Comparison of Ion Release Chromium Soaked in Artificial Saliva and Extract the Starfruit Wuluh (Averrhoa Bilimbi L.)

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Abstract

The Orthodontic Wire has a stainless steel metal content that can undergo corrosion on the inside of the mouth. Corrosion can be influential, bad for the human body and can release ions that can affect the process of corrosion. Stainless steel wire can release chromium ion and ways to reduce the rate of corrosion of materials by using inhibitors. Inhibitors can be extracts from natural materials and are not harmful to the environment. One of them is the extract of star fruit wuluh that has active content can stabilize ions of chromium on the surface of the stainless steel wire and can form a passive layer so that corrosion can be inhibited.

To know the ability of inhibition the star fruit wuluh extract power to prevent corrosion on Stainless Steel wire.

Materials used artificial saliva and fluid extract of star fruit wuluh. The research was conducted in experimental laboratories with 4 sample treatment group using the extract of star fruit wuluh and 4 sample control group using artificial saliva fluids. The release of chromium ion Atomic Absorption Spectrophotometric instruments used.

Cr metal ion release Occurs with the amount of discharge varies from the treatment group and the control group on day 1, 3, 7 and 14 days. An increase in the amount of deposition of chromium ion on each sample research.

The release of chromium ion from Stainless Steel wire that is soaked in the extract of star fruit wuluh less than immersed in artificial saliva. Extract of starfruit wuluh have corrosion inhibition against stainless steel wire.

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Introduction

The treatment of orthodontics is one of the treatments that plays an important role in improving the tooth structure, corrected a malformation and malrelasi dentokraniofasial, so as to restore the function of chewing, talking and facial appearance.[1,2]

One of the components used in the treatment of orthodontia i.e. the wire orthodontia.[3,4] Currently various types of wire orthodontia seat has been circulating in the market, such as stainless steel wire, chromium cobalt, beta-titanium and nickel-titanium (NiTi). The orthodontic wire is often used, namely, a stainless steel orthodontic wire has advantages like a good elasticity, strength, easily shaped, economical, and resistant to corrosion, but the nature of corrosion resistant wire orthodontia stainless steel can be influenced by the circumstances in the oral cavity.[2]

Stainless steel wire, also known as corrosion resistant steel that contains iron (Fe), carbon (C), chromium (Cr) and nickel (Ni). Price is more economical, but the process of making different power levels can affect corrosion resistant stainless steel wire.[3,4]

The oral cavity is an environment that is ideal for the occurrence of biodegradation of metal due to temperature as well as the quality and the saliva pH can affect the stability of the metal ion.

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Organic acids from decomposition of sulfur-containing food scraps can also be pushing the occurrence of Cr and Ni ion release from the stainless steel wire orthodontia so long submerged in the oral cavity.[3]

Saliva contains inorganic ions (N+, K+, Cl- and HCO3-). Inorganic components in the saliva media act as the electrolyte electrochemical reaction that can trigger. Electrochemical reaction is occurring due to the release of Cr and Ni ion of orthodontia stainless steel wire as a sign of the onset of corrosion.[5]

The corrosion cannot be prevented but its speed can be reduced. Various ways have been done to reduce the rate of corrosion, one of them with the use of inhibitors of corrosion inhibitor Addition.[6] Has been used in industries such as oil and gas. Corrosion inhibitor itself is defined as a substance that when added to the amount a little into the environment will lower the attack against environmental corrosion of metals.[7]

Corrosion inhibitors comprising inorganic and organic inhibitors (green inhibitor). Among other inorganic inhibitors arsenate, chromate, phosphate, and silicate which is a type of chemicals are expensive, dangerous, and not environmentally friendly, so it will give bad effects when interacting directly with the human body. It is therefore currently being developed use of organic material that is more natural to be used as corrosion inhibitor material more safe and biocompatible bonding agent with body.[8]

One of the many natural materials contain antioxidant substances and potentially used as a corrosion inhibitor is a starfruit wuluh (Averrhoa bilimbi l.). Starfruit wuluh plant is one of the popular medicinal plants in Indonesia society so easily obtained.

