The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 8||Pages|| 31-35||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

Evaluation of Corn Water for Corrosion Inhibitors Extract

T.A Yusuf[1], D.T Gundu[1], M.I Oseni[1], B.O Bolaji[2] and S.O Ismaila[2]
[1]*Mechanical Engineering Department, University of Agriculture, P.M.B 2373 Makurdi Benue State, Nigeria.*
[2]*Mechanical Engineering Department, University of Agriculture, P.M.B 2240 Abeokuta, Ogun State, Nigeria.*

ABSTRACT
: *Corrosion Inhibitors are used as concentrates in water-based engine coolants to prevent corrosion. However, researches are still progressive on the new sources of these inhibitors as they are majorly inorganic and expensive. Meanwhile, corn water is cheaply available and organic. It is mostly decanted off fermented corn paste, Ogi as waste products. This study investigated whether corn water contains organic corrosion inhibitors which when extracted makes it an alternative source of corrosion inhibitors. Two samples of corn water were produced from fermented white and yellow corn. The samples were subjected to standard analytical test for related physicochemical properties. Organic corrosion inhibitors such as Phosphates, Nitrites and Silicates were determined.*

Keyword: *Corn Water, Corrosion Inhibitors, Engine Coolants, Fermentation, Physicochemical Properties.*

Date of Submission: 26 June, 2013 ⟷ Date of Acceptance:05,September 2013

I. INTRODUCTION

Corrosion poses a serious challenge to various engineering systems such as in engines of machines and automobiles. Thus, solving various problems relating to it is of utmost concern to the engineers in research, design and applications. Among the methods to combat corrosion related problems in cooling and lubricating systems is the selection and use of fluid that are resistant to corrosion. Water is regarded as the best heat transfer fluid because of its cheap availability, biodegradability and relatively appreciable thermo physical and physicochemical properties. However, water in itself is not perfectly suitable as excellent coolant in automobile engines. Water is corrosive due to the presence of ions and minerals. Hence, it is mostly deionized and enhanced with corrosion inhibitors. Consequently, research is on-going on a substitute fluid, probably similar to water in its characteristics but contains corrosion inhibitors as part of its constituent compounds. Meanwhile, Corn water belongs to such classes of fluid. It is a member of water family and may be necessary to investigate it for organic corrosion inhibitors. This is the objective of this study so that it could be better utilized as substitute for water since it would only probably need to be deionized. It would require no or low enhancement with corrosion inhibitive compounds.

II. REVIEW OF RELATED LITERATURES

2.1 Corn and Its Fermentation

Although development of new or expanded industrial (non-food) markets for corn has been of concern for several decades, perhaps interest has never been more intense than in recent years (Doan, 2007). According to (Adegunwa *et al*, 2011), Ogi (corn starch) is the product obtained by fermentation of corn. Meanwhile, Ogi, being an important cereal porridge in the West African sub-region, has for sometime been a subject of scientific evaluations (Osungbaro, 2009). Past work by Steinkraus (1996) showed that about one third of the Nigerian population consume ogi for at least once in a week.

Fermented foods, unlike non-fermented foods, have a longer shelf-life, making fermentation a key factor in the preservation of such foods (Holzapfel, 2002; Omar *et al.*, 2006). Because fermentation improves keeping quality and nutritional value, it is a predominant food processing and preservation process (Lei *et al.*, 2006; Shetty *et al.*, 2007).Corn is an important agricultural product that in the period of 2008-2009, nearly 789 million tons of corn was produced throughout the world (CRAR, 2009). Corn processing industries take corn apart and purify its different constituents and condition these constituents to be used in food and other industries (Anderson & Watson, 1982). Starch, gluten, dextrin, glucose and fructose are the main products produced by corn processing.

