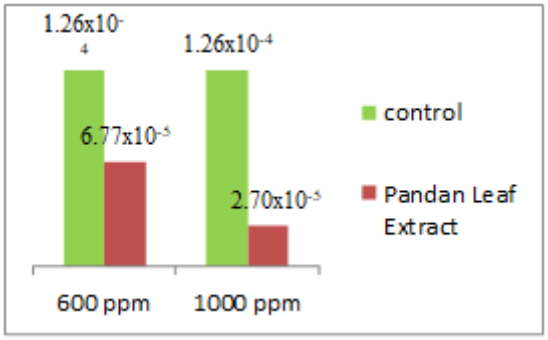

Figure 1. Average Measurement of Orthodontic Wire Stainless steel Corrosion Rate that soaked in Saline Solution, Pandan Leaf Extract (*Pandanus amaryllifolius Roxb*) with concentratrion of 600 ppm and 1000 ppm

Results and average measurement of stainless steel orthodontic wire corrosion rate can be seen in figure 1. Average corrosion rate with saline solution immersion is greater than average corrosion rate with soaking in pandan leaf extract. Average rate of corrosion with soaking in pandan leaf extract of 600 ppm is greater than average corrosion rate with soaking in pandan leaf extract of 1000 ppm.
Based on the result of normality test using Shapiro Wilk, it is known that the control group significance value is p = 0,530, the significance value of treatment group soaked with pandan leaf extract of 600 ppm is p = 0,764 and the significance value of treatment group soaked with pandan leaf extract of 1000 ppm is p = 0,322. The next step is to test the homogeneity of data variance using Levene's Test. Homogeneity test result obtained significance value of 0.190 and the data continued with the One Way Anova parametric test. One Way Anova test result showed a significance value of 0.000 (p <0.05).

Preliminary study analysis of pandan leaf extract as corrosion rate inhibitor obtained average value of corrosion rate and standard deviation value of the three groups in table 1.

Table 1. Average corrosion rate and SD

No	Group	Mean ± SD
1.	Control	$1,26x10^{-4} \pm 4,22x10^{-5}$
2.	600 ppm of Pandan Leaf Extract	$6,77x10^{-5} \pm 1,09x10^{-5}$
3.	1000 ppm of Pandan Leaf Extract	$2,70x10^{-5} \pm 4,22x10^{-6}$

The data is continued with Post-Hoc test using Bonferroni.Test. The results can be seen in table 2 as follows:

Table 2. Post-Hoc Bonferroni Test

Group	**Control**	**600 ppm**	**1000 ppm**
Control	-	0,000*	0,000*
600 ppm	0,000*	-	0,022*
1000 ppm	0,000*	0,022*	-

* = There is a significant difference ($p < 0.05$)

Table 2 shows the Bonferroni test results indicating that there was a significant difference between the control group and the treatment group soaked with the extract of 600 ppm pandan leaf. There was a significant difference between control group and treatment group soaked with the extract of 1000 ppm pandan leaf. There was significant difference between treatment group soaked with the extract of 600 ppm pandan leaf and treatment group soaked with the extract of 1000 ppm pandan leaf.

DISCUSSION

This study aims to prove the ability of pandan leaf extract in reducing the corrosion rate of orthodontic wire made from stainless steel. Saline solution is an electrolyte solution with NaCl content which can cause corrosion. The chloride ion content in the saline solution can damage the coating on the surface of the wire, resulting in the release of metal ions such as iron, nickel and chromium which are important ions in stainless steel orthodontic wire. The nickel ions contained in the stainless steel wire have saline soluble properties, so the duration of orthodontic wire use in the oral cavity in contact with saliva may affect the release of metal ions.[7,23]

The more sodium chloride, the greater chloride ion content too, so the corrosion rate will be higher. Sodium chloride (salt kitchen) is one of the salts that will form a strong electrolyte solution. The ion attacks the outermost layer of the stainless steel wire. Therefore, the chloride ions are the most aggressive ions to causing corrosion in the metal.[7,23] Formation of chemical reactions between Fe and NaCl is as follows: [24]

$$Fe + 2NaCl \longrightarrow FeCl_2 + 2Na^+$$

The average result of the corrosion rate was decreased in the pandan leaf extract group, but the highest corrosion rate reduction was obtained at concentration of 1000 ppm. In this study, the use of corrosion inhibitor 600 ppm and 1000 ppm are the optimum concentration. From the results of phytochemical test to the content of chemical compounds in pandan leaf extract positively contain of alkaloids, tannins, flavonoids and polyphenols.[19] The presence of tannin can protect the metal surface due to tissue formation of ferric tanninate salts.[30] Tannins have water-soluble or alcoholic properties due to tannin many contain phenol having OH groups that can bind heavy metals. The more the tannin content, the greater the inhibition power to inhibit the oxidation process.[25,26]