Stainless Steel

Stainless steel is an iron alloy Metallurgy in with the content of Cr 10.5%-11%. The addition of ion Cr it aims to improve corrosion resistance by forming a layer of oxide Cr 2O3 in the surface of the stainless steel metal. Other elements besides iron, carbon and Cr, namely nickel, molybdenum, and titanium with different compositions resulting in variations of mechanical properties of stainless steel are some of the products circulating in the market.[9.10]

Chromium is an additional component that serves to increase resistance to corrosion. Chromium on the surface of the metal reacts with oxygen to form chromium oxide that is resistant to corrosion. Nickel functions help metal against corrosion resistance as well as strengthen the metal.[9,11,12,13] However the weakness of Ni and Cr is can cause allergic reaction in uncoupled in the oral cavity.[14]

The classification of stainless steel is based on its metallurgical structure, ie Austenitic, Ferritic, Martensitic, Duplex and Precipitation Hardening 9. Austenitic SS usually gets an 8% increase in nickel preventing austenitic transformation to martensite during cooling, so that austenite is more stable even at room temperature. Austenite SS has widely used in the field of dentistry especially orthodontics because of its corrosion-resistant properties. While SS Ferritic is type AISI 400 with good corrosion resistance properties, although not as good as austenitic SS is due to lower Cr content. Composition Cr 11,5 - 27%, carbon 0,20% and without nickel. Although widely used in industry, but these alloys are rarely used in the field of dentistry. Martensitic stainless steel, composition containing Cr 12-14%, molybdenum 0.2-1%, 0-2% Nickel and 0.1 to 1% carbon. These alloys have good hardness properties but the lowest corrosion resistance compared to Austenitic and Ferritic type SS.

Mechanism and Various Corrosion

Although stainless steel is known as a corrosion-resistant metal alloy, different manufacturing processes produce different qualities as well, thus affecting corrosion resistance. Corrosion indicates visually sighting when it happened in a long time. Corrosion can be detected in the presence of oxidation and reduction processes resulting in the release of ions from the elements contained in the wire.[16]

Corrosion will weaken the power of the archwire and trigger surface roughness. Nickel metal element which can cause bad effects regardless of the body, be it in the form of hypersensitivity reaction, trigger cancer, and certainly are toxic.[17]

Corrosion is a damage that occurs in a material due to reaction with the surrounding environment. The corrosion process involves two simultaneous reactions namely oxidation and reduction (redox). When a pure metal specimen (called an electrode) is placed on a liquid

medium (called an electrolyte) containing no specimen ions, the metal ion will tend to dissolve into the medium and the lost metal surface of the ion will begin the process of redeposition to retain its properties, the metal ion to the liquid medium is called the oxidation process (loss of electrons) and the redeposition that causes the reduction.[18,19]

Several kinds of corrosion that can occur on a metal bracket related usage time and the environment of the oral cavity:

1. Corrosion evenly (uniform attack)
   In normal conditions, the metal bracket stainless steel sheathed oxide of chromium coating that prevents the occurrence of corrosion agent penetration.[18,20]
2. Corrosion wells (pitting corrosion)
   At the microscopic level, orthodontic brackets can have many pits and slits. The condition is estimated to increase its susceptibility to corrosion because it can accommodate plaque-forming microorganisms.[20]
3. Corrosion cracks (crevice corrosion)
   Corrosion this can occur due to bacteria and biofilm surface between the wire and acrylic, resulting in corrosion cracks of metals.[20]
4. The galvanic Corrosion (galvanic corrosion)
   In orthodontia, Galvanic corrosion can arise when two different metals are put together in the making of bracket or posted archwire. This is because the solder connections of the active part of the mechanically so that causes it is more prone to corrosion.[21]
5. Fretting Corrosion (Fretting corrosion)
   Fretting corrosion occurs at the contact area of the metals are experiencing sustained load.[20]

