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Corrosion Resistance of Developed Bolted Flange Made of *Momordica Angustisepala* Fiber (MAF) and Breadfruit Seed-Shell Particles (BFSAP)

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Abstract

Connecting pipe systems and pressure vessels requires bolted flanged joints. One of the most frequent reasons why bolted flanged joints leak is corrosion of the flange surface. This research investigates the corrosion resistance of composite bolted flanges made of *Momordica angustisepala* fiber (MAF) and breadfruit seed-shell particles (BFSAp). The result shows 100% polarization resistance with a corrosion rate of 0.00 mil per year was obtained for the developed composite. This shows that the corrosion problem of a metallic bolted flange can be reduced using the developed composite.

Keywords: *Bolted Flanged Joints, Corrosion Resistance, Composite Flanges, Momordica angustisepala Fiber (MAF), Breadfruit Seed-Shell Particles (BFSAp, Polarization Resistance*

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1. Introduction

Bolted flanged joints (BFJs) are a kind of seal mechanism that uses bolts, gaskets, and flanges to link pipe components and pressure vessels [1]. In industrial applications, such as connecting pipes, pumps, and pressure vessels, bolted flange joints, or BFJs, are frequently utilized. It is impossible to overstate their use in the oil and gas sector, particularly for parts that need to be removed on a regular basis for maintenance [2]. Metallic materials are frequently used for these components because of their high strength and hardness. However, it is generally known that metallic materials are highly susceptible to corrosion effect, a type of chemical attack. Fig 1 depicts corrosion adverse effect on metallic bolted flange. This results from metals' desire to return to a stable condition. In the oil and gas industries, this has been a major obstacle for many years [3].

Reports state that reinstalling corroded parts and monitoring for corrosion cost billions of dollars annually [4, 5]. Consequently, research interest has been piqued in the pursuit of highly corrosion-resistant materials for BFJs, pipes, and other associated applications. Braide *et al*. [6, 7, 8] developed a hybrid of aluminum composites with carbon nanotubes using a braking disc made from used aluminum beverage cans, carbon nanotubes formed from rice husk (CNTs-derived RH), and periwinkle shell nanoparticles (PWSnp). Due to their great inertness to chemical attack, polymer materials have been shown to be capable of replacing metallic materials in the majority of oil and gas applications [9, 10, 11]. This has prompted a number of research studies on the use of polymers in the majority of applications in highly corrosive environments, such as the oil and gas industry.

This class of polymer composite materials has shown excellent properties in terms of corrosion resistance and strength. However, the glass fibers used for this class of composite materials are expensive and also are not environmentally friendly as they are not biodegradable.

Figure 1: Corrosion effect (rusting) on metallic flange [12].

2. Materials and Method

2.1 Material

The corrosion test samples were cut from the metallic flange and the developed composite. The samples were first coated with epoxy and aluminum tape to provide corrosion prevention and conductivity, respectively, and thereby exposing one surface for the test. The electrochemical analysis was done using the corrosion tester model CHI604E (refer to figure 2). The test was done at 0.0012 V s^{-1} and potential -1.5 V to 1.5 V as per the ASTM G19 Standard in simulated seawater (3.5% NaCl) [13]. Equation 1 was used in computing the polarization resistance.

$$R_P = \frac{\beta_a \beta_c}{2.3icorr(\beta_a + \beta_c)} \quad \text{.....................................(1)}$$

Where βa is the Tafel anodic constant, βc is the cathodic Tafel constant and current density (color)

Figure 2: Electrochemical Analyzer

3. Results and Discussion

3.1 Electrochemical Analysis

Corrosion analysis in a simulated marine environment using 3.5% NaCl was analyzed using Tafel polarization curves. Figure 3 displayed the Tafel curves. It was observed that the composite sample had the potential shifted to a higher potential than the metallic materials. (compare Figure 3 with Figure 4). The quick reaction of the metallic sample with the medium at the initial period until the steady potential was obtained was attributed to the active reaction of the sample in the seawater as described in equations 2-3, which increase the numbers of electrons released from the anode to the cathode and increase the damage of the sample The fast reaction generates many deep pits covered with an iron oxide layer, which shows the formation of pits.

$Fe + H_2O + Cl^-$---------------------[FeClOH] ads …………..(2)

[FeClOH] + H^+ --------------------$Fe2^+ + Cl_- + H_2O$ ………….. (3)