Polyphenol compounds are phenolic derivatives that have activity as antioxidants. The antioxidant compound is a compound which can delay, hold up and prevent oxidation process.[18] In tannin, there is a hydroxyl functional group attached to the aromatic ring so tannins can form complex compounds with Fe (II) and Fe (III) then the complexes are transformed into Fe (III) -tranin complex due to oxygen. It is this compound which will inhibit the oxidation process, because that complex compounds will form a hydrophobic thin protective layer.[27,28]

The formation reaction of such complex compounds may be either anodic and cathodic reactions or both. An anodic reaction is an oxidation reaction of a metal characterized by the release of electrons from neutral metal atoms to form the corresponding ions. The cathodic reaction is a reduction reaction characterized by electron

absorption, usually non-corrosive but can suffer damage under certain conditions.[28] The formation of the chemical reaction of Fe with tannins is as follows:[29]

$n\ Fe^{3+} + ne^{-} \longleftrightarrow nFe^{2+}$

tannins $\longleftrightarrow$ *tannate* $+ ne^{-} + nH^{+}$

$n\ Fe^{3+}$ + *tannins* $\longleftrightarrow (Fe^{2+})_n$ tannate $+ nH^{+}$

The addition of proper inhibitor concentration will be more effective in lowering corrosion rate. The higher the concentration of the inhibitor, the formation of complex compounds of the inhibitor will be increase too. It will increase the formation of better protective layer and the covered metal part.[32] Based on the results of this study, it can be concluded that the immersion of pandan leaf extract has the ability to reduce the rate of stainless steel orthodontic wire corrosion and there is a significant difference between the concentration of 600 ppm and 1000 ppm.

REFERENCES

1. Loblobly M, Anindita PS, Leman MA. Gambaran maloklusi berdasarkan indeks handicapping malocclusion assesment record (HMAR) pada siswa SMAN9 Manado. *Jurnal e-GiGi (eG)*. 2015. 3(2): 625-631.
2. Laguhi VA, Anindita PS, Gunawan PN. Gambaran maloklusi dengan menggunakan Hmar pada pasien di Rumah Sakit Gigi dan Mulut Universitas SAM Ratulangi Manado. *Jurnal e-GiGi (eG)*. 2014. 2(2).
3. Oley AB, Anindita PS, Leman MA. Kebutuhan perawatan ortodonti berdasarkan index of orthodontic treatment need pada usia remaja 15-17tahun. *Jurnal e-GiGi (eG*). 2015. 3(2): 292-293.
4. Dewi SA, Jazaldi F, Soegiharto BM. Herbal and conventional toothpastes roles in gingivitis control in orthodontic patients. *Journal of Dentistry Indonesia.* 2011. 18 (3): 68-72.
5. Mantiri SC, Wowor VNS, Anindita PS. Status kebersihan mulut dan status karies gigi mahasiswa pengguna alat ortodontik cekat. Jurnal e-GiGi (eG). 2013. 1(1): 1-7.
6. Foster DT. *Buku ajar ortodonsi.* Ed.3. EGC. Jakarta. 2014. Hal 226-238.
7. Rasyid NI, Pinandi PS, J C P Heryumani. Pelepasan ion nikel dan kromium kawat australia dan stainless steel dalam saliva buatan. *Dental Journal*. 2014. 47(3): 168-172.
8. Murniyanti E, Ardhana W, Karunia D.Pengaruh pengulangan pembakaran braket EDGEWISE standar terhadap deformasi slot braket akibat gaya torque kawat stainless steel. *Jurnal Kedokteran Gigi.* 2015. 6(2): 133-135.
9. Bonde MM, Fatimawali, Anindita PS. Uji pelepasan ion logam nikel (Ni) kromium (Cr) kawat ortodontik stainless steel yang direndam dalam air kelapa. *Pharmacon Jurnal Ilmiah Farmasi-UNSRAT*. 2016. 5 (4): 42-44.
10. Situmeang MA, Anindita PS, Juliatri. Perbedaan pelepasan ion nikel dan kromium pada beberapa merek kawat stainless steel yang direndam dalam asam cuka. *Pharmacon Jurnal Ilmiah Farmasi-Unsrat*. 2016. 5(4): 252-257.
11. Ardhy S, Gunawarman, Affi J. Perilaku korosi titanium dalam larutan modifikasi saliva buatan untuk aplikasi ortodontik. *Jurnal Mekanikal*. 2015. 6 (2): 585-593.
12. Afandi YK, Arief IS, Amiadji. Analisa laju korosi pada pelat baja karbon dengan variasi ketebalan coating. *Jurnal Teknik ITS.* 2015. 4 (1): G1-G2.
13. Anggaretno G, Rochani I, Supomo H. Analisa pengaruh jenis elektroda terhadap laju korosi pada pengelasan pipa api 5L grade X65 dengan media korosi FeCl3. *Jurnal TEKNIK ITS*. 2012. 1 (1): 124-125.
14. Ludiana Y, Handani S.Pengaruh konsentrasi inhibitor ekstrak daun teh (Camelia Sinensis) terhadap laju korosi baja karbon schedule 40 Grade B ERW. *Jurnal Fisika Unand.* 2012. 1(1): 12-13.
15. Sari DM, Handani S, Yetri Y. Pengendalian laju korosi baja ST-37 dalam medium asam klorida dan natrium klorida menggunakan inhibitor ekstrak daun teh (Camelia Sinensis). *Jurnal Fisika Unand.* 2013. 2(3): 204-205.
16. Machfudzoh PA, Amin MN, Putri LSD. Efektivitas ekstrak daun belimbing wuluh sebagai bahan inhibitor korosi pada kawat ortodonsi berbahan dasar Nikel-Titanium. *Artikel Ilmiah Hasil Penelitian Mahasiswa*. 2014.
17. Turnip L. Br, Handani S, Mulyadi S. Pengaruh penambahan inhibitor ekstrak kulit buah manggis terhadap penurunan laju korosi baja ST-37. *Jurnal Fisika Unand.* 2015. 4(2): 144-146.
18. Kayadoe V, Fadli M, Hasim R, Tomasoa M. Ekstrak Daun Pandan (Pandanus amaryllifolius Roxb) sebagai inhibitor korosi baja SS-304 Dalam Larutan H2SO4. *Molekul.* 2015. 10(2): 88-96.