Causes of Corrosion

Saliva is an electrolyte that allows the presence of the reaction between metal ions a bracket with saliva so that it occurs damage in electrochemistry at the bracket. Saliva contains organic and inorganic components such as sodium ions, chlorine, potassium, bicarbonate, calcium, magnesium, hydrogen phosphate, thiocyanate and fluorine.[5]

The corrosion starts from the occurrence of tarnish on metals, then continues with the release of metal ions, eventually there was corrosion. Tarnish is a reduced surface staining metal or changes on the surface of a metal that has been polished. The cause of tarnish is (1) water, oxygen and chlorine ion contained in saliva, (2) Deposit-a deposit in her mouth which stick to the surface of the metal, (3) the Stain caused by bacteria, (4) the establishment of specific compounds like oxides, sulfides or chlorine.

Corrosion Prevention

The occurrence of corrosion is inevitable, but the rate of corrosion can be reduced. A reduction in the rate of corrosion processes can be carried out with cathodic protection, protection anodic, coating (coating), and the addition of the inhibitor.[24]

The corrosion inhibitor is one way that can be done to prevent the occurrence of corrosion is a chemical substance that when added to an environment can reduce the rate of attack of the corrosion of the environment against a metal. The inhibitory mechanism is sometimes more than one type. A number of inhibitors inhibit corrosion by means of adsorption to form an invisible thin film with a thickness of only a few molecules, others due to environmental influences.[23]

Corrosion inhibitors comprising inorganic and organic inhibitors (green inhibitor). Among other inorganic inhibitors arsenate, chromate, phosphate, and silicate which is a type of chemicals are expensive, dangerous, and not environmentally friendly, so it will give bad effects when interacting directly with the human body. It is therefore currently being developed use of organic material that is more natural to be used as corrosion inhibitor material more safe and biocompatible bonding agent with the body.[8]

Starfruit Wuluh

Starfruit wuluh is a plant that is included from the family Oxalidaceae. Starfruit wuluh (a. Bilimbi l.) contains secondary metabolite compounds including tannins, also contains sulfur, formic acid.[25] Starfruit wuluh extract also contains flavonoids, saponins, and tannins.[26]

Figure 1. Starfruit Wuluh

Starfruit Wuluh Extract Benefits

Starfruit Wuluh (a. bilimbi l.) planted as many fruit trees. This tropical American plant can be used to treat various ailments.[25] Starfruit wuluh said can cure illness starfruit wuluh stroke since the extract contains tannins, moreover can be utilized as a remedy stomach aches, rheumatism, parotitis and cough medicine. Starfruit wuluh also helps to reduce the pain, as well as germ-killers can lower blood sugar levels. Starfruit wuluh contains secondary metabolites including tannin compounds contain sulfur, formic acid and flavonoids.[25]

The results of some research indicate, the tannins as an inhibitor of corrosion. [28,29,30,7] Other than the tanin, inhibition of corrosion on the metal surface may also occur with the granting of flavonoids.[31] Extraction is the process of separation of a substance based on the difference in solubility of two liquids not mutually soluble; The principle of extraction is dissolving polar compounds in polar solvents and nonpolar compounds in nonpolar compounds.[32]

Atomic Absorption Spectrophotometric

Spectrometry is a method of quantitative analysis of the measurement based on the number of radiation generated or absorbed by the atom or molecular analytes species. One part of the Atomic Absorption Spectrometry is Spectrophotometric (AAS), is a method of analysis of quantitative elements of a measurement based on the absorption of specific wavelengths of light by atoms of the metal in a State free of.[34]

Tools and Materials Research

Tool

1. Tubes
2. Measuring Cup
3. a wire cutter Pliers
4. AAS (Atomic Absorption Spectrophotometric)

Figure 2: AAS (Atomic Absorption Spectrophotometric)

Materials

1. stainless steel Wire
2. artificial Saliva
3. Extract the star fruit wuluh

Figure 3: stainless steel orthodontic Wire diameter 0.4

Figure 4. Extract the star fruit wuluh

Way of Working

1. Stainless steel wire used with a diameter of 0.40 mm which is then prepared with a length of 40 mm to produce 8 samples of wire of the same length.