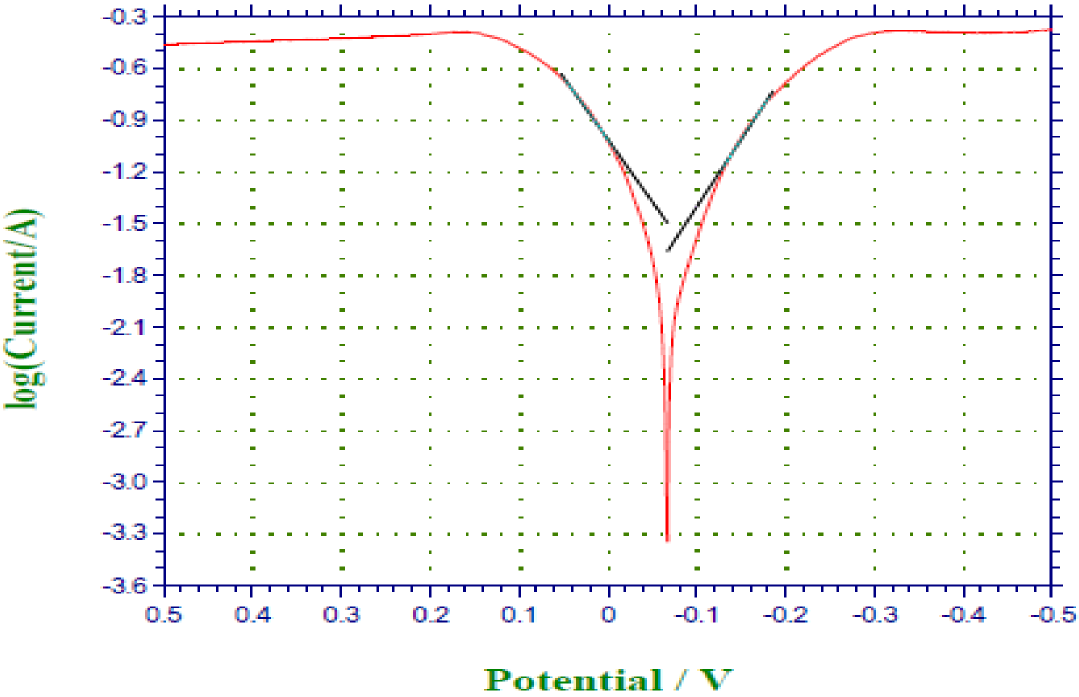

Figure 3: Tafel polarization plot of the electrochemical process of the metallic sample

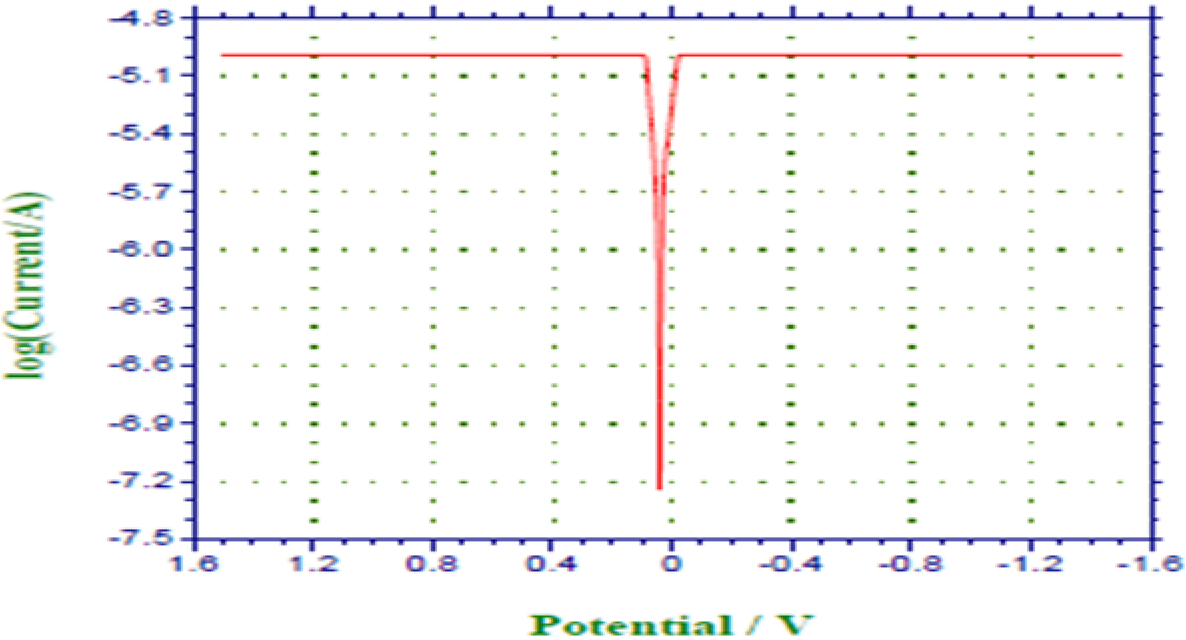

Figure 4: Tafel polarization plot of the electrochemical process of the composite sample

As visible in Figure 3, the sample is shifted to higher current density and lower corrosion potential as compared with the composite sample. There was a wide range in the cathode and anode branch in the metallic sample in Figure 3, which resulted in an increased reaction of the sample with the medium. In the case of the composite sample, the flow of electrons did not occur as a result of no moveable electrons, which led to the narrow ranges of the cathode and anode branches observed in Figure 4. A corrosion rate of 7.8 x 10^3 mil per year and linear polarization of 1 were obtained for the metallic sample. While 100% polarization resistance with a corrosion rate of 0.00 mil per year was obtained for the developed composite. This shows that the corrosion problem of a metallic bolted flange can be reduced using the developed composite.

Conclusion

The comparison of polarization results revealed that when compared to metallic flanges, the created composite flange demonstrated 100% polarization resistance and a corrosion rate of 0.00 mil annually.

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Author Contributions

All the authors contributed to the development of the work. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

Data Availability

The authors confirm that the data supporting the findings of this study are available within the article.

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