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COW URINE AS CORROSION INHIBITOR FOR ALUMINUM METAL IN ALKALINE MEDIA

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ABSTRACT

The objective of this work is to investigate the corrosion inhibition property of cow urine in alkaline medium for aluminum metal at room temperature. Cow urine contains about 2.5% urea which has N and O atoms. The compounds having such atoms bear lone pair of electrons through which they show ability to be adsorbed on metal surface by coordinate bonding. This characteristic is responsible for its corrosion inhibitive action. In present investigation the weight loss method was adopted for corrosion inhibition test for aluminum metal in 1M NaOH and 1M KOH solution in absence and in presence of various concentration of cow urine. The corrosion rate decreased significantly in presence of the inhibitor and percent inhibition efficiency increased with increasing concentration of the urine. The corrosion rate was observed higher in case of 1M KOH. The inhibition efficiency was recorded maximum (73.41%) for 10% cow urine concentration with 1M KOH solution. Adsorption behavior obeyed the Langmuir, Freundlich and Temkin adsorption isotherms.

Keywords: cow urine, corrosion inhibitor, aluminum, alkaline medium, Langmuir, Freundlich and Temkin adsorption isotherm.

INTRODUCTION

Aluminum has got a unique position in large number of applications due to its light weight, white shining surface and corrosion resistance towards atmosphere and considerable strength. Pure aluminum and its alloys have various industrial applications. Aluminum anodes are used in aluminum/air batteries in alkaline medium where a large amount of metal loss is observed as corrosion of aluminum in NaOH. A solution of sodium hydroxide or potassium hydroxide is generally used in finishing of the surface of aluminum before its use [1]. The aluminum surface is normally coated with protective alumina (Al_2O_3) layer. Aluminum and alumina are amphoteric, i.e., can be attacked both by acids HF/HCl and by bases such as NaOH/KOH. The protective Al_2O_3 layer gets degraded by the use of NaOH and/or KOH as pickling solution. Aluminum and aluminum alloys are very sensitive to alkaline media. Therefore, some chemicals are required to prevent the metal solubility [2-3]. The aluminum metal dissolution in such environment can be minimized by putting an obstacle between metal and corrosive environment. Corrosion inhibitors are the substances that retard corrosion rates through adsorption process. They form a passive layer on the surface of metal through lone pair electrons of N, O and/or S atoms present in the inhibitor [4-5].

Chemical corrosion inhibitors based on heavy metal atoms have been extensively used for the protection of metals in various corrosive media but they are environmentally unsafe [6]. Natural products such as extracts of different parts of plants and trees have also been more widely considered due to their nontoxic and environmentally benign nature [7-12].

In Ayurvedic therapy a lot of medicinal values like antiseptic and disinfectant nature of cow urine have been reported. Even though urine of many animals is used in preparing medicines, cow's urine has been found to be the best among all. A general composition of cow urine comprises 95% water, 2.5% urea (H_2N-CO-NH_2) and rest minerals & salts. It contains 24 types of salts as well as iron, calcium, magnesium, phosphorous, potash, chlorides, sulfates, uric acid and lactose. The main constituent of cow urine that shows disinfectant activity is carbolic acid, which is a mixture of phenol and cresol [13]. However, the corrosion inhibition ability of cow urine has not been reported in detail so far.

The present work was carried out to investigate the corrosion inhibition property of cow urine for aluminum in 1M NaOH and 1M KOH solution.

EXPERIMENTAL

Materials and Methods

Alloy Used

The coupons of size 2×2×0.1 cm mechanically cut from commercially available aluminium sheet were used for all experiments.

Cow Urine

Crude cow urine was collected from a cow of Fijian breed domestically pet in Gorakhpur city of India.

pH of the Cow Urine

The pH value of the cow urine was measured with the help of a pH meter and it was found to be 7.9 which indicated the urine was basic in nature.

Corrosion Medium

1M NaOH and 1M KOH solutions with 2, 4, 6, 8 & 10 % cow urine and without cow urine were used for weight loss studies.

