Corrosion In Petroleum Pipelines

Badmos, A.Y.
Department of Mechanical Engineering, University of Ilorin, PMB 1515, Ilorin, Nigeria
E-mail: bayobadmos@yahoo.com
Ajimotokan, H.A.
Department of Mechanical Engineering, University of Ilorin, PMB 1515, Ilorin, Nigeria
E-mail: hajims@unilorin.edu.ng, haajims@yahoo.com
Emmanuel, E.O
Department of Mechanical Engineering, University of Ilorin, PMB 1515, Ilorin, Nigeria

ABSTRACT: The corrosion in petroleum pipelines has been investigated by the study of the corrosion of mild steel in crude oil and refined petroleum products which include premium motor spirit (PMS), dual purpose kero (DPK), automotive gas oil (AGO), and engine oil. Weight loss technique was used in which test coupons, with a known weight, were immersed in the test media for a total exposure time of 60 days, the weight loss was measured at an interval of 10 days, and the corrosion rate was determined. The results show zero weight loss and zero corrosion rate for engine oil while both quantities are highest for PMS followed by DPK, AGO and crude oil, in that decreasing order. The observed pattern in the corrosion behavior is consistent with the density and weight percent of hydrogen in the hydrocarbon products. The weight loss and corrosion rate increase with decreasing density and increasing weight percent of hydrogen. [New York Science Journal. 2009;2(5):36-40]. (ISSN: 1554-0200).

Keywords: Mild steel, corrosion rate, weight loss, crude oil, petroleum products, hydrocarbon

INTRODUCTION

Transmission pipelines have a good safety record due to a combination of good design, materials and operating practices. However, like any engineering structure, the best-designed and maintained pipeline will become defective as it progresses through its design life. One of the major causes of pipeline defects around the world is corrosion (Callister, 1997). The selection of pipe for a particular situation is dependent on what is going through the pipe, the pressure and temperature of the contents. Pipes are fabricated from different material types to suit stringent needs and services desired. The most commonly used material for petroleum pipelines is mild steel because of its strength, ductility, weldability and it is amenable to heat treatment for varying mechanical properties (Smith and Hashemi, 2006; AbdulHameed, 2005**;** Bolton, 1994; Davies and Oelmann, 1983). However, mild steel corrodes easily because all common structural metals form surface oxide films when exposed to pure air but the oxide formed on mild steel is readily broken down, and in the presence of moisture it is not repaired (Badmos and Ajimotokan, 2009). Therefore, a reaction between steel (Fe), moisture (H_2O), and oxygen (O_2), takes place to form rust. This reaction is complex but it can be represented by a chemical equation of the following type:

$$4Fe + 2H_2O + 3O_2 = 2Fe_2O_3.H_2O \qquad (1)$$

$Fe_2O_3.H_2O$ is the rust, and as it is not usually protective, therefore, the corrosion process is not impeded (British Steel Corporation Corrosion (BISRA), 1965).

This work examines the corrosion of mild steel in crude oil and its various refined products which include premium motor spirit (PMS), dual purpose kero (DPK), automotive gas oil (AGO), and engine oil. The aim of this study is to assess the corrosiveness of the various hydrocarbons to enhance material selection and effective surface treatments of pipelines for apt quality of passivity layers to prevent corrosion.

MATERIALS AND METHODS

The crude oil was obtained from the oil field while the refined products, Premium Motor Spirit (PMS), Dual purpose kero (DPK), Automotive gas oil (AGO), and Engine oil were procured from the Filling Station and the pH of each medium was measured. Sheets of mild steel metal of 0.15 cm thickness was mechanically cut into coupons, 6x3.5cm, centrally perforated with hole of 0.7cm diameter and were surface-prepared using emery cloth, ethanol and water. Previously weighed coupons were exposed to the various test media in beakers; and the beakers were kept stationary to avoid displacement effect. Each test coupon was exposed for a total period of 60 days with six weight measurements taken at an interval of 10 days. The average corrosion rates of the coupons, measured in millimeter per year, (*mpy*), were determined using the following established relation (Lawal, 2005; Osarolube et al., 2004; Avwiri, 2004; Gregory, 2004; Ovri and Ofeke, 1998; Fontana, 1987):

$$Corrosion\ Rate = 534\ W/\rho AT \qquad (2)$$

where W is the weight loss in mg, ρ is the metal density in mg/m^3, A is the exposed area of the test coupon in m^2 , T is the exposure time in hours. The exposed area of the test coupon is determined as, A = total surface area of coupon-area of the drilled hole.

