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Optimizing the Effect of Gambir Sap Extract as an Organic Inhibitor to Reduce Scale Formation at Pertamina Hulu Energi (OK/RT) Peninjauan District, OKU Regency

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Abstract

The formation of scale can cause a decrease in production at the well due to obstruction of flow in tubing flowlines and other production equipment; besides that, it can also cause damage to production equipment. The contents contained in the scale include calcium sulfate, ferrous sulfate, calcium carbonate, and barium sulfate. Among some of the scale content, the highest content of barium sulfate to reduce the content of barium sulfate scale can use inorganic materials such as HCL and H_2SO_4 for this study using H_2SO_4 because the dilution solvent is large enough compared to HCL so that it can be used to reduce scale in addition to inorganic materials can also use organic materials such as in this study using gambier sap extract which has a fairly high tannin acid content which is certainly more environmentally friendly and inexpensive.

Keywords: Scale, H_2SO_4, Gambir Sap, Barium Sulfate, Tannic Acid

1. Introduction

Scale formation is a significant issue in the oil and gas industry. Scale is formed when inorganic salts, such as calcium and magnesium carbonate, precipitate and create hard layers within pipes, equipment, and oil wells. It can lead to various operational and productivity problems (Putra & Kiono, 2021) [5].

The formation of scale in wells can cause production decline by obstructing flow in tubing, flowlines, and other production equipment. Scale forms when certain mineral compounds precipitate, creating solid layers on pipe surfaces and production equipment. Common types of scale found in the oil and gas field include Calcium Carbonate (CaCO3), Calcium Sulfate (CaSO4), and Barium Sulfate (BaSO4). Calcium Carbonate (CaCO3) usually forms when calcium-rich water reacts with carbon dioxide. Calcium Sulfate (CaSO4) can form due to pressure drop, temperature changes, or seawater interaction with freshwater. Apart from these types, there are also scales like Gypsum (CaSO4.2H2O), Strontium Sulfate (SrSO4), and Ferrous Carbonate (FeCO3). Pressure drop in the well can lead to scale deposition. Temperature changes can also trigger scale formation as they affect mineral solubility in water. Additionally, an increased pH (acidity level) can influence scale formation (Asmah, 2020) [2].

The formation of scale in distribution pipes and well production equipment can reduce well productivity. Moreover, scale forms when dissolved salts in production water residue create hard layers on pipe and equipment surfaces. Two common methods are often used: scale inhibitor injection and acidizing to address scale issues (Alida *et al*., 2018) [1].

Inhibitor injection is one method used to prevent or inhibit scale formation in systems susceptible to scale deposits. Scale inhibitors are chemicals that inhibit scale growth and deposition, consisting of mineral deposits like calcium carbonate, magnesium, barium, and others (Effendi & Pramurti, 2019) [3]. EDTA is a compound that can form complexes with metal ions, including the ions responsible for scale formation, like calcium and magnesium. It reduces the tendency of these metal ions to form deposits in oil piping systems and production equipment (Nugroho *et al*., 2015) [4].

It is also important to note that polyphenols in gambier plants are mainly found in their leaves. The maturity level of gambier leaves can affect the content and types of polyphenols present in the plant. Therefore, to obtain gambier products with high polyphenol content, it is recommended to use relatively young leaves (Sri, 2013) [6].

Catechin and *quercetin* also possess similar properties. They can form complexes with metals and can inhibit oxidation processes. This means they can help slow down the formation of scale or mineral deposits on surfaces frequently exposed to water or other fluids (Yazid *et al*., 2018) [10]. In 2009, Gambier's production reached 185 tons, then increased to 189 tons in

2010 and 270 tons in 2015. This increase in production indicates a high demand for gambier plants, making them an important plantation commodity in South Sumatra (Sufyan, 2017) [7]. This study aims to use gambier latex as an inhibitor in scale formation and test the content of the extracted solution using UV-Vis Spectrophotometry. The main component expected in the extracted liquid is tannic acid, which has the potential as an organic inhibitor against scale formation (Supriyanto, 2011) [8].

