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Technical Report

Comparative study of corrosion behaviour of galvanized steel and coated Al 3103 roofing sheets in carbonate and chloride environments

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ABSTRACT

This work studied the comparative corrosion behaviour of Al 3103 and galvanized steel roofing sheets in 1 M, 0.5 M and 0.3 M solutions of sodium carbonate and sodium chloride. Samples of the aluminium and galvanized sheets were subjected to the different environments for thirty days. The electrode potentials, in mV (SCE), were measured every day. Electrode potential measurements were taken everyday for thirty consecutive days. Weight loss or gain measurements were taken every three days for the duration of the exposure period.

The results showed sodium chloride environment had higher corrosive effect on the galvanized roofing sheet than sodium carbonate environment while the reverse was true for aluminium sheets. Also, galvanized steel roofing corroded more than aluminium roofing in both carbonate and chloride environments. Corrosion of galvanized steel roofing was continuous throughout the exposure period in all the environments used. Galvanized steel roofing sheet is not good material for roofing in carbonate and chloride environments or in industrial environments where chloride or carbonate contamination is possible.

1. Introduction

Ceramic roofing is widely used in temperate and cold countries. Despite the strength of ceramic roofing, the use of galvanized steel for roofing is very common in tropical countries with the subsequent defacement of aerial view of settlements due to corrosion of the roofing sheets. The massive production of Al 3103 roofing sheets has brought an option to the building industry. It is necessary to study the comparative corrosion behaviour of the two in chloride (from sea water) and carbonate (from industrial pollutants) environments.

The aluminium metal itself is a silvery white metal, ductile and malleable; hence its alloys can be made into foil, wire and sheets. It is a good conductor of both heat and electricity. It is corrosion free, burns in air to form oxide and nitride and reacts with mercury to form amalgam. It does react with dilute HCl as well, passive because of non reaction with oil or concentrated H_2SO_4 and HNO_3 due to protective layer of aluminium oxide and it is amphoteric [1–3]. The 3103 grade of aluminium alloy has some content of copper, magnesium and manganese which confer on it some of its hardness and toughness properties useful for roofing.

Galvanized sheet is a type of roofing sheet which consist of mild steel as the base metal but coated with zinc either by hot dip galvanizing process or metallic coating process. The rapid corrosion of galvanized sheet is because sacrificial protection by zinc is a temporary phenomenon and it is only effective for a short time because zinc dissolves quickly once electrolytic action begins [4].

2. Materials and methods

2.1. Materials

2.1.1. Al 3103 roofing sheet

The Al 3103 roofing sheet samples were obtained from Tower Aluminium Company located at Ogba Industrial Estate Ikeja, Lagos, Nigeria. The chemical composition is presented in Table 1.

2.1.2. Galvanized steel roofing sheet

The galvanized steel sheet sample work was obtained from Qualitec Aluminium Company located at Plot 620 Idu Industrial Estate, Abuja, Nigeria. The chemical composition is presented in Table 2.

2.2. Preparation of corrosion media

Solutions (0.3, 0.5 and 1 M) of sodium chloride were prepared by dissolving 17.55, 29.25 and 58.5 g of sodium chloride crystals in 1 dm^3 of distilled water, respectively.

0.3, 0.5 and 1 M solutions of sodium trioxocarbonate (iv) were prepared by dissolving 31.8, 53.0 and 106 g of the salt in 1.0 dm^3 of distilled water, respectively.

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Table 1
Chemical composition of aluminium roofing sheet in Wt%

Chemical composition	Al	Cu	Mg	Mn	Cr	Pb	Ni	Si	Co
Weight %	98.8	0.20	0.15	0.20	0.20	0.05	0.15	0.15	0.10

Table 2
Chemical composition of galvanized steel roofing sheet in Wt%

Chemical composition	Fe	Zn	C	Co	Mn	Ni	V	Si	S
Weight %	75.8	20.4	1.2	0.35	0.35	1.3	0.4	0.15	0.05

2.3. Experimental method

The prepared media were poured into plastic containers and test coupons of the roofing sheets measuring 50 mm × 50 mm were immersed in the plastic containers containing the various concentrations of the corrosive media.

2.3.1. Electrode potential measurement

The electrode potentials of the test specimen were read everyday for thirty days using digital multimeter (DT 830D model) with zinc rod as reference electrode. The reference electrode was immersed in the media when readings were to be taken and removed afterwards. These electrode potential values were converted into standard calomel electrode using relation:

$$\text{Electrode potential mv(SCE)} = \text{Ezn} - 1030\ \text{mV} \quad [5]$$

where Ezn is Electrode potential reading obtained using the zinc rod. SCE is standard calomel electrode.

