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Use of Sacrificial Anode for Corrosion Protection of Tradition Well Cover

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ABSTRACT

The use of sacrificial anode for corrosion protection of a tradition well cover in Nigeria is the focus of this investigation. The unprotected unpainted and unprotected painted mild steel coupon samples served as control. Measurements were taken every five days for 90 days. The rate of zinc consumption during cathodic protection of the well cover was measured by the 'loss in weight' technique. The result shows that the synergetic effect of sacrificial anode protection and painting is highly more protective for mild steel well cover. The corrosion of the cathode (mild steel) decreased negatively and progressively from 0 (zero) mg.yr/mm^2 to -8.9 x 10^{-2} mg.yr/mm^2 after 90 days of exposure in well water. The rate of zinc consumption increases with decreasing level of cathodic protection by sacrificial anode with increasing time. The rate of zinc consumption during cathodic protection of protected unpainted and protected painted steel coupon ranged from zero (0) to 6.77 x 10^{-2} mg.yr./mm^2 and from zero (0) to 3.28 x 10^{-2} mg.yr./mm^2 respectively.

Keywords: *Sacrificial anodes, zinc, well cover, mild steel*

1. INTRODUCTION

Owing to the obvious corrosion problem associated with ferrous materials, intensive study has been in place attempting to protect such materials from corrosion. Several methods have been adopted in the corrosion control mechanism (Fontana, 1986). In history, the effects of sacrificial anode in the protection of steel cannot be overemphasized as environmental factors such as humidity and rainfall formed the major driving force responsible for the corrosion problem common with well covers used in underground water environment (Natesan et al, 2008).

Sacrificial anodes as a form of Cathodic Protection (CP), are highly active metals that are used to prevent a less active material surface from corroding when exposed to aggressive medium/media. Sacrificial anodes are created from a metal alloy with a more negative electrochemical potential such as zinc, and used to protect a lesser active metal such as steel from corrosive environment. In this process, the sacrificial anode will be consumed in place of the metal it is protecting, which is why it is referred to as a "sacrificial" anode (Petrucci et al, 2007). The effects of zinc addition on the performance of aluminium as sacrificial anode in seawater have been reported by Muazu and Yaro (2011).

Traditionally sacrificial anodes were usually made of zinc, they can also be made from magnesium or a special alloy of aluminum. This type of anode comes in all shapes and sizes but they all perform the same task of corrosion protection. They have to be connected "electrically" to the valuable metal parts of the component that need protecting. Zinc has find applications in various sectors. As sacrificial anodes, zinc has been used to protect the hull of ships, water heaters, pipelines, distribution systems, above-ground tanks, underground tanks and refineries (Petrucci et al, 2007). Zinc alloy that was doped with tin was investigated as sacrificial anode in seawater environment (Ige and Umoru, 2007). They reported that the sample without tin showed the least susceptibility to the corrosion attack, followed by the alloy with 0.01% tin. Also, in recent years, zinc alloys have been preferentially selected as sacrificial anode materials for CP of steel due to their high current efficiency, low specific weight and low cost (Song et al, 2004).

Sacrificing zinc for steel offers a unique combination of properties unmatched by any other material such as high strength, formability, light weight, corrosion resistance, aesthetics, recyclability and low cost (Sander et al, 2006; Syed, 2006). We are however investigating the use of commercially available zinc as sacrificial anode in a well water environment.

Well-cover is made of steel and has been in used in developing countries to protect water from being contaminated. With time however, the well cover deteriorates as a result of corrosion. For this reason, the use of zinc as sacrificial anode in the protection of well-cover serves as impetus to this work.
In the preliminary work carried out earlier, inappropriate mass of the sacrificial anode to cathode ratio was used and the result was inaccurate due to the inconsistent corrosion attack on the sacrificial anode. However, this approach is different, as adequate volume of sacrificial anode to cathode ratio was used.

2. EXPERIMENTAL SET UP

2.1. Materials

The materials used in this research are 0.13% C mild steel coupons, zinc anodes, zinc rod, digital weighing balance, pH meter, digital multimeter, handkerchiefs, copper wire, distilled water, acetone, ethanol, 750ml plastic container and nital as etchant.

