

**Tristaniopsis merguensis Griff. Extract as Inhibitor for Corrosion of Stainless Steel**

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**Abstract.** Green inhibitors are inhibitors that utilize secondary metabolites of plant to reduce the rate of corrosion. Secondary metabolites with heteroatom content phosphate, nitrogen, oxygen, and sulfur function as ligands and adsorption centers to bind metals. These metabolites compounds include alkaloids, flavonoids, and tannins. *Tristaniopsis merguensis* Griff. is a local plant of Bangka Belitung which contains alkaloid, flavonoids and tannins. The focus of this research is to analyze the effect of *T. merguensis* leaf extract on corrosion rate of stainless steel. *T. merguensis* extract was obtained by maceration for 3 x 24 hours using ethanol solvent. Determination of corrosion rate using the mass reduction method. Then, functional group analysis contained in extract uses the Fourier Transform Infrared (FT-IR) at wave number region 4000–400 cm⁻¹. The results obtained that at the highest concentration of 1000 mg/L the extract of *T. merguensis* was able to inhibit the corrosion rate of stainless steel until the corrosion rate was 0.3826 mmpy equal to inhibition efficiency 85.27%. This inhibiting ability is more likely because *T. merguensis* leaf extract containing phenolic compounds. Therefore *T. merguensis* extract can be used as a green inhibitor.

**1. Introduction**

Corrosion is a natural event that causes degradation of metal quality due to the electrochemical reaction between metals and the environment [1]. One way to inhibit the corrosion rate in metals is by adding inhibitors [2]. Corrosion inhibitors are chemical compounds that can form a protective layer on the metal surface so that the corrosion rate between metal surfaces and the environment can be inhibited [3]. Corrosion inhibitors can be synthetic and natural chemical compounds. The use of synthetic chemical compounds as corrosion inhibitors is limited by environmental regulations because they are toxic, so they have a negative impact on the environment and humans [4]. For this reason, corrosion inhibitors are needed that are environmentally friendly, inexpensive, biodegradable, efficient, and non-toxic [5]. Plant extracts can be used as inhibitors for corrosion known as Green Inhibitors. Plants are a renewable source of corrosion inhibitors, abundant and inexpensive. Plant extracts containing organic compounds such as flavonoids, alkaloids, tannins, and nitrogen bases have heteroatoms (O, S, and N), double bonds, and electronegative groups as centers of adsorption on corrosion inhibitors [6]. The Pelawan tree (*Tristaniopsis merguensis* Griff) is a local plant in the area of Bangka Belitung. Previous research on the *Tristaniopsis* genus found that the genus contained high phenolic compounds such as alkaloids, flavonoids, and tannins [7]. The high phenolic content contented in plants can be used as a safe corrosion...
inhibitor in metals. Therefore, in this study qualitative and quantitative tests were carried out on the phenolic content contained in the T. merguensis Griff leaves, and tested the strength of the inhibitory properties of the leaf extract against corrosion in metals. The corrosion medium solution used in this study was 0.1 M HCl solution.

2. Materials and methods

2.1 Material and equipment
The materials used in this study include leaves of T. merguensis Griff from Sempan Village, Stainless Steel 304 Plate, technical ethanol, filter paper, aluminum foil, HCl, aquadest, Mayer reagent, Wagner reagent, FeCl$_3$, ethanol pro analysis, methanol pro analysis, chloroform, Mg powder. The equipment used in this study included blenders, 100 ml beakers, test tubes, analytic balance, erlenmeyer, measuring cup, vial bottle, rotary evaporator, vacuum pump, Buchner funnel, tweezers, and 1000 mL volumetric spatula, 250 mL volumetric flask.

2.2 Sample Preparation
Fresh leaves (Tristaniopsis merguensis Griff) as much as 1 kg are washed to remove the dust impurities that are attached, then dried by drying in the sun. The dried leaves are ground to enlarge the contact between the solvent and the sample. Furthermore, 400 gram of leaf powder was taken to macerate.

2.3 Extraction
400 gram leaf powder of T. merguensis Griff was macerated with ethanol solvent with a comparison between the sample and solvent 1:10. Then vacuum filtration was carried out using a Buchner funnel. The filtrate obtained was evaporated to evaporate the solvent using a rotary evaporator. The content of phenolic compounds contained in ethanol extract will be tested qualitatively and functional group analysis contained in ethanol extract using Fourier Transform Infrared (FT-IR) in the range of wave numbers 4000-400 cm$^{-1}$.