Corn based glucose products are significant ingredients in major international markets (food, biochemical, pharmaceutical). According to (Eremektar et al., 2002; Ersahin et al., 2007), there are two distinct processes for corn processing; wet-milling and starch slurry derivatives production (refinery) and each process generates unique co-products. Banigo and Muller (1972) have also evaluated the production and physicochemical properties of ogi from maize and millet.

2.2 Engine Coolant and Corrosion

Karshan et al (2012) has evaluated agricultural byproducts to determine their potentials as nonhazardous corrosion inhibitors. According to (Walters and Duke, 2009), the corrosiveness of various source waters is generally a function of the concentration of corrosive ions (such as chloride and sulfate) and electrolytic (or ionic) strength that are concentrated in evaporative systems that cool heat transfer surfaces. Accordingly, varying source water quality will impact system corrosion, and determines the required level of protection needed from a corrosion inhibiting mechanism.A coolant is a fluid which flows through or around a device to prevent its overheating, transferring the heat produced by the device to other devices that use or dissipate it. An ideal coolant has high thermal capacity, low viscosity, low cost, non-toxic, and chemically inert, neither causing nor promoting corrosion of the cooling system (www.en.wikipedia.org/wiki/coolants). In spite of much advancement in the field of corrosion science and technology, the phenomenon of corrosion (mainly of Fe, Al, Cu, Zn, Mg and their alloys) remains a major concern to industries around the world (Viswanathan, 2010). Many factors can influence the corrosion, including pH, hardness, alkalinity, oxidizing agents, carbon dioxide, dissolved solids, temperature, velocity of flow, bacteria, metal characteristics, and stray electric currents. (www.water.me.vccs.edu/courses/env110/lesson8.pdf). According to (Bennick and Frauenhoffer, 2008), Pitting is the most common type of corrosion when metalworking fluids contain excessive minerals and ions. Simply thought of as dissolved salts in the coolant solution, these minerals and ions usually come from the make-up water used for dilution.

2.3 Phosphates, Silicates and Nitrites as Corrosion Inhibitors

Corrosion Inhibitors are additives in coolants that inhibit corrosion and scale formation in the engine cooling system. Corrosion inhibitors have ample significance as individual inhibitors or as a component in chemical formulations. They have wide commercial applications such as in cooling waters, oil and gas fields, paints pigments, lubricants etc. (Nathan, 1973). According to (Garbutt, 2004), Corrosion inhibitors fall into many general classes like phosphates, silicates and organic acids. Sodium molybdate is a common and very effective broad-spectrum corrosion inhibitor as is Tolytriazole. Sodium salts of molybdate, nitrate, nitrite, borate, benzoate, phosphate, silicate, etc. are used because they dissolve so well in water. Coolant additives may include organic acids, silicates and phosphates, nitrites, defoamers and bittering agents (Penrite, 2011). Qun and Lang (2011) also listed silicates and phosphates as commonly used inhibitors. The conventional inorganic inhibitors continue to be the best choice in inhibitor packages. Many of the recent patents contain inhibitors such as silicates, phosphates, molybdates and tungstates as a component in the proposed combination (Viswanathan, 2010). Corrosion inhibitors such as nitrite and/ or molybdate are preferably used in coolant to combat this cavitation corrosion since they form barrier films on metal surfaces preventing corrosion resulting from localized bubble implosion (www.coolantexperts.com). Silicates are often used for both ferrous and yellow metal corrosion control in soft portable water applications, where minimal heat transfer is involved (Ray and Reggiani, 2006). And according to the findings of Szilágyi (2009), organic inhibitors deplete much slower than inorganic ones.