2.2. Method

The sacrificial anode (zinc) was machined to a standard dimension (20 mm x 40 mm) in accordance to ASTM G1-4. The unprotected unpainted mild steel and unprotected painted mild steel served as control 1 and 2 respectively. The protected and unprotected bare and coated mild steel was immersed in well water at intervals of every five days for 90 days using a digital multi-meter (DT9205A Model) coupled with zinc rod as reference electrode. The pH measurements of the corrosive medium were taken at intervals of five days for 90 days using pH meter. Mass and total surface area of each anode and the well cover (cathode) were measured.

The corrosion rate and the weight loss were determined at room temperature in seven plastic containers filled with 750 ml of water each. The unprotected and protected unpainted and painted mild steel were immersed in well water medium. Initial weight of the anode and the cathode was taken. Each sample initially rinsed and cleaned in distilled water and allowed to dry for five minutes before immersion. The weight loss of the cathodes and anodes were taken and recorded using electronic weighing balance (FA2104A Model).

The chemical composition of the mild steel used (Akinribide et al, 2014)

ELEMENT	C	Si	Mn	P	S	Cr	Mo	Ni	Sn	Cu	V	Fe
PERCENT	0.13	0.15	0.47	0.043	0.006	0.01	0.01	0.01	0.001	0.03	0.002	Bal