2.4 Phytochemical testing
Testing the content of phenolic compounds on ethanol extract of T. merguensis Griff leaves was carried out qualitatively using several chemical reagents. Phytochemical testing is carried out on the content of alkaloids, tannin/phenol hydroquinone, and flavonoids.

2.4.1 Alkaloid testing. The ethanol extract was added 0.5 mL 2% HCl, then the solution was put into two test tubes of the same volume. The first tube was dropped 2-3 drops of Wagner reagent and the second tube was dripped with 2-3 drops of Mayer reagent. The extract was positive for alkaloids when brown precipitation formed on Wagner reagents and yellowish white precipitation formed on Mayer's reagents.

2.4.2 Testing of phenol hydroquinone/tannin. 50 mg of extract was put into 5 mL ethanol analysis. Then add 3 drops of FeCl$_3$ solution. The extract is positively stated to contain phenol hydroquinone / tannin if it is formed in green or blue green.

2.4.3 Flavonoids testing. 50 mg of the extracted sample was dissolved in 2 mL of 50% hot methanol, then added Mg metal powder and 0.5 mL concentrated HCl. The extract is positive for flavonoids if red, orange or yellow are formed.

2.5 Stainless Steel Preparation
Stainless steel 304 dimensions used in this test measuring 3 x 3 cm². Cleaning of metal surfaces is done by using grit scouring paper 240, 500 and 1000. Furthermore, the metal is soaked in acetone to remove fat attached to the metal surface and dried in an oven at 40°C for 30 minutes. The dried metal is weighed to determine the initial mass.

2.6 Inhibitor solutions preparation
8.212 ml of concentrated HCl is put in a 1000 mL volumetric flask, then diluted with the addition of aqua dm to the boundary mark and shaken until homogeneous. 0.1 M HCl solution is used as a blank solution and inhibitor solvent.

2.7 Corrosion media preparation
The 3 x 3 cm² metal plate prepared has been immersed in 30 mL of corrosion media with variations in concentrations of concentrated ethanol extract (25, 50, 75, 100, 250, 500, and 1000 mg/L) for 48 hours. After that, the plate is cleaned using tissue and dried. Then the mass is weighed after soaking (final mass). The data obtained calculated the Corrosion Rate (CR) using equation (1) and Inhibition Efficiency (EI%) using equation 2:

\[
CR \left( \frac{mm}{year} \right) = \frac{K W}{D At}
\]

where \( K \) is the constant 87600, \( W \) is the weight reduction (g), \( D \) is the density (g/cm³), \( A \) is the area of the specimen (cm²) and \( t \) is the time of immersion (hours).

\[
EI\% = \frac{CRo - CRi}{CRo} \times 100\% \times 100\% (2)
\]

where \( CRo \) is the corrosion rate on metal plates without inhibitors, \( CRi \) is the corrosion rate on metal plates with inhibitors (concentrated ethanol extract).

3. Result and Discussion
Phytochemical testing of leaves *Tristaniopsis merguensis* Griff was carried out qualitatively and quantitatively. Qualitatively, phytochemical tests are screened for phenolic compounds including alkaloids, tannins / phenol hydroquinone, and flavonoids. Based on the results of the tests that have been carried out, the data in the form of Table 1 are presented.

| Table 1. Screening of Phenolic Compounds Ethanol Extract Leaves *T. merguensis* Griff |
|-----------------------------------------------|-----------------|-----------------|-----------------|
| Groups of compounds   | Test Method  | Indicator | Results |
|----------------------|--------------|-----------|---------|
| Alkaloid             | Wagner       | Brown precipitation are formed | +        |
|                     | Mayer        | Yellowish white precipitation are formed | +        |
| Tannins / Phenol Hydroquinone | FeCl₃     | green or blue green colours are formed | +        |
| Flavonoids           | Wiltster sianidin | Formed orange colour | +        |

Information
+: Samples react positively to test reagents
-: Samples react negatively to test reagents
Tests for the content of alkaloid compounds on an ethanol extract of *T. merguensis* Griff found brown deposits against Wagner reagents. This is due to the reaction between alkaloid nitrogen atoms forming covalent bonds of coordinates with potassium ions from Wagner's reagent to form a potassium-alkaloid complex in the form of brown deposits [8]. The testing of alkaloid compounds using Mayer's record also gives positive results which are indicated by the formation of yellowish white deposits. Due to the formation of potassium-alkaloid complexes in the form of white deposits as a result of a reaction between nitrogen in alkaloids and potassium metal ions from Mayer's potassium tetraiodomercurate (II).