RESULTS AND DISCUSSION

The chemical composition, density and pH values of the various media are shown in Table 1. Generally, the density appears to increase with decreasing weight percent of hydrogen content of the media. The densities of PMS and AGO are respectively 763.2 and 835.4 kg/m^3 while their weight percent hydrogen contents are 14.4 and 12.8 respectively.

Uniform corrosion was observed in all the test coupons immersed in the media and the results of the weight loss and corrosion rate measurements are as shown in Tables 2 and 3, respectively. The corresponding plots of weight loss and corrosion rate as a function of exposure time are shown in Figures 1 and 2. Weight loss and corrosion rates are shown to be highest in PMS and negligible in engine oil. The values of the weight loss and corrosion rates for the other media are in the following decreasing order, DPK, AGO and Crude oil.

Table 1: Elemental compositions, densities and pH values of Test Media

Elemental Composition	PMS *(wt.%)*	DPK *(wt.%)*	AGO *(wt.%)*	Engine oil *(wt.%)*
Carbon c	85.5	86.3	86.3	86.1
Hydrogen H	14.4	13.6	12.8	11.8
Sulfur S	0.1	0.1	0.9	2.1
Density (kg/m^3)	763.2	794.0	835.4	823.0
pH value	6.6	7.0	6.2	7.0

Sources: Adebayo, 2004; Beckwith et al., 1987

Table 2: Weight Loss by Mild Steel in the Test Media

Exposure Period (Days)	PMS *(gm)*	DPK *(gm)*	AGO *(gm)*	CRUDE OIL *(gm)*	ENGINE OIL *(gm)*
10	0.004	0.002	-	-	-
20	0.007	0.004	0.002	0.002	-
30	0.011	0.006	0.004	0.004	-
40	0.015	0.009	0.006	0.004	-
50	0.019	0.011	0.008	0.006	-
60	0.023	0.014	0.010	0.006	-

Table 3: Corrosion Rate of Mild Steel in the Test Media

Exposure Time *(Days)*	PMS *(mpy)x10^{-05}*	DPK *(mpy)x10^{-05}*	AGO *(mpy)x10^{-05}*	Crude oil *(mpy)x10^{-05}*	Engine oil (mpy) *x10^{-05}*
10	2.54	1.27	-	-	-
20	2.23	1.27	0.637	0.637	-
30	2.33	1.27	0.849	0.849	-
40	2.39	1.43	0.955	0.637	-
50	2.41	1.40	1.01	0.784	-
60	2.44	1.49	1.06	0.637	-