III. MATERIALS AND METHODS

3.1 Ogi/Corn Water Preparation

Two colour samples of corn water were decanted from white and yellow varieties of Ogi prepared separately through fermentation process which took five to six days. The method was described by Akinrele (1970) and as shown in fig.1

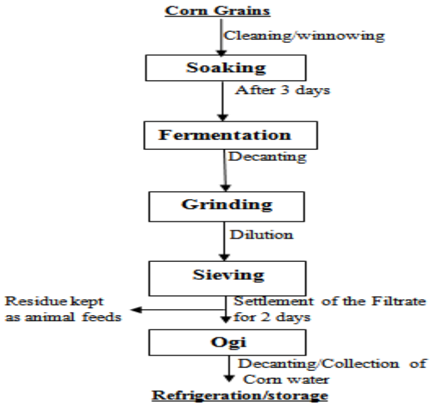

Figure 1: Process Diagram for Ogi/Corn Water Production

3.2 Samples Preparation

The two samples were separately kept in 5litre kegs for analytical test for the following physicochemical parameters: pH, hardness, Cu, Lead, Iron, Zinc, Aluminium, Magnessium, calcium, Chlorine, Silicate, phosphate Nitrites and bacterial.

3.3 Analytical Laboratory and Methods

The study was carried out at Benue State Rural Water Supply and Sanitary Agency (BENWASSA), 179 Ahmadu Bello way, Old GRA Makurdi Benue State Nigeria. It was a state government owned establishment for sanitation, qualification and regulation of water supply to the citizens of the state.

3.4 Analytical Methods

The routine standard methods for water, wastewater and seawater were used for the analysis. Digestion was initially carried out prior to analysis of some few parameters such as heavy metals of Copper and Lead. Few of the methods are presented on Table 1

Table 1: Analytical Methods for specific Parameters

Parameters	Method
pH	pH meter from HANNA Company
Total Hardness	Hardness Test Kit Model HA-4P-MG-L
Copper	Digestion and Bicinchoninate (Powder Pillows); EPA Approved
Iron	FerrroVer Powder Pillow
Phosphate	Phosver 3 Method
Nitrite	Diazotization (Powder pillows); EPA Approved
Silicate	Heteropoly Blue Method
Bacterial	Plate Count Method

IV. RESULTS

The results of the analysis for each of the samples are given in Table 2

Table 2: Physicochemical Properties of Corn Water

S/N		Parameters	Yellow Corn Water	White Corn Water
1	Corrosion Factors	pH	6.24	6.30
		Hardness (mg/l)	260	200
2	Corrosion Minerals (mg/l)	Copper (Cu)	1.84	1.36
		Lead (Pb)	0.07	0.05
		Zinc (Zn)	2.14	2.08
		Iron (Fe)	1.63	2.21
		Aluminium (Al)	0.20	0.17
		Magnesium (Mg)	100	80
		Calcium (Ca)	160	120
		Chlorine (Cl)	19.7	15.9
3	Bacterial(CFU)*	Load/100ml	900	550
		E-Coli (x 10^5)	86	74
		Proteus spp (x10^5)	1.0	1.0
		Salmonella spp	Nil	Nil
4	Corrosion Inhibitors (mg/l)	Silicate	0.18	0.14
		Phosphates	2.42	2.36
		Nitrites	0.14	0.08

***Colifom Forming Unit**

V. RESULT DISCUSSIONS

5.1 PH

The pH is slightly acidic. Meanwhile, this result corresponds to what was reported by Ajima, et al (2011) that the pH of Ogi was acidic due to fermentation which led to accumulation of some acids. As acidic pH has been reported to favour corrosion though, it may not be pronounced in corn water as the recorded pH value is not only weakly acidic but also close to neutral. Giving this consideration, white corn water is better than yellow corn water. Meanwhile, some utilities adjust pH and/or alkalinity for corrosion control to mitigate lead and copper corrosion. Others add phosphate corrosion inhibitors (WRF, 2009).

5.2 Hardness

Just like the pH, the higher the hardness the higher the probability of corrosion. This result is expected as hardness is the concentration of Magnesium and Calcium ions. Apparently, the hardness values are fairly significant but when the samples are deionized, the hardness is reduced. From the result, white corn water is less hard than the yellow in terms of their corrosion resistance power.