Tests on the content of tannins / phenol hydroquinone compounds produced in blue green in the sample solution after reacted with FeCl₃. A green or blue green is produced as a result of the reaction between Fe³⁺ and phenol hydroquinone to form an iron-phenol hydroquinone compound. The formation of these complexes occurs between hydroxyl groups in phenol hydroquinone with Fe³⁺[9]. The presence of flavonoids with the cyanidin Wilstater test is indicated by the change in color of the test sample solution to orange or red. Color changes that are produced as a result of the formation of flavillium salts. The test results on the ethanolic extract showed a change in color to red. Due to the reduction of the benzopyrone nucleus by concentrated Mg and HCl metals [10].

![FTIR Analysis](image)

**Figure 1. FTIR Analysis**

Widespread uptake of 3400-3100 cm⁻¹ indicates the presence of –OH (hydroxyl) group vibrations, the widening band due to the interaction of intermolecular hydrogen bonds [11]. This hydroxyl group can also be derived from a phenol (Ar-OH) group which is strengthened by absorption at a wave number 751 cm⁻¹. This widening uptake of OH groups may also overlap with aromatic C-H stretching uptake which is usually at 3159-3050 cm⁻¹ [12]. This indicates the presence of an aromatic group in the extract. The presence of aromatics is also supported by the presence of vibrations C=H stretching at 1610.69 cm⁻¹. The analysis shows that extracts of *Tristaniopsis merguensis* Griff have aromatic compounds in the form of phenolic compounds or polyphenols.

The ribbon with wave number 2935.47 cm⁻¹ shows the presence of CH₃ (methyl) group and asymmetric vibration CH₂ (methylene) [13]. The presence of these groups is also supported by the absorption at wave numbers 1446.54 to 1328.12 cm⁻¹. This indicates that extracts of *T. merguensis* Griff contain methyl, methylene and methine groups.

Strong absorption at 1709.43 cm⁻¹ indicates the vibration of the C = O (carbonyl) group. If seen from other absorption, this carbonyl group might be a ketone group [14]. This is because there is no band at wave number 1280-1150 cm⁻¹ which indicates the presence of C-O-C ester groups, or there is no absorption in the range of 2800 which indicates the presence of C-H aldehyde.
Based on the analysis of FT-IR spectrum data (Figure 1), *T. merguensis* Griff extract contains compounds that have Ar-OH (phenolic) groups, -OH (hydroxyl), C = O (ketones) and C = C (aromatic). This indicates that the functional group is a functional group on the structure of the polyphenols which is more specifically the structure of flavonoids.

![Figure 2. Corrosion rate vs concentration extract](image)

![Figure 3. Concentration extract vs inhibition efficiency](image)

Based on the Figure 2 and Figure 3 shows that the increase in the concentration of ethanolic extract of *T. merguensis* Griff was able to reduce the corrosion rate of stainless steel metal which caused the inhibitor efficiency to be higher. At the highest concentration of 1000 mg/L, the extract was able to inhibit the corrosion rate of stainless steel metal in 0.1 M solution until the corrosion rate was 0.3826 mmpy with inhibition efficiency 85.27%. Reduction in corrosion rate due to the addition of inhibitor concentrations due to the formation of a protective layer capable of inhibiting diffusion of electrons from or towards the electrode surface so that the corrosion rate can be inhibited [15]. Besides that, the ability of corrosion inhibitory possessed by the ethanolic extract of *T. merguensis* Griff leaves indicates that the extract can be used as a mixed inhibitor.

4. Conclusion
Ethanolic extract of leaves of *Tristaniopsis merguensis* Griff contains phenolic compounds, namely alkaloids, tannin/phenol hydroquinone and flavonoids. The content of phenolic compounds in the *T. merguensis* Griff leaves was able to inhibit the corrosion rate of stainless steel metal corrosion media 0.1 M HCl. The concentration of 1000 mg/L has the lowest corrosion rate of 0.3826 mmpy with percent inhibition reaching 85.27%.
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