3. RESULTS AND DISCUSSION

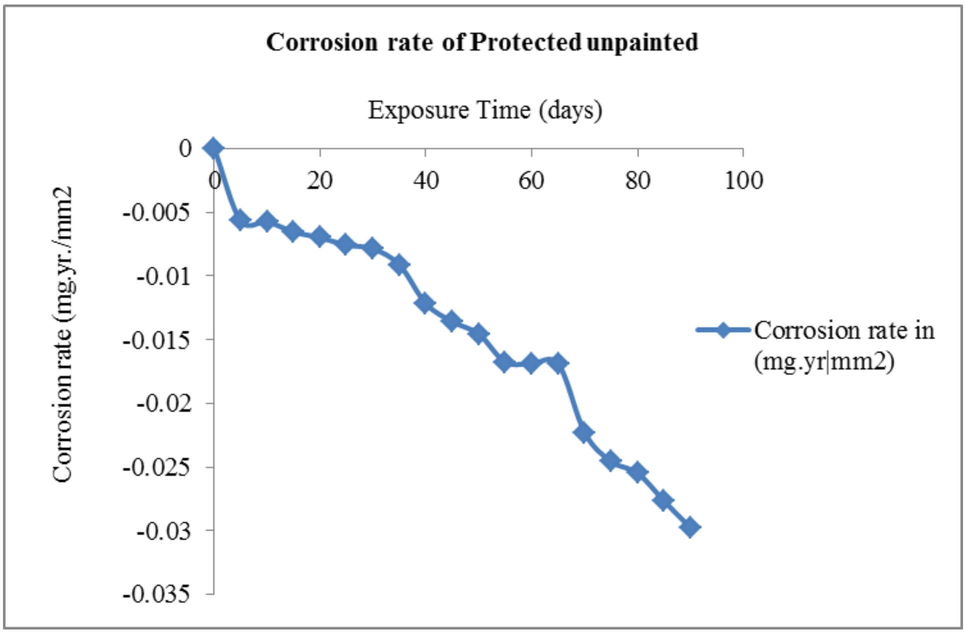

Figure 1 Corrosion Behaviour of protected unpainted steel well cover

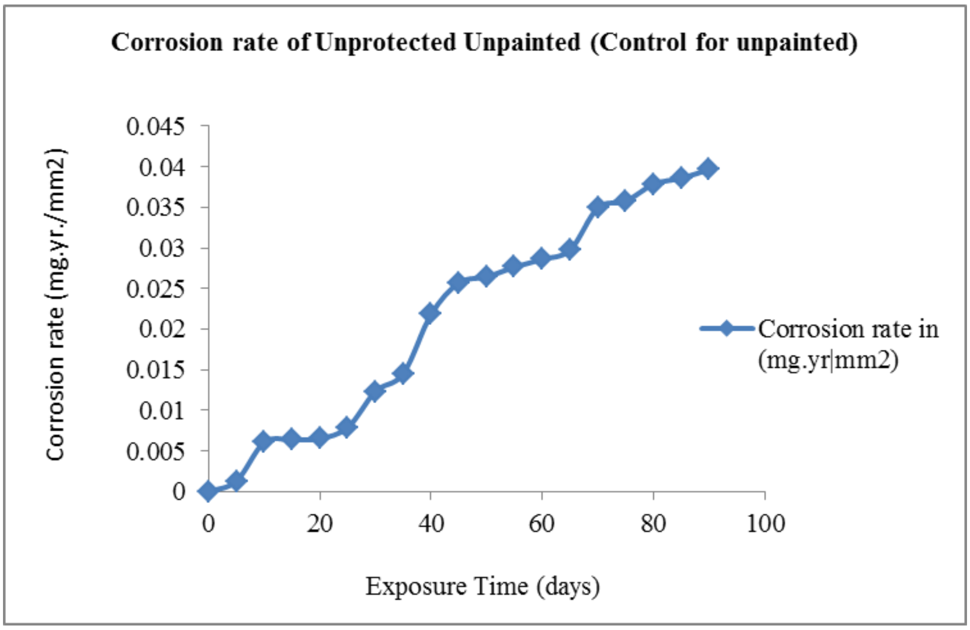

Figure 2 Corrosion Behaviour of unprotected unpainted steel well cover

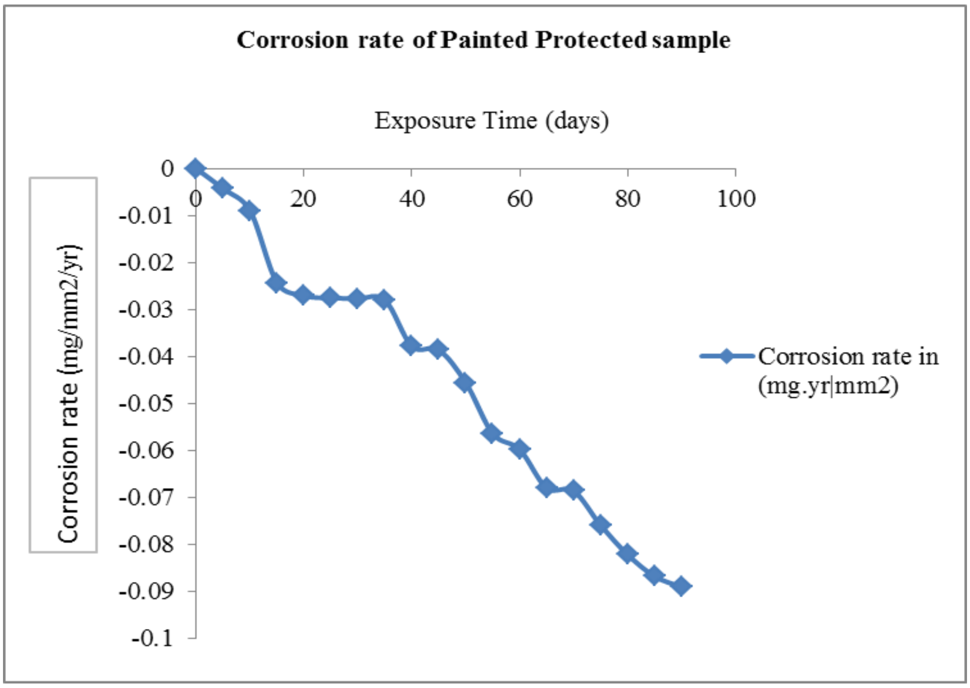

Figure 3 Corrosion Behaviour of sacrificial anode protected and painted steel well cover

