



Underside Corrosion of above Ground Storage Tanks (ASTs)

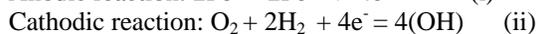
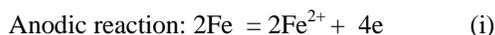
¹RIM-RUKEH, A ; ²OKOKOYO, P. A

¹Integrated Science Department, ²Chemistry Department College of Education, PMB 2090, Agbor, Delta State, Nigeria

ABSTRACT: Underside corrosion of a failed above ground storage tank (AST) was investigated by the physico-chemical analysis of water sample that was ingress between the tank bottom plate and the concrete foundation. The results of the water sample analysis showed pH (5.8), temperature (30°C), Conductivity (4800 µs/cm), dissolved oxygen (3.5 mg/l), chloride (674 mg/l), carbonate (16.90mg/l) and nitrate (23.10 mg/l). The levels of the parameters studied were generally high and above statutory safe limits. The results showed that the physico-chemical characteristics of the water sample have diagnostic and predictive values to implicate and promote underside corrosion of the studied above ground storage tank. @JASEM.

Above ground storage tanks (ASTs) are simple ambient containers that are usually constructed with metals. They are commonly used for the storage of hydrocarbons (premium motor spirit kerosene or natural gas) and in rare case, water. ASTs operational reliability and its services life can be affected by underside corrosion. For example, in the coastal region of Saudi Arabia, Ahmed (1996) had reported the failure of ASTs resulting from underside corrosion.

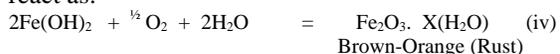
Habiby *et al* (2003) defined underside corrosion as a corrosion occurring between the tanks metallic bottom plate and its foundation. Underside corrosion is an electrochemical process as it involves transport of electron(s) from a source (anode) to a receptor (cathode) through an electrical path created by a conductive medium (electrolyte). In underside corrosion, the anode and cathode are usually localized on the tanks bottom plate. Jones (1992) affirmed that in the presence of a thin film of electrolyte, under the tank's bottom plate and its foundation underside corrosion proceeds by anodic and cathodic reactions as outlined below.



Combining (i) and (ii) gives the total redox reaction as:



The ferrous hydroxide Fe (OH)₂ of (iii) further react as:



Failure of ASTs can be very costly and environment threatening. Unlike atmosphere corrosion on visible parts and accessories, underside corrosion often remains hidden and unnoticed until leaks develop. This paper brings

into focus a study of underside corrosion in ASTs operationing in the coastal environment of Onne in Port Harcourt and whether chemical analysis of the environment has diagnostic and predictive values to implicate underside corrosion in ASTs.

STUDY AREA

Onne is located in the eastern part of Port Harcourt (Fig. 1), the home of National fertilizer complex of Nigeria (NAFCON) and other service industries. Untreated industrial and fugitive emissions are discharged directly into the atmosphere of the area. Previous study of the meteorology of the area (Gobo, 1998) reveals that the atmospheric temperature to be 25.5°C in the rainy season and 30.1°C in the dry season. The daily relative humidity values ranged from 55.5 percent in the dry season to 96 percent in the rainy season. The wind speed around Onne area is generally within 5.5-7.9 m/s, occasioned mostly by the South West wind that blows from the Atlantic Ocean. Analysis of monthly rainfall data indicates the lowest rainfall average values of 25.33mm in the dry season to 314.82mm in the rainy season.

MATERIALS AND METHODS

In order to study underside corrosion, an above ground storage tank that was constructed of low carbon steel (85% Fe, 0.6% carbon, 0.01% Ni and density 7.82g/cm³) installed in 1995 to store kerosene was investigated. The tank was installed on a concrete foundation. Eight years after the tank was put into service, leakage was observed through its bottom plate. After inspection, holes and severe pitting with the largest measuring approximately 12mm were observed in the tank's bottom plate. In corrosion failure analysis, Stein (1993) suggested the laboratory examination of the environment where the affected structure is located. As part of root-cause failure analysis,

water that has ingressed between the tank's bottom plate and the concrete foundation was collected with an automated pipette into a 250ml plastic container. The plastic container had been pre-treated by washing with dilute hydrochloric acid and rinsed twice with demonized water. The sample was analysed for pH, temperature, conductivity, dissolved oxygen (DO), chloride, carbonate and nitrate concentrations. These parameters were chosen because they are good environmental indicators for corrosion risk assessment (Bradford, 1993).