Figure 5. 40 mm-sized stainless steel Wire.

2. Do the grouping of each into 8 groups, each of which consists of 2 pieces.
3. Do stainless steel wire to soaking in a solution of artificial saliva pH 6.75 ± 0.15 and extras star fruit wuluh as much as 5 ml borosilicate glass tubes in closed meetings, as well as performed on storage temperature 37o C for 1, 3, 7, and 14 days.

Figure 6. the stainless steel Wire immersed in artificial saliva.

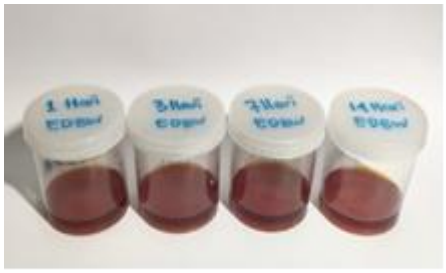

Figure 7. Stainless steel Wire that is soaked in the extract of star fruit wuluh.

4. Measurements of ion loss Cr on each immersion using AAS (Atomic Absorption Spectrophotometric).

Results

Samples that tested eight samples of four samples of stainless steel wire that is soaked in the extract of star fruit wuluh and four stainless steel wire sample soaked in artificial saliva for 1, 3, 7 and 14 days with a length of wire used 40 mm with a diameter of 0.41. Measurement of ion release by using Atomic Absorption Spectrometry (AAS), and obtained the following results.

No	Code Samples	Form	The Parameters Of	Unit	Results			
					1	2	3	Average
1	1 day	Liquid	Cr (Cr)	ppm	1,673	1,478	1,319	1,491
2	3 day	Liquid	Cr (Cr)	ppm	1,638	1,620	1,726	1,661
3	7 day	Liquid	Cr (Cr)	ppm	2,010	1,957	1,939	1,970
4	14 day	Liquid	Cr (Cr)	ppm	2,170	2,064	2,188	2,140

Table 1. The result of the release of the ion Cr on a wire that is immersed in the extract of star fruit wuluh for 1, 3, 7, and 14 days is seen using AAS.

No	Code Samples	Form	The Parameters Of	Unit	Results			
					1	2	3	Average
1	1 day	Liquid	Cr (Cr)	ppm	2,702	2,578	2,738	2,672
2	3 day	Liquid	Cr (Cr)	ppm	2,791	2,738	2,667	2,732
3	7 day	Liquid	Cr (Cr)	ppm	2,844	2,755	2,862	2,821
4	14 day	Liquid	Cr (Cr)	ppm	2,809	2,986	2,844	2,880

Table 2. The result of the release of the ion Cr on a wire immersed in artificial saliva for 1, 3, 7, and 14 days is seen using AAS.

The results of this study indicate that the results soaking on the first, third, seventh and fourteenth an increase in precipitation of ions Cr on each sample solution research namely artificial saliva and extract the star fruit wuluh.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval Difference	
		F	Sig.	t-test Equality of means	Df	Sig (2-failed)	Mean Difference	Std.Error Difference	Lower	Upper
Result	Equal variances assumed	1.022	369	10.442	4	.000	1.18267	.11326	.86821	1.49712
	Equal variances not assumed			10.442	2.854	.002	1.18267	.11326	.81154	1.55380

Table 3. The independent samples t-test 1-day soaking.