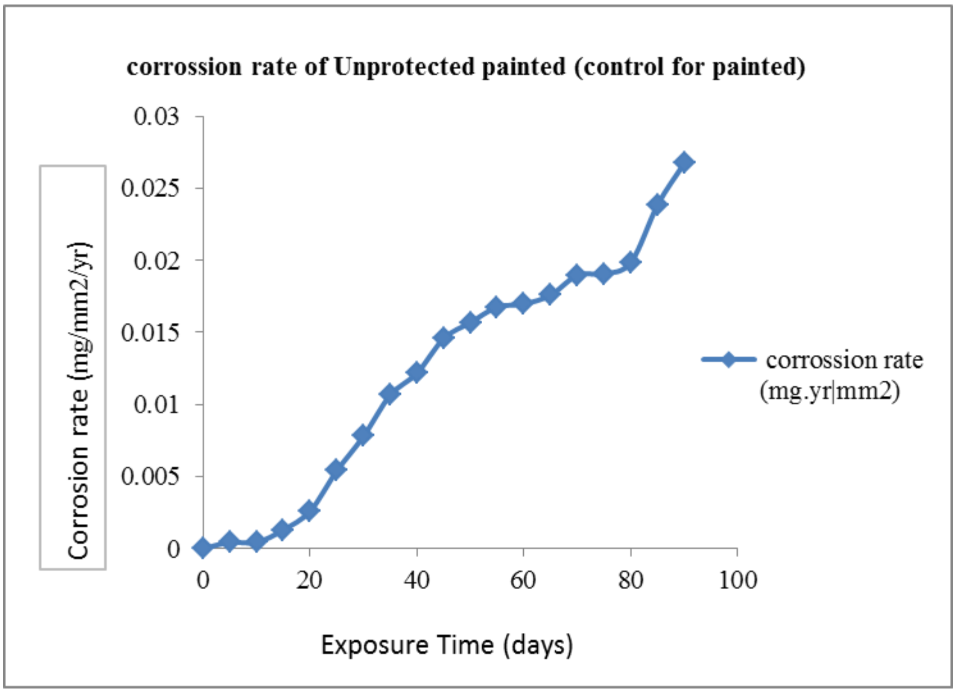

Figure 4 Corrosion Behaviour of unprotected painted steel well cover

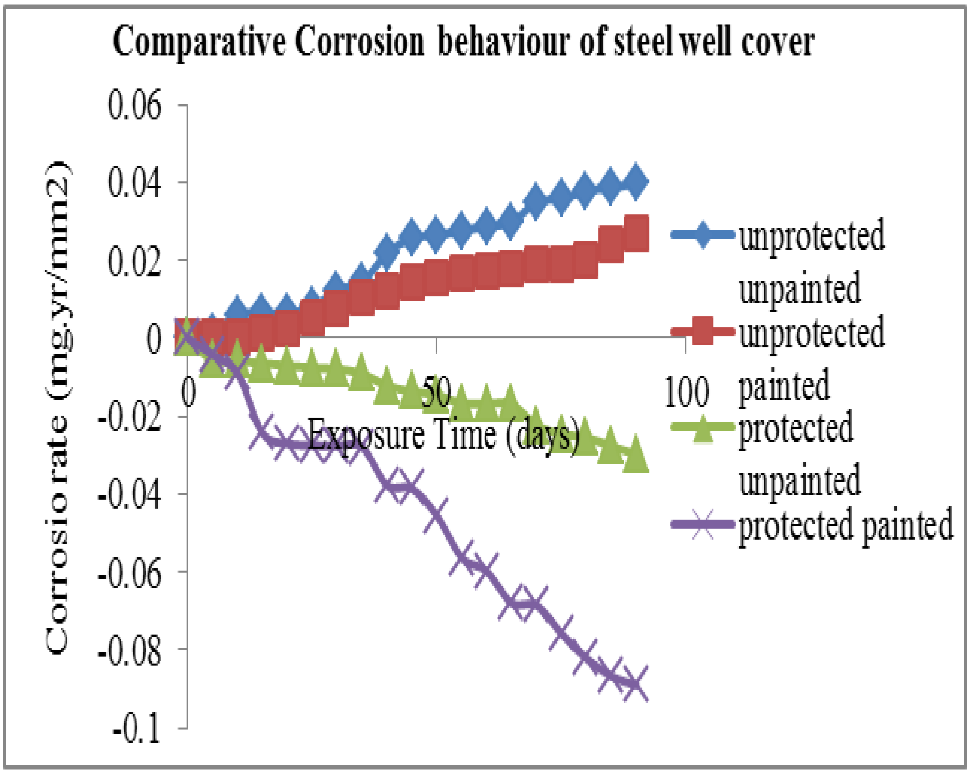

Figure 5 Comparative Corrosion Behaviour of steel well cover

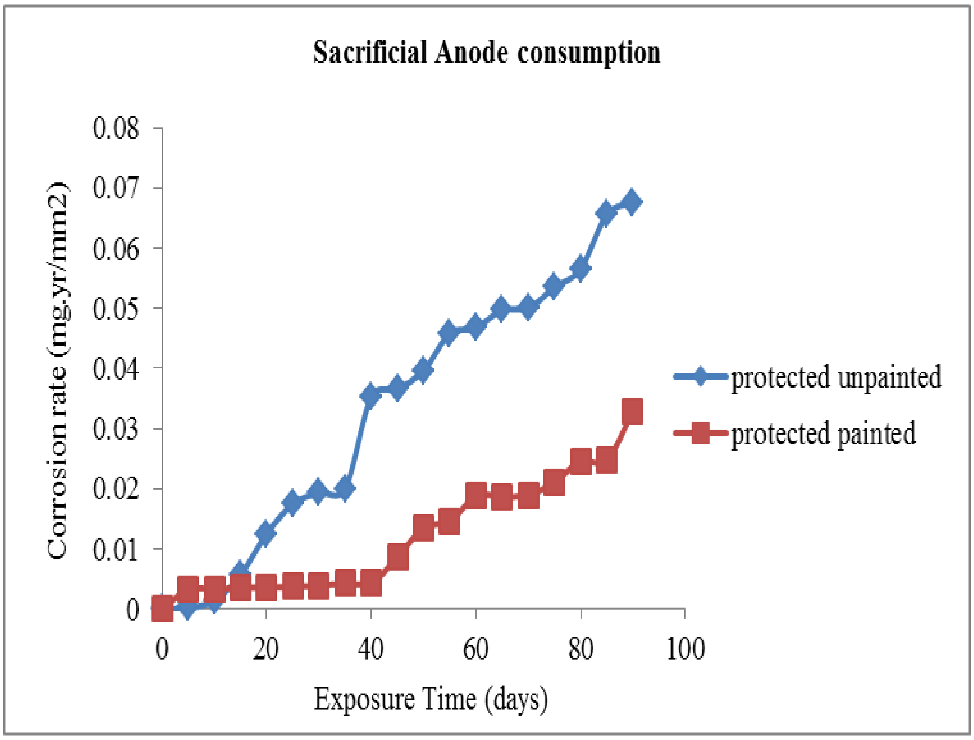

Figure 6 Rate of sacrificial anode consumption in corrosion protection of steel well cover

Figure 1 shows the corrosion behaviour of protected unpainted steel well cover immersed in well water. It can be observed that the use of zinc as sacrificial has conferred a degree of corrosion resistance on the steel well cover. The rate of corrosion decreased from 0 (zero) mg.yr/mm^2 to - 2.9 x 10^{-2} mg.yr/mm^2.

Figure 2 shows the corrosion behaviour of unprotected unpainted steel well cover immersed in well water. It can be observed that the bare mild steel deteriorated increasingly with increasing time. The rate of corrosion increases from 0 (zero) mg.yr/mm^2 to 3.9 x 10^{-2} mg.yr/mm^2. Physical observation of the coupon showed that the coupon has begun to give way to corrosion attacks.

Figure 3 shows the corrosion behaviour of sacrificial anode protected and painted steel well cover. It can be observed that the potential of the steel surface is polarized (pushed) to more negative until the surface has a uniform potential. At this stage, the driving force for the corrosion reaction is halted. The galvanic or sacrificial anode continues to corrode and thus consuming the anode material until it is eventually replaced. The polarization is caused by the current flow from the anode to the cathode. The driving force for the CP current flow is the difference in electrochemical potential between the anode and the cathode (the steel being protected). The corrosion of the cathode (mild steel) decreased negatively and progressively from 0 (zero) mg.yr/mm^2 to -8.9 x 10^{-2} mg.yr/mm^2 after 90 days of exposure in well water environment.