2. Materials and Methods

The equipment and materials used in this study were 1. 1000 ml measuring cylinder, 2. Digital scale, 3. Stopwatch, 4. Erlenmeyer flask, 5. Filter paper, 6. UV-Vis spectrophotometer, 7. 80 mesh sieve, 8. pH meter, 9. Rotary evaporator, and 10. Heating oven. As for the materials, they included: 1. Gambier latex, 2. Analytical-grade ethanol solvent, 3. Scale samples, and 4. Hydrochloric acid.

The extraction process of Gambier leaves using the maceration method was as follows: Drying 3000 grams of fresh Gambier latex for two days to remove moisture content, aided by a heating oven. Grinding the dried Gambier leaves into powder using a blender or grinder to facilitate and optimize the extraction process, sieving the powder through an 80-mesh sieve (0.420 mm). Adding 500 grams of finely ground gambier latex powder, dissolved in 96% ethanol solvent at a weight-to-volume ratio of 1:2 (w/v) or 1000 ml, and if necessary, mixed with distilled water at a ratio of 1:2 (v/v). Then, stir and soak for one day or 24 hours. It filtered the sample using filter paper to separate the filtrate and residue and evaporated the obtained filtrate using a vacuum (rotary evaporator) at 200 rpm. A temperature of 79°C to produce a concentrated extract. UV-Vis spectrophotometry is used to identify the chemical compounds present. Sample feasibility testing is conducted at the Integrated Research and Testing Laboratory (LPPT) of Sriwijaya Polytechnic Palembang, using spectrophotometric analysis to determine whether it suits a scale inhibitor.

The testing procedure for scale reduction using the weight loss method with organic gambier latex extract as an inhibitor includes Weighing the scale samples, filling a container with 10 ml of organic gambier latex extract solution, placing the weighed scale samples into the container filled with a 10 ml organic gambier latex extract solution, with a test duration of 10 minutes. After 10 minutes, lift the scale samples using tweezers, dry the scale samples using an oven, and then re-weigh the dried scale samples. Steps 1-6 are repeated for variations in immersion time of 15, 20, 25, 30, and 35 minutes and variations in immersion volume of 10, 15, and 20 ml.

The Sulfuric Acid (H2SO4) Testing Procedure Using 10% Concentration for Scale Reduction with Time involves Weighing the scale samples, preparing a 10% concentration of Sulfuric Acid (H2SO4), filling a container with 10 ml of 10% inorganic sulfuric acid (H2SO4), placing the weighed scale samples into the container filled with 10% inorganic sulfuric acid (H2SO4) for 10 minutes. After 10 minutes, lift the scale samples using tweezers, dry the scale samples using an oven, and then re-weigh the dried scale samples. Steps 1-6 are repeated for variations in immersion time of 15, 20, 25, 30, and 35 minutes and variations in immersion volume of 10, 15, and 20 ml.

3. Results and Discussion

Quantitative testing was conducted to determine the percentage of tannic acid compounds in the organic inhibitor extracted from gambier leaves. The analysis was performed using a UV-Vis spectrophotometer with the Spectrophotometric test method directly at the Integrated Research and Testing Laboratory (LPPT) of Sriwijaya Polytechnic Palembang. The results of the tannic acid compound in the sample can be seen in the following Table 1.

Table 1: Percentage of a tannic acid compound in gambir latex extract organic inhibitor

Test parameters	Result	Unit	Method
Total Tannins in Tannic Acid Equivalents	72,038	ppm	UV-vis spectrophotometry

The Scanning Electron Microscope (SEM) is a tool used for microscopic analysis of samples, including qualitative and quantitative analysis of chemical components within a sample. SEM produces high-resolution images of the sample's surface using electrons as the radiation source (Susilo *et al*., 2017) [9]. The results of the Scanning Electron Microscope (SEM) testing indicate the presence of four chemical components within the scale. These four types of chemical components can be observed in Table 2.

Table 2: Chemical components in scale

Components	Chemical formula	Results (%)
Barium	Ba	60.7
Sulphur	S	20.3
Calcium	Ca	5.90

The testing of organic inhibitors from gambier latex extract and sulfuric acid (H2SO4) for scale reduction involves the use of two types of acids: organic acid (tannic acid from gambier leaf extract) and inorganic acid (10% concentration sulfuric acid H2SO4). Before conducting the scale reduction testing, both reducers underwent pH value testing using a digital pH meter. The pH testing results are presented in Table 3.