Temperature, pH, dissolved oxygen, and conductivity were determined using the multi-parameter water quality monitor. At determination of any parameter, the instrument was properly checked and calibrated before and after use. Chloride concentration was determined by Argentometric method. 5ml of representative sample was transferred into a conical flask and 2 drops of potassium chromate was added. The resulting yellow coloured solution was titrated with 0.1M solution of silver nitrate until a pink colour end point was obtained. The volume of the used titrant was noted and used to calculate the concentration of chloride (Rodier, 1975).

Nitrate concentration of sample was determined using the Brucine colourmetric technique. To 50ml of filtered sample was added 1ml HCl solution and thoroughly mixed. Calibration standards were prepared for nitrate in the range of

0 to 7mg/l by diluting to 50ml. The following volumes of intermediate nitrate solution were used (1,2,4,7.....35ml). Absorbance was read against distilled water set at zero absorbance using a Unicam UV/visible spectrophotometer. A wavelength of 220nm was used for nitrate reading and a wavelength of 275nm to determine interference due to dissolved organic matter. A standard curve was constructed by plotting absorbance due to nitrate against standard nitrate concentration. Nitrate concentration of sample was obtained directly from the standard curve.

Carbonate concentration in the sample was determined titrimetrically. 10ml of sample was introduced into a conical flask and 2 drops of phenolphthalein indicator added. The amount of carbonate was calculated by titrating the pick coloured water sample against 0.02M sulphuric acid until a colourless neutralization point was obtained (Rodier, 1975). All methods of analyses and examination are consistent with APHA (1990) and DPR (2002).

RESULTS AND DISCUSSION

The concentration of the studied parameter in the water sample is presented in Table 1.0 by comparison with standard data for clean rain water (FME, 2002), the concentration of parameter reported are indicative of a polluted environment.

Table 1. Physicochemical parameters

Parameter	Range	Mean Values (\bar{x})	SD	FME 2002
pH	5.2 – 6.4	5.8	±0.11	6.5-8.5
Temperature (°C)	22-48	30	±1.41	25-32
Cond. ($\mu\text{s}/\text{cm}$)	4000-7100	6800	±2.39	4000
DO mg/l	1.07-4.18	3.50	±0.20	5.0
Chloride (mg/l)	1018-1400	1132	±9.65	600
Carbonate (mg/l)	11.08-21-75	16.90	±0.10	40
Nitrate mg/l	19.41-31.70	23.10	±0.13	10

From the results obtained the pH value of the water sample indicates an acidic medium. Bradford (1993) suggested that acid environment with pH < 6 are more corrosive than pH from 6-8 or alkaline pH < 8. The acidity of the water sample may have resulted from substances such as ammonia, nitrogen oxides and carbon dioxide that have entered the atmosphere via industrial activities in the area, which were converted, into nitric acid, carbonic acid and ammonium hydroxide. This is further confirmed with the concentration of carbonate of (16.90 mg/l) and nitrates (23.10 mg/l) in the water sample. The

high value of nitrate (23.10 mg/l) may have resulted from photochemical oxidation of nitrogen to give oxides of nitrogen during lightening and thunderstorms. The acidic medium may have promoted underside corrosion of the failed ASTs, because the corrosiveness of water due to the aggressive nature of carbon dioxide, and acidic pH has been reported (Nielson, 1985). The pH value has a significant effect on water corrosivity through hydrogen ion reaction.

Corrosion by differential oxygen concentration in surface equipment promoted by the presence of deposits (dirt, sand and bacterial slime) has been reported (Bradford, 1993). As water ingress between the bottom plate and the foundation it is possible that differential oxygen concentration may have been regenerated thus promoting the underside corrosion of the failed ASTs. The low concentration of dissolved oxygen (3.2 mg/l) in the water sample also suggests the possibility of anaerobic corrosion in the failure of the studied structure.

The contribution of chloride concentration (1132 mg/l) to the underside corrosion of the failed structure is very significant. Chloride concentration promotes localized corrosion forms as was observed in the failed ASTs. The dissolution of CO₃, chloride salts and other deposits increases conductivity (6800 µs/cm) and hence promotes corrosion. The high concentration of chloride ion maybe due to seawater evaporation.

In conclusion, results obtained in this study showed that the physico-chemical characteristics of the water sample that ingress between the bottom tank plate and its foundation had diagnostic and predictive values to implicate and promote underside corrosion of the studied AST.

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