5.3 Minerals

Mineral presence also aid corrosion tendency of a fluid. Except for Iron, yellow corn water has more percentages of minerals than white corn water. The recorded 120mg/l concentration of Calcium was the same with what was reported for phase III high alkalinity test water (WRF, 2009). The higher concentrations of these ions in yellow corn water are responsible for the higher hardness in the sample. Thus, it may pose more corrosion challenges. Meanwhile, the quantities of the minerals may not be used for evaluating the samples as all the minerals would have to be removed through the deionization.

5.4 Bacterial

Bacterial also catalyze the rate of corrosion. Yellow corn water has a total mass number of 900 colliform bacteria while the white corn water contains 550. When isolated, E.coli and Proteus spp were uniquely identified in their respective recorded amount while Salmonella spp was not found. White sample has less and for this reason, may be regarded better than yellow sample. However, these bacteria can also be isolated to improve corrosion inhibitive strength of the samples.

5.5 Corrosion Inhibitors

The recorded value for nitrites, silicates and phosphates for yellow corn are higher than respective values for white corn water. Therefore, it suggests that Corrosion inhibitors are in larger amount in Yellow corn water.

VI. CONCLUSIONS

Corn water contains nitrites, phosphates and silicates as corrosion inhibitors. This is an advantage over water. Meanwhile, they are present in more quantities in yellow corn than in white corn water. Its properties of pH, Hardness, minerals and bacterial constituents are easily adjustable or extractable to meet requirement for corrosion inhibitors. Hence, corn water can serve as a new source of organic inhibitors extract. Meanwhile, the literatures reviewed indicate that little or nothing has been done by previous researchers on properties of corn water in relation to technology and engineering. Most previous works were related to fermented corn paste, Ogi and its food utility value. Corn water is more or less a waste product and may at present have no significant contribution but may hold a promising future in coolant technology if well researched and adapted.

6.1 Implication of the study

This study is significant for following implications:

(i) Corn water is largely decanted and discarded as a waste product. This study has exposed its vital utility and values in scientific researches.

(ii) Previous researches were focused on corn paste, Ogi and are mostly related to its food and agricultural interest. This study adapted corn water to its prospects in engineering and technology.

(iii) The study is possibly the first to identify minerals, bacterial and other physicochemical properties of corn water, not paste (Ogi). This accounts for why there is dearth of literatures on discussion of the results.

REFERENCES

[1]. Adegunwa, M. O; Alamu, E.O; Bakare, H.A; Godwin, P.O (2011). Effect of Fermentation Length and Varieties on the Qualities of Corn Starch (Ogi) Production. Am. J. Food. Nutr, 1(4): 166-170

[2]. Ajima, U; Ogbonna, A.I; Olotu , P.N; Asuke, A.U (2011). Evaluation Of Fungal Species Associated With Dried Ogi. Continental J. Food Science and Technology 5 (1): 17 – 25.

[3]. Akinrele, I.A. (1970) Fermentation Studies on Maize during the Preparation of Traditional African Starch-cake Food. Journal of food, Science and Agriculture 21:279-280

[4]. Anderson, R. A. & Watson, S. A. (1982). The corn milling industry, In: Handbook of Processing and Utilization in Agriculture, Wolff, I. A. (Ed.), 31-78, CRC Press, ISBN: 0-8493-3872-7, Florida, USA

[5]. Banigo, E.O.I., Muller, HC. (1972). Manufacture of Ogi (A Nigerian Fermented Cereal Porridge: Comparative Evaluation of Corn, Sorghum and Millet. Canadian Journal of Food Science and Technology 5, 217 – 221. 72.

[6]. Szilágyi, Balint (2009). Corrosion Inhibitors in Antifreeze Coolants. 44th International Petroleum Conference, Bratislava, Slovak Republic, September 21-22; Pp1-20.