Table 3: Testing the pH value of organic inhibitors of Gambier sap extract and sulfuric acid (H_2SO_4) Concentration of 10%

Reducing Type	Ph value
Gambier sap extract organic inhibitor	4,14
Sulfuric acid (H_2SO_4) with 10 % concentration	0,03

The initial testing phase involves breaking down several parts of the scale samples obtained from the PHE OK/RT field. Subsequently, the samples are thoroughly washed and dried using the heating oven available in the Sriwijaya Polytechnic Palembang laboratory. The next step is to weigh the initial weight after drying, followed by immersion processes with varying durations of 5 to 35 minutes. The samples are then cleaned again and dried using the heating oven. Finally, the final weight of the scale samples is measured, and the weight before and after is calculated to determine the percentage reduced. The process of testing the efficacy of organic inhibitor from gambier latex extract in reducing scale using the weight loss method can be observed in Fig 1.

During the reduction process, a chemical reaction occurs between the scale and the organic inhibitor, indicated by the formation of bubbles. Additionally, after the immersion process is completed, the scale samples are observed to have dissolved along with the organic inhibitor solution, resulting in a decrease in the weight of the scale samples. The graph above illustrates no notable increase in weight at a soaking time of 5 minutes. However, at 10 minutes, there is an increase from 0.000 to 0.162, and from 15 to 35 minutes, there is a gradual increase. However, for the testing with a 10 ml additive volume, there is no significant increase observed. The subsequent testing will be conducted with a larger additive volume to determine the saturation limit of the inhibitor in reducing scale.

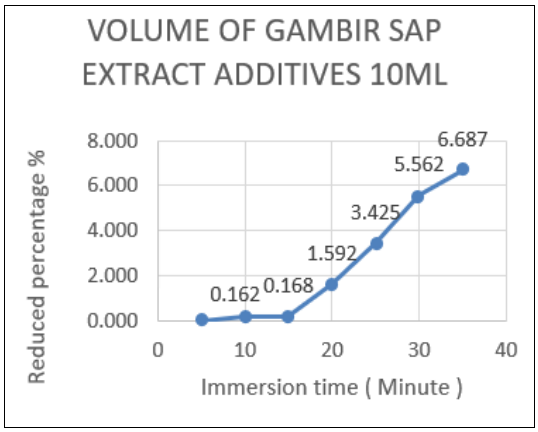

Fig 1: Efficiency of Organic Inhibitor from Gambier Leaf Extract on Scale Reduction with 10 ml Additive Volume of H2SO4

In Fig 2, the testing results with an additive volume of 15 ml from gambier latex extract can be observed at the 20-25 minute mark, where there is a rapid ionization process from 16.698 to 4.647. Hence, extending the soaking time is a viable solution to maximize and increase scale reduction. Therefore, the subsequent testing will be conducted with a larger additive volume of 20 ml.

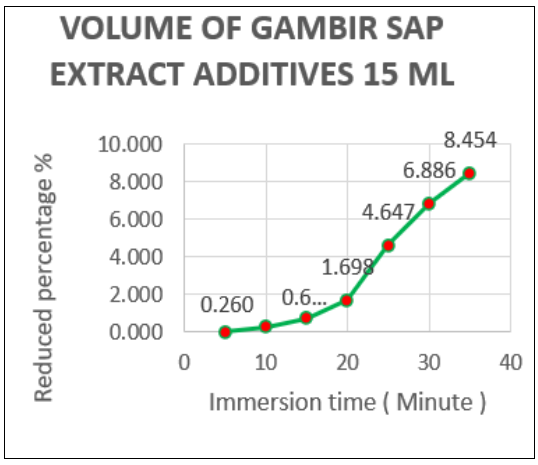

Fig 2: Efficiency of Organic Inhibitor from Gambier Leaf Extract on Scale Reduction with 15 ml Additive Volume of Gambier Latex Extract

In Fig 3, the testing results with an additive volume of 20 ml from gambier latex extract can be observed at the 25-30 minute mark, where there is a rapid ionization process from 4.847 to 9.898. Hence, extending the soaking time is a viable solution to maximize and increase scale reduction.