19. Prameswari OM, Widjanarko SB.Uji ekstrak air Daun Pandan Wangi terhadap penurunan kadar glukosa darah dan histopatologi tikus diabetes mellitus. *Jurnal Pangan dan Agroindustri.* 2014. 2(2): 16-27.
20. Saputri ID, Joelijanto R, Putri LSDA. Daya inhibisi korosi ekstrak daun Belimbing Wuluh (Averrhoa blimbi L.) terhadap kawat thermal NiTi ortodonti (Corrosion Inhibition of starfruit leaves extract (Averrhoa blimbi L.) on thermal NiTi orthodontic wire. *e-Jurnal Pustaka Kesehatan.* 2015. 3 (2): 119-202.
21. Fajria L.Pengaruh pemberian ekstrak Daun Pandan Wangi (Pandanus amaryllifolius Roxb) terhadap berat testis dan diameter tubulus mencit (Mus Musculus). *NERS Jurnal Keperawatan*. 2011. 7 (2): 161-169.
22. Mataliana GNA, Yudhari I DAS, Dewi IAL.Keragaman usaha tani Pandan Wangi (Pandanus amaryllifolius Roxb) di Subak Tegenungan desa Kemenuh kecamatan Sukawati kabupaten Gianyar. *E-Jurnal Agribisnis dan Agrowisata.* 2015. 4(1): 1-3.
23. Wasono P R, Assa A Y, Anindita S P. Pelepasan ion nikel dan kromium bracket stainless steel yang direndam dalam minuman isotonik. *Pharmacon Jurnal Ilmiah Farmasi-UNSRAT*. 2016. 5 (1): 158-162.
24. Windarta. Pengaruh jenis media korosif terhadap laju korosi besi cor kelabu. *Jurnal Sintek.* 2012. 8 (2): 26-31.
25. Irianty RS, Sembiring MP. Pengaruh konsentrasi inhibitor ekstrak Daun Gambir dengan pelarut Etanol-Air terhadap laju korosi besi pada air laut. *J. Ris. Kim.* 2012. 5 (2): 165-174.
26. Indrayani NL. Studi pengaruh ekstrak eceng gondok sebagai inhibitor korosi untuk pipa baja SS400 pada lingkungan air. *Jurnal Ilmiah Teknik Mesin.* 2016. 4 (2): 47-56.
27. Ali F, Saputri D, Nugroho F R. Pengaruh waktu perendaman dan konsentrasi ekstrak daun Jambu Biji (Psidium guajava, Linn) sebagai inhibitor terhadap laju korosi baja SS304 dalam larutan garam dan asam. *Teknik kimia*. 2014. 1 (20): 28-36.
28. Sidiq FM. Analisa korosi dan pengendaliannya. *Jurnal Foundry*. 2013. 3(1): 25-30.
29. Rahim, A A, Kassim J. Recent development of vegetal tannins in corrosion protection of iron and steel. Penang: School of Chemical Sciences. Universiti Sains Malaysia. 2012
30. Malfinora A, Handani S, Yetri Y. Pengaruh konsentrasi inhibitor ekstrak daun Kakao (Theobroma cacao) terhadap laju korosi baja hardox 450. *Jurnal Fisika Unand.* 2014. 3 (4): 222-227.
31. Dahlan MS. *Besar sampel dan cara pengambilan sampel dalam penelitian kedokteran dan kesehatan.* Ed 3. Salemba Medika. 2011. Hal 68-75.
32. Hussin MH, Kassim MJ. The corrosion inhibition and adsorption behavior of uncaria gambir extract on mild steel in 1 M HCL. *Material Chemistry and Physics.* 2011. 125 (3): 461-8.