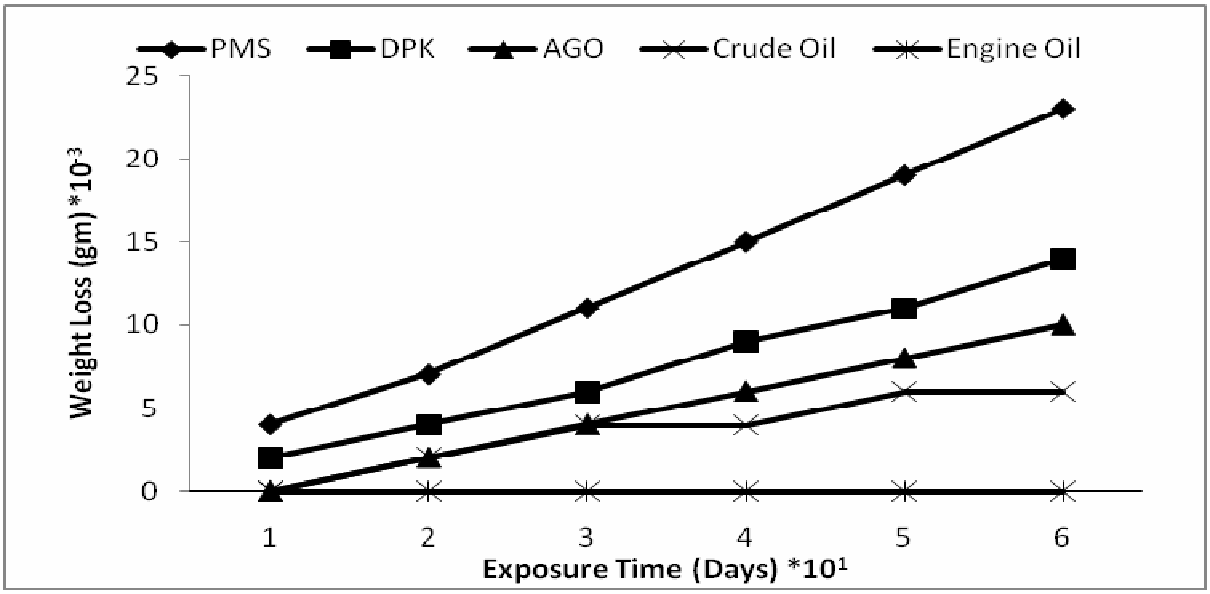

Figure 1: Variation of Weight Loss Vs Exposure Time for all Media

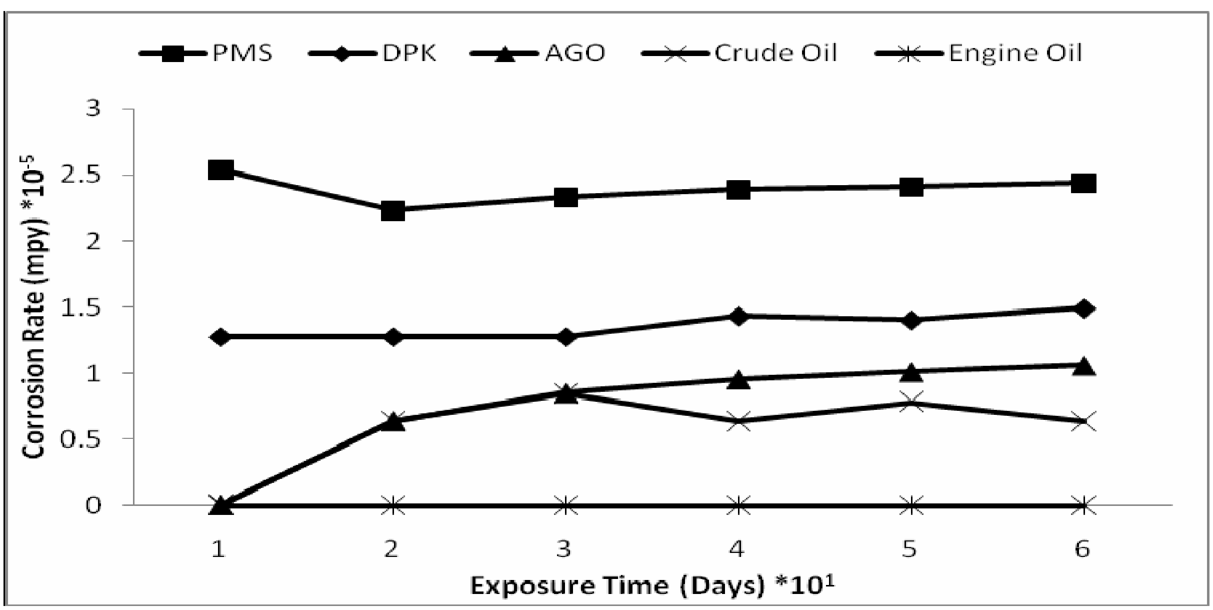

Figure 2: Variation of Corrosion Rate Vs Exposure Time for all Media

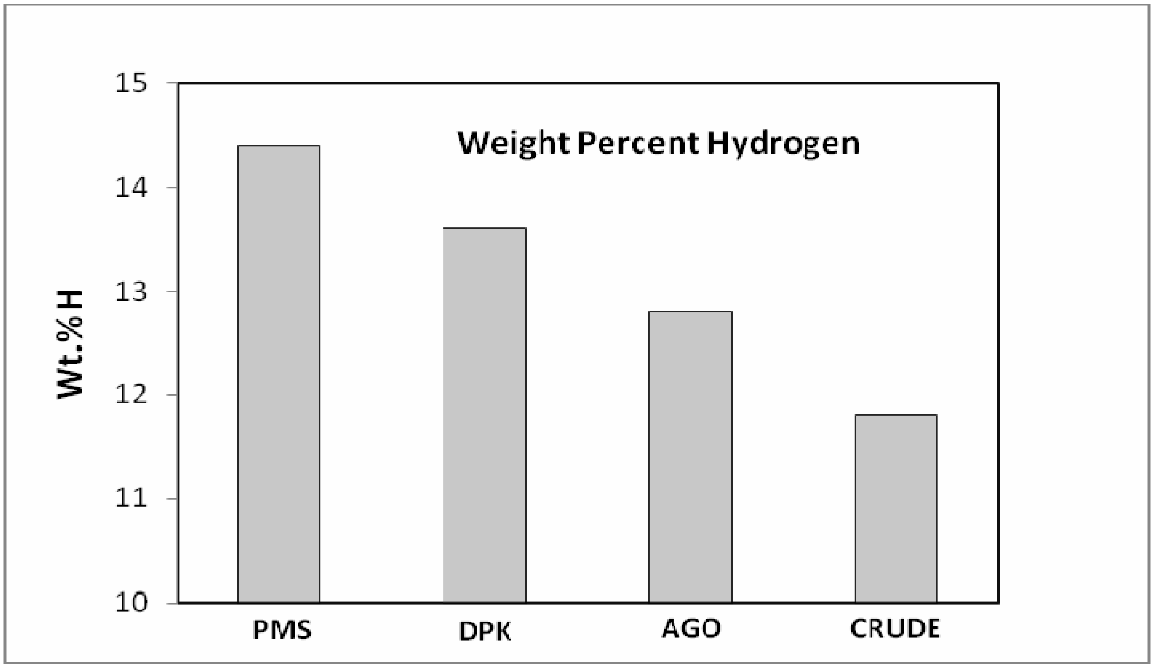

Figure 3: Weight Percent of Hydrogen in the Hydrocarbon Media

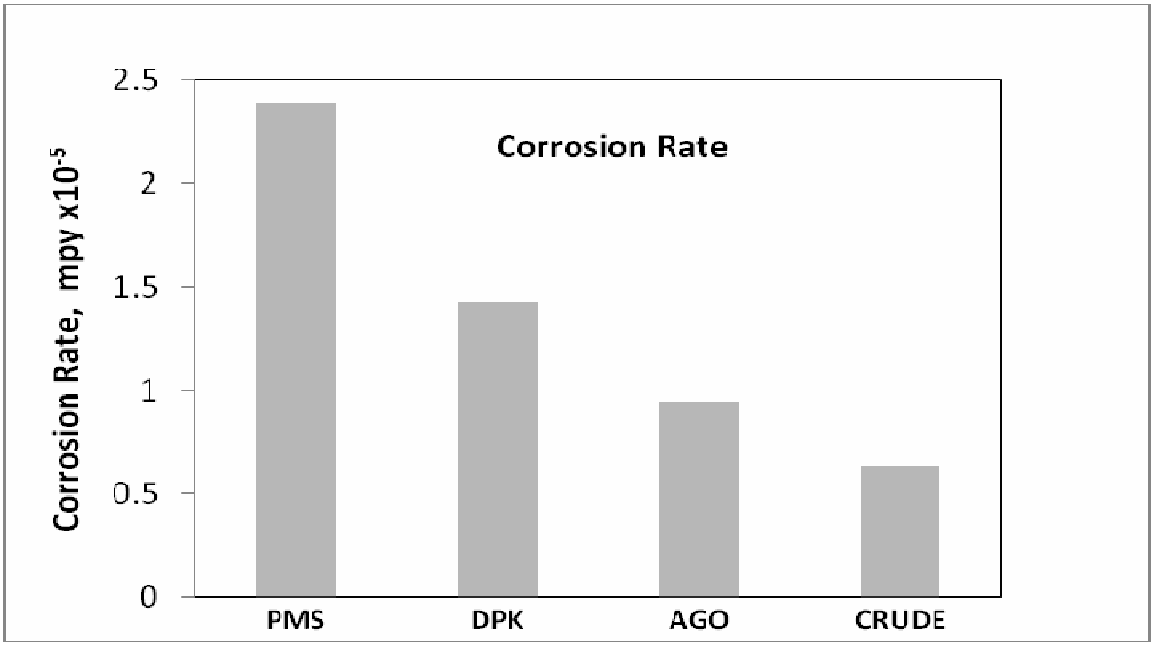

Figure 4: Average Corrosion Rates of the Hydrocarbon Media

CONCLUSIONS

Corrosion in petroleum pipelines have been investigated by the study of the corrosion of mild steel in crude oil and its products which include the premium motor spirit, PMS, dual purpose kero, DPK, automotive gas oil, AGO, and engine oil. The following observations were made.

1. Generally, density appears to increase with decreasing weight percent of hydrogen in the hydrocarbon media.
2. Corrosion rate is highest in PMS, negligible in engine oil, and in the following decreasing order for the other media, DPK, PMS, and Crude oil.
3. Corrosion rate is observed to decrease with decreasing weight percent of hydrogen content in the hydrocarbon media.

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