[7]. CRAR(2009). Corn Refiners Association 2009 Annual Report, http://www.corn.org/CRAR2009.pdf. Accessed 10 August 2010.

[8]. Doan, W.M (2007). New Industrial Uses of Corn. Northern Regional Research Center, Agricultural Research Service U.S. Department of Agriculture, Peoria, IL 61604.

[9]. Eremektar, G.; Karahan-Gul, O.; Babuna, F. G.; Ovez, S.; Uner, H. & Orhon, D. (2002). Biological treatability of a corn wet mill. Water Science and Technology, 45, 12, 339– 346.

[10]. Ersahin, M. E.; Insel, G.; Dereli, R. K.; Ozturk, I. & Kinaci, C. (2007). Model based evaluation for the anaerobic treatment of corn processing wastewaters. Clean-Soil Air Water, 35, 6, 576-581.

[11]. Garbutt Lee (2004). PC Water Coolant Chemistry – Part II.www.overlockers.com

[12]. Holzapfel, W.H. (2002). Appropriate Starter Culture Technologies for Small-scale Fermentation in Developing Countries. International Journal of Food Microbiology, 75: 197-212.

[13]. Kharshan, M. et al (2012). Novel Corrosion Inhibitors Derived from Agricultural Byproducts. Cortec Supplement to Materials Performance. Cortec Corp. St. Paul, Minnesota.

[14]. Lei, V.; Friis, H.; Michaelsen, K.F. (2006). Spontaneously Fermented Millet Product as a Probiotic Treatment for Diarrhea in Young Children: An Intervention Study in Northern Ghana. International Journal of Food Microbiology 2006; 110, 246-253.

[15]. Nathan, C.C (1973). Corrosion inhibitors. National Association of Corrosion Engineers: Houston.

[16]. Omar N.B.; Abriouel H.; Lucas R.; Martinez-Caňamero, M.; Guyot, J.; Gálvez A. (2006). Isolation of Bacteriocinogenic Lactobacillus plantarum Strains from Ben Saalga, a Traditional Fermented Gruel from Burkina Faso. International Journal of Food Microbiology, 112: 44-50.

[17]. Osungbaro, T.O (2009). Physical and Nutritive Properties of Fermented Cereal Foods. Afr. J. Food Sci. Vol 3(2) pp. 23-27.

[18]. Penrite Oil Company Pty Ltd (2011). Engine Coolants. Fact Sheet December 2011; Australia.

[19]. Qun Xu and Lang Li. (2011). An Improved Method for Determination of Corrosion Inhibitors in Engine Coolants. Thermo Fisher Scientific Inc. San Jose, CA USA.

[20]. Ray, S. and Reggiani, G.M (2006). Molybdenate and Non-Molybdenate Options for Closed Systems-Part II. National Colloid Company and eastern technologies Inc. 2005 AWT Annual Convention, palms Springs califonia. Pp17-37.

[21]. Shetty, P.H.; Hald, B.; Jespersen, L. (2007). Surface Binding of Aflatoxin B1 by Saccharomyces cerevisiae Strains with Potential Decontaminating Abilities in Indigenous Fermented Foods. International Journal of Food Microbiology, 113: 14-46.

[22]. Steinkraus, K.H. (1996). Indigenous Fermented Food Involving an Acid Fermentation. Handbook of Indigenous Fermented Foods, Mercel Dekker, Inc. New York.

[23]. Viswanathan S. Saji (2010). A Review on Recent Patents in Corrosion Inhibitors. Recent Patents on Corrosion Science, vol. 2, 6-12. Bentham Open Acess Journal.

[24]. Walters, J & Duke, D (2009). Effective Use of Recycled Water in Cooling Towers With New Green Technology. West Basin Municipal Water District, Carson CA & Water Conservation Technology International, Temecula CA.

[25]. Water Research Foundation (2009). Impact of Phosphate Corrosion Inhibitors on Cement-Based Pipes and Linings; USA.