Table 3 shows the test result, independent samples t-test, a test of the independent samples t-test was conducted after the unknown data is distributed normally. The results obtained by the group with a level of significance of 0.00 ($p < 0.05$) which means that there are meaningful differences between the release of the ion Cr stainless steel wire between soaked in extract starfruit wuluh and artificial saliva for 1 day.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval Difference	
		F	Sig.	t-test Equality of means	Df	Sig (2-failed)	Mean Difference	Std.Error Difference	Lower	Upper
Result	Equal variances assumed	.000	.993	22.026	4	.000	1.07067	.04861	.93571	1.20563
	Equal variances not assumed			22.026	3.966	.000	1.07067	. 04866	. 93525	1.20608

Table 4. The independent samples t-test 3 days soaking.

Table 4 shows the test result, independent samples t-test, a test of the independent samples t-test was conducted after the unknown data is distributed normally. The results obtained by the group with a level of significance of 0.00 ($p < 0.05$) which means that there are meaningful differences between the release of the ion Cr stainless steel wire between soaked in extract starfruit wuluh and artificial saliva for 3 days.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval Difference	
		F	Sig.	t-test Equality of means	Df	Sig (2-failed)	Mean Difference	Std.Error Difference	Lower	Upper
Result	Equal variances assumed	1.164	.341	21.645	4	.000	.85167	.03935	.74242	.96091
	Equal variances not assumed			21.645	3.416	.000	.85167	.03935	. 73465	.96868

Table 5. The independent samples t-test 7 days soaking.

Table 5 shows the test result, independent samples t-test, a test of the independent samples t-test was conducted after the unknown data is distributed normally. The results obtained by the group with a level of significance of 0.00 ($p < 0.05$) which means that there are meaningful differences between the release of the ion Cr stainless steel wire between soaked in extract starfruit wuluh and artificial saliva for 7 days.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval Difference	
		F	Sig.	t-test Equality of means	Df	Sig (2-failed)	Mean Difference	Std.Error Difference	Lower	Upper
Result	Equal variances assumed	.645	.467	11.109	4	.000	.73900	.06652	.55430	.92370
	Equal variances not assumed			11.109	3.621	.001	.73900	.06652	.54642	.93158

Table 6. The independent samples t-test 14 days soaking.

Table 6, shows the results of a test of the independent samples t-test, a test of the independent samples t-test was conducted after the unknown data is distributed normally. The results obtained by the group with a level of significance of 0.00 ($p < 0.05$) which means that there are meaningful differences between the release of the ion Cr stainless steel wire between the star fruit wuluh extract soaked in an artificial saliva for 14 days.

Discussion

The measurement results show that happens to release metal ions Cr with a varied amount of discharge in the control group, namely orthodontic stainless steel wire that is soaked in artificial saliva.

According to Kristianingsih (2014), inorganic components in artificial saliva media into an electrolyte electrochemical reaction that can trigger. The electrochemical reaction is a reaction that occurs at the anode (oxidize) and cathode (undergoing reduction), metal ions as the anode and the ions from the electrolyte media as the cathode. The existence of the electrochemical reaction of this process occurs, causing the corrosion that was marked by the release of the ion Cr of stainless steel orthodontic wire.[36]

According to Einer (2004), Cr ions can form protective surface oxides due to oxygen activity on metal surfaces. The presence of Cr ion which reacts with oxygen from the electrolyte medium will be deposited on the surface of the metal as chromium oxide (Cr2O3) which is further protection of the underneath of the metal from corrosion.[37]

According to Wan Nik (2011), decrease the rate of corrosion in groups with the addition of an inhibitor is caused due to the active compounds in the extract of star fruit wuluh like tannins, saponins, flavonoids, and alkaloids containing functional groups – C = O, O-H, and C = C serve as antioxidants so it could be a couple for free electrons on the surface of the metal. Active content in the extract of star fruit wuluh used indeed diverse and almost all contain the element oxygen, sulfur, and nitrogen, making it difficult to determine which component plays the best in inhibits the rate of corrosion or possible all content can also inhibit the rate of corrosion.[38]