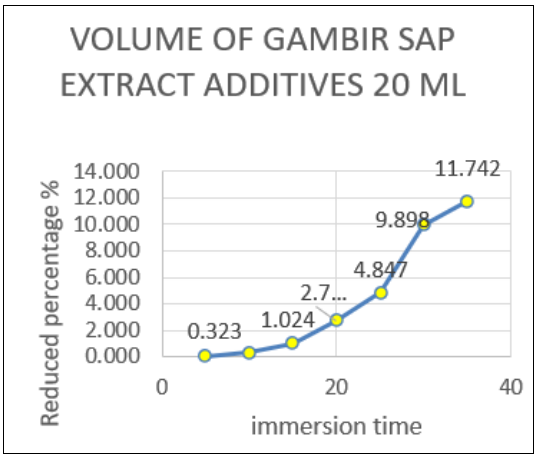

Fig 3: Efficiency of Organic Inhibitor from Gambier Leaf Extract on Scale Reduction with 20 ml Additive Volume

From all the testing tables above, a combined graph can represent the relationships between reduced scale weight, soaking time, and additive volume of the organic inhibitor from gambier latex extract. The soaking time is directly proportional to the increased weight of the reduced scale, indicating that extending the soaking time is a solution for enhancing reduction efficiency. This research obtained the lowest reduction value with a 10 ml additive volume. However, with a 20 ml additive volume, the polyphenol compounds were adsorbed perfectly, resulting in a significant increase. It is attributed to the incomplete adsorption of polyphenol compounds from the organic inhibitor of gambier leaf extract onto the scale samples at a relatively short soaking time. Nonetheless, with a 20 ml additive volume, the polyphenol compounds were adsorbed completely, leading to a significant increase.

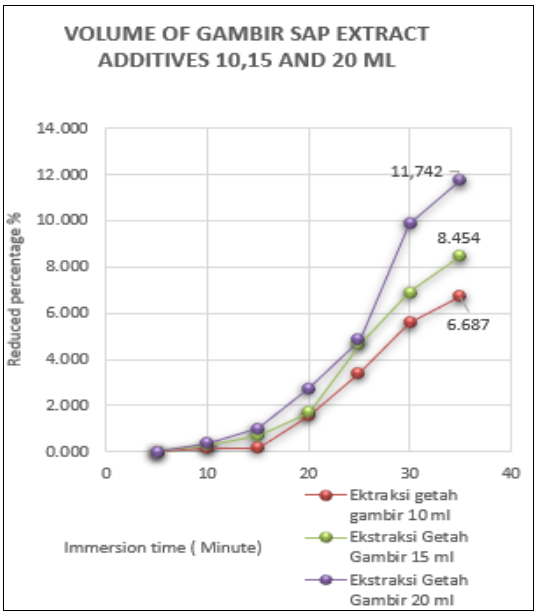

Fig 4: Graph of the Effect of Organic Inhibitor from Gambier Latex Extract on Scale Reduction Ability

10% Concentration Sulfuric Acid (H2SO4) was tested on Scale Reduction Ability. The process and results of testing the inorganic inhibitor sulfuric acid (H2SO4) with a 10% concentration on the ability to reduce scale using the weight loss method can be seen in Fig 5. From Fig 5, it can be observed that the hydrolysis reaction rate is influenced by

the abundance of H+ ions in the H2SO4 solution, where Sulfuric Acid (H2SO4) is a strong acid type with a rapid reaction rate at the initial stages. As a result, a significant reduction occurs within the first 5 minutes. Therefore, since changes occur from the beginning, namely at the 5-minute mark, it can be concluded that the soaking time significantly affects scale reduction through organic inhibition.