Figure 4 showed the corrosion behaviour of unprotected painted steel well cover. It can be observed that the paint application has conferred a degree of corrosion resistance on the steel well cover. The presence of the paint presents a barrier to corrosion attack over time. The reasons of that are attributed to continuous growth of the corrosion products layer with time, which affects the transport of oxygen to the metal surface and the activity of the surface and hence the corrosion rate. Physical observation of the coupon showed a thick layer of corrosion product. The corrosion rate increased from 0 (zero) mg.yr/mm^2 to 2.6 x 10^{-2} mg.yr/mm^2 after 90 days of exposure.

Figure 5 shows the comparative corrosion behaviour of steel well cover. It can be observed that the corrosion rate of the unprotected unpainted sample is the highest followed by the unprotected painted, protected unpainted and protected painted. The conjoint use of coatings (painting) and cathodic protection takes advantage of the most attractive features of each method of corrosion control. Thus, the bulk of the protection is provided by the coating and cathodic protection provides protection to flaws in the coating. As the coating degrades with time, the activity of the cathodic protection system develops to protect the deficiencies in the coating.
Figure 6 shows the rate of sacrificial anode consumption in corrosion protection of steel well cover with time. It can be observed that the zinc used as sacrificial anode in protecting unpainted sample was consumed faster and hence lower protection than what is observed with the same size of anode in protecting the painted.

4. CONCLUSION

1. Zinc sacrificial anode cathodic protection and painting is highly more protective for mild steel well cover.

2. Zinc sacrificial anode is also protective for bare mild steel in well water; however, its rate of dissolution by corrosion is minimal.

3. A combination of coating and cathodic protection will normally result in the most economic protection system.

REFERENCES

Akinribide, O.J. Adewuyi, B.O and Idowu, G.O. (2014): Adsorption Modeling of Corrosion Control of Ship Hulls in Marine Environment, A paper presented at 1st African Corrosion Conference Pretoria, South Africa.

ASTM G-1 & G-4: Corrosion coupon and weight loss analysis. NACE Recommended Practice RP-0775 and ASTM G-1 & G-4

Fontana M.G (1986): Corrosion engineering, Published by McGraw-Hill, Professional Publishing. USA.

Ige O.O. and Umoru L.E (2007): Effects of Tin on Aluminum – Zinc – Magnesium Alloy as Sacrificial Anode in Seawater, *Journal of Minerals & Materials Characterization & Engineering*, Vol. 7, No.2, pp 105-113.

Petrucci Ralph H., William S. Harwood, Geoffrey Herring and Jeffry D. Madura (2007); General Chemistry: Principles and Modern Applications, Ninth Edition Upper Saddle River, N.J.; Pearson Education, 848. In Print.

Muazu A. and Yaro S.A. (2011): Effects of Zinc Addition on the Performance of Aluminium as Sacrificial Anode in Seawater, *Journal of Minerals & Materials Characterization & Engineering,* Vol. 10, No.2, pp.185-198.

Natesan, M.; Selvaraj, S.; Manickam T.andVenkatachari, (2008): "Corrosion Behaviour of Metals and Alloys in Marine – Industrial Environment," *Science and Technology of Advanced Materials*, Vol.9, No.4, Article ID 045002. doi:10.1088/1468-6996/9/4/045002.

Sander,A.; Berghult, B.; Elfstrom Broo, A.; Lind Johansson, E. and Hedberg, T. (2006): Iron Corrosion in Drinking Water Distribution Systems - The Effect of pH, Calcium and Hydrogen Carbonate. *Corrosion Science, Vol.* 38, No. 3, pp 443.

Song, R., Guo, Z., Fan, A. (2004): *Corrosion Science and Protection Technology*, 16, 25.

Syed S. (2006): "Atmospheric Corrosion of Materials", *Emirate Journal of Engineering Research*, Vol.11, No.1, Pp.1-24.