According to Siagan (2010), the presence of inhibitors on the stainless steel surface due to the adsorption. Adsorption that occurs in the extract of star fruit wuluh occurs between the ions on the surface of stainless steel wire with active groups present in the active compounds in

extract starfruit. Adsorption arises because of the adhesion force between the inhibitor and the stainless steel surface. Adsorption of molecular inhibitors on the stainless steel surface will produce a thin film (film) in stainless steel that can inhibit the corrosion rate. However, wuluh star fruit extract does not react with or eliminate aggressive ions. The molecule of the active compound in the extract of starfruit is an adsorbate or molecule that will accumulate on the metal surface and form a thin layer that is a bond between CR ions and the more stable -OH group and can block metal interaction with the environment.[39]

The results showed differences occurred ion release Cr soaked in artificial saliva and extract the star fruit wuluh. The release of the ion Cr artificial saliva soaked in bigger than soaked in the extract of starfruit wuluh. This shows the addition of the inhibitor proven to slow down the rate of corrosion. The decline in the rate of corrosion on the metal because of the organic compounds in accordance with the research was ever undertaken by Hermawan et al. (2012) indicating that tannins from extracts of cocoa fruit skin play a role in the decline in the rate of steel corrosion.[40]

According to Favre (1993), tannin compounds in the extracts can form complexes with Fe (III) on the surface of steel so that the rate of corrosion will decline. The complex would deter attacks corrosive ions on the surface of steel, so the corrosion reaction rate will decrease.[41]

According to Billy (2012), astringent tannins have been shown to inhibit the rate of corrosion that occurs on the metal by giving some sort of protective coating on metal surfaces in order not to corrode.[42]

The same thing is expressed by Nasution (2012) about the role of tannin extract of mangosteen rind in the decline rate of corrosion on steel and on the research of Al-Qudah (2011) which shows a decline in the rate of corrosion due to organic compounds, namely Flavonoids from a plants can play a role in the process of the inhibition of corrosion on the metal.[43,44]

According to Habiebie (2014), organic inhibitor in the form of tea and guava extracts containing tannins show an impact on slowing the rate of corrosion in steel plate stainless steel 304.[45]

According to Diah (2016), a decrease in the rate of corrosion on carbon steel FIRE 1.5 l jar declined with the use of organic inhibitors in the form of a greeting containing tannins (21.7%), flavanoid (0.4%).[46]

On the results of the research appear that the longer the wire, the greater the submersion also release ions Cr on both variables. Look at research results ion release Cr soaked in artificial saliva and extract the star fruit wuluh for 1, 3, 7, and 14 days has increased. The results of this study are in line with the research ever undertaken by Habiebie (2014), shows that the higher the temperature and the longer the time to soak the sample then the rate of corrosion caused will be higher.[45]

According to Eliades (2002), the release of the ion Cr overload or corrosion occurring in a long period of time will give negative effects on orthodontic stainless steel wire itself or on a person's health. In the event of corrosion or discharge ion Cr too much can cause changes in the dimensions form wire and affect the strength of stainless steel orthodontic wire resulting fragile wire.[47]

According to Sfondirini (2009), the release of Cr stainless steel orthodontic wire can also give a negative impact on the health if the entry exceeds the normal intake of the body. CR is the heavy metal groups who may be allergic, carcinogenic even cytotoxic to the human body.[48]

According to Nasser (2017), in the Study of the Inhibitory Effect of the Jasminum Sambac Extract on the Corrosion of Dental Amalgam in Saliva Media, it states that the results obtained by the scanning electron microscopy absence of attack signs on the surface in the presence of extract and adsorption of the inhibitors on the surface of amalgam.[49]

Conclusion

1. There is a difference of ion release Cr stainless steel wire that is soaked in artificial saliva and star fruit wuluh extracts in for 1, 3, 7, and 14 days.
2. The release of the ion Cr of wire that is soaked in the extract of star fruit wuluh less than soaked in artificial saliva.
3. Extract of star fruit wuluh proved to have corrosion inhibition against power orthodontic wire made of stainless steel.

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