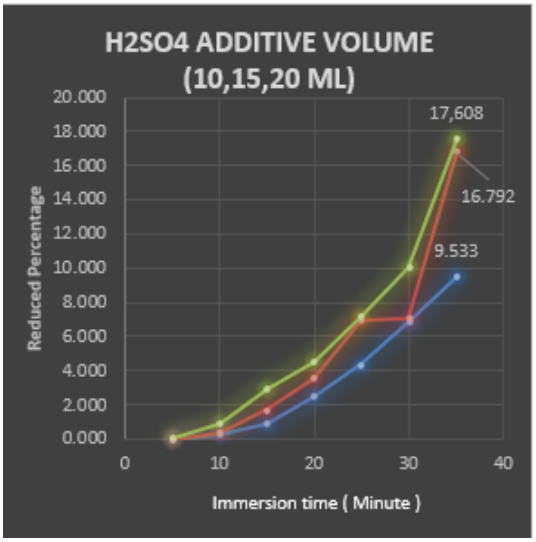

Fig 5: Graph of the Effect of 10% Concentration Inorganic Inhibitor Sulfuric Acid (H2SO4) on Scale Reduction Ability

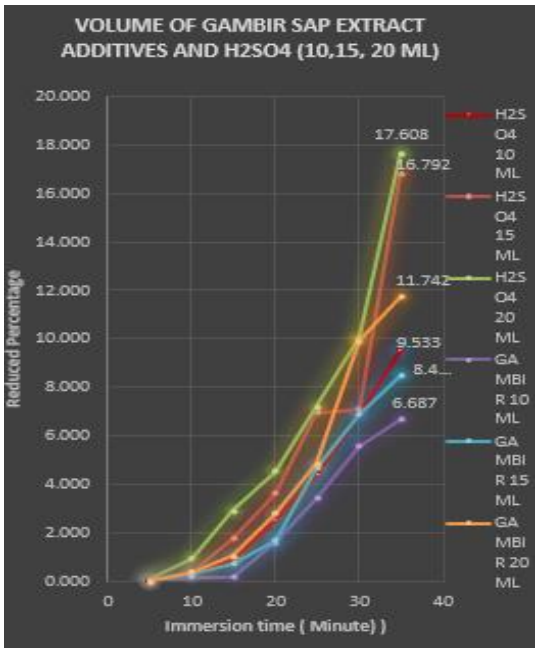

Fig 6: Comparison graph of scale reduction using gambir latex extract inhibitor with 10% H_2SO_4 concentration

Analysis of Scale Reduction Results Using Organic Inhibitor from Gambier Latex Extract with Inorganic Inhibitor H_2SO_4 10% Concentration. This analysis compares the gambier leaf extract as an organic acid solution with 10% Sulfuric Acid (H_2SO_4) as an inorganic acid solution in terms of their ability to reduce scale. It considers variations in soaking time, soaking volume, and the weight of the reduced scale, aiming to find the optimal inhibition efficiency peak against the scale sample. From Fig 6 above, it can be observed that there is no change in scale reduction at the 5-minute soaking time. However, a slight change occurs at the 10-minute mark. All soaking volumes of 10% H_2SO_4 consistently outperform the organic inhibitor. Referring to the literature (Alida & Fandra, 2018) [1], inorganic substances like H_2SO_4 have lower pH levels, indicating strong acidic properties and containing reactive chemical components that make reactions with inorganic acids like H_2SO_4 faster in reducing scale compared to organic substances such as the weak acid from gambier leaf extract, which is also not corrosive and can serve as a corrosion inhibitor.

4. Conclusion and Recommendations

Tannic acid compound, a polyphenol with acidic properties, can be an organic inhibitor for scale reduction. The study found the tannic acid concentration to be 72.038 ppm using the UV-Vis spectrophotometer in the Chemical Engineering Laboratory of Politeknik Sriwijaya Palembang. The pH value of the gambier latex extract in this study was 4.14, while the pH value of the 10% diluted sulfuric acid (H2SO4) was 0.03. Both reduction agents, the gambier latex extract and sulfuric acid, are acidic; however, the acid nature of the gambier latex extract is weaker than the strong acid nature of sulfuric acid. Utilizing gambier latex extract as an organic inhibitor offers advantages in reducing equipment damage, such as preventing corrosion in production pipes or water injection pipes due to its weak, acidic nature. The optimal conditions for gambier latex extract and sulfuric acid as reduction agents are at a 20 ml additive volume and a 35-minute immersion time. For gambier latex extract, the achieved reduction percentage is 11.742%, whereas for sulfuric acid, the reduction percentage is 17.068%. The research underscores the significant impact of immersion time and additive volume, as longer immersion time enhances the scale-reduction efficiency of gambier latex extract.

Recommendations for future work include exploring other organic and inorganic substances for scale inhibition.

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