2.3.2. Weight loss/gained measurement

The weight loss measurements were taken at intervals of three days (48 h) for thirty days using sensitive digital chemical weighing balance.

2.3.3. Cumulative weight difference

This is the increase or decrease in weight of each samples of Al 3103 and galvanized steel roofing sheets after being exposed to carbonate and chloride environments.

2.3.4. Corrosion rate

The corrosion rate of each of the specimens in different corrosion media of various concentrations were determined and calculated using the given relation below

$$R = W/AT$$

where R = corrosion rate (mg/mm^2/yr), W = weight loss/gain (i.e weight difference), A = Area of the specimens and T = exposure time.

2.3.5. Experimental conditions

(1) The experiment was carried out at normal room temperature.
(2) All experiments were performed under prevailing relative humidity.
(3) All experiments were carried out under stagnant conditions.
(4) Pressure is 1 atm that is, normal atmospheric pressure.
(5) Total immersion was used for all the experimented specimens in various corrosion media.

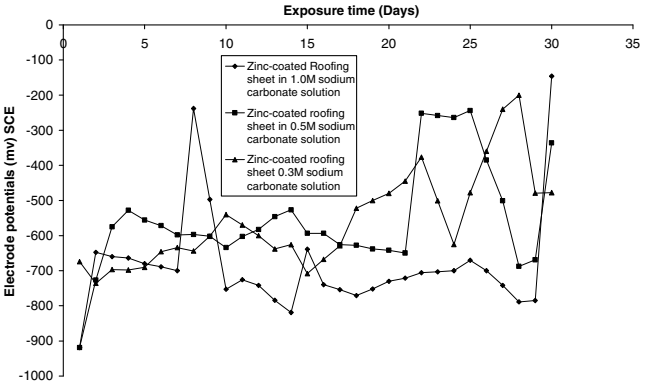

Fig. 1. Variation of electrode potential of galvanized steel roofing in sodium carbonate solutions with exposure time.

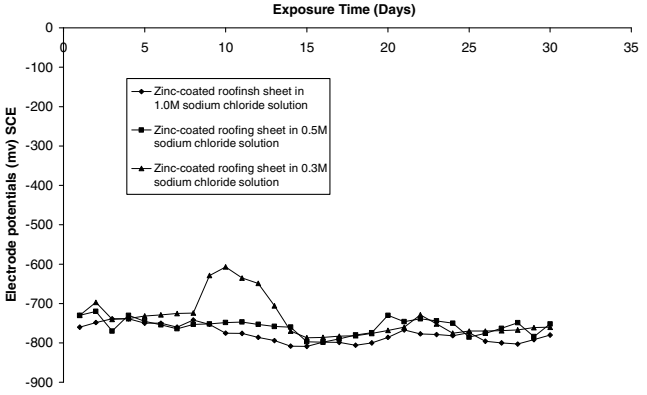

Fig. 2. Variation of electrode potential of galvanized steel roofing in sodium chloride solutions with exposure time.

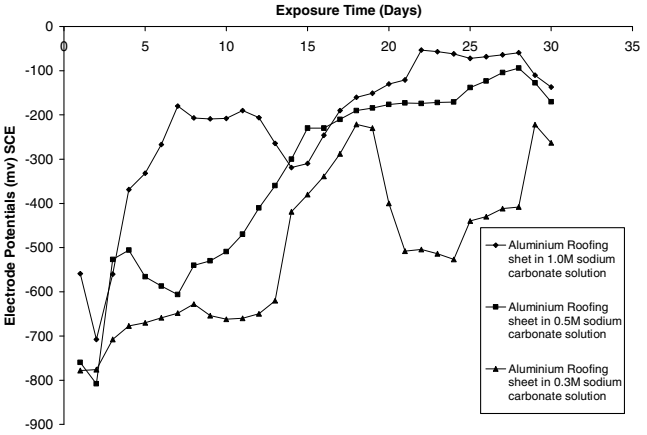

Fig. 3. Variation of electrode potential of Al 3103 roofing in sodium carbonate solutions with exposure time.

3. Results and discussions

3.1. Results

The results of this investigation are presented in Figs. 1–3.

Fig. 1 shows variation of electrode potential of galvanized steel roofing in 0.3, 0.5 and 1 M sodium carbonate solutions with exposure time. The plot shows corrosion potential higher in the 1 M carbonate solution compared with corrosion potential in the other solutions.