Weight Loss Studies:

Wight loss studies were carried out at room temperature (27 °C). The aluminium coupons were weighed and weights per unit surface area were calculated. The aluminium samples were immersed in 100 ml test solutions of molar sodium hydroxide and molar potassium hydroxide without and with various percent concentration of cow urine as inhibitor. The weight loss studies were carried out for 150 minutes duration. The reaction of aluminum in alkaline solution is due to the dissolution of oxide layer.

(1) The reaction that occurs between the aluminum and the sodium hydroxide is

$$2Al+2NaOH+6H_2O \rightarrow 2Na[Al(OH)_4]+3H_2$$

(2) Aluminum may also dissolve as aluminate (AlO_2^-) under hydrogen release, according to the reaction[14].

$$4Al + H_2O + OH^- \rightarrow 2AlO_2^- + 3/2\ H_2$$

Corrosion rates (weight loss per cm² per hour) were calculated using following expression [15], surface coverage and inhibition efficiency were also estimated.

Corrosion Rate = $(\Delta M/M_1)\times 100$

Where, ΔM = weight loss and

M_1 = initial weight of coupon

Surface coverage (θ) = $(R_1-R_2)/R_1$

Where, R_1 and R_2 are corrosion rate in absence and in presence of inhibitor respectively.

% Inhibition Efficiency = $\theta \times 100$

RESULTS AND DISCUSSION

Weight Loss Reaction Kinetics: Effect of Inhibitor Concentration on Corrosion Rate

Figure 1 showed the plots of corrosion rates of aluminium in g/cm²/h with the percent concentration of cow urine in 1M NaOH and 1M KOH solutions. It is indicated from the plot that the corrosion rate was higher in absence of cow urine in both that cases of 1M NaOH and 1M KOH as compare to in presence of cow urine as inhibitor and corrosion rate was decreased with increasing concentration of the cow urine. Initially the corrosion rate decreased rapidly at lower concentration of inhibitor and on increasing the concentration the corrosion rate decreased gradually.

A sudden break in corrosion rate at initial stage is supposed to be due to the formation of a protective layer of inhibitor molecules on the surface of aluminium metal which cut off the reaction between metal and corrosive media.

INHIBITION EFFICIENCY OF INHIBITOR

Figure 2 showed that the percent inhibition efficiency was increased significantly in presence of cow urine. The efficiency also increased with increasing percentage of inhibitor. The protection of metals from chemical corrosion using corrosion inhibitors has been extensively investigated. One of the predominant mechanisms is adsorption of compounds through atoms containing lone pair of electrons like Nitrogen and Oxygen is well known. As the cow urine contains about 2.5 % urea which has one oxygen and two nitrogen atoms, such atoms are supposed to participate in coordinate bonding with metal atoms forming a protective film on the surface of aluminium metal which retards the corrosion rate [16]. The strength of the adsorption bond depends on the electron density on the donor atom of the functional group.

ADSORPTION ISOTHERM

The experimental data were applied to different adsorption isotherm equations. The result showed that the data followed the Langmuir, Freundlich and Temkin adsorption isotherms. All these isotherms are of the general form:

$$f(\theta, x)\exp(-2a\theta) = KC$$

where, $f(\theta, x)$ is the configurational factor, 'θ' is the surface coverage degree, 'C' is the inhibitor concentration, 'x' is the size factor ratio, 'a' is the molecular interaction parameter and K is the equilibrium constant of the adsorption [17].

Langmuir adsorption isotherm

Langmuir adsorption can be represented by following equation [18],

C/θ = C + 1/k

Where,
C = concentration, θ = surface coverage,
k = equilibrium constant.

A plot of C/θ against C (Figure-3) showed a straight line (Statistical Linear Coefficient R^2= 0.997 for KOH and 0.991 for NaOH, approaching unity) indicated that adsorption follows the Langmuir adsorption isotherm.

Freundlich Adsorption Isotherm

Freundlich isotherm can be formulated as

$$\frac{\theta}{1-\theta} = C + B$$

Where, θ = surface coverage. When a graph is plotted between θ/1-θ and concentration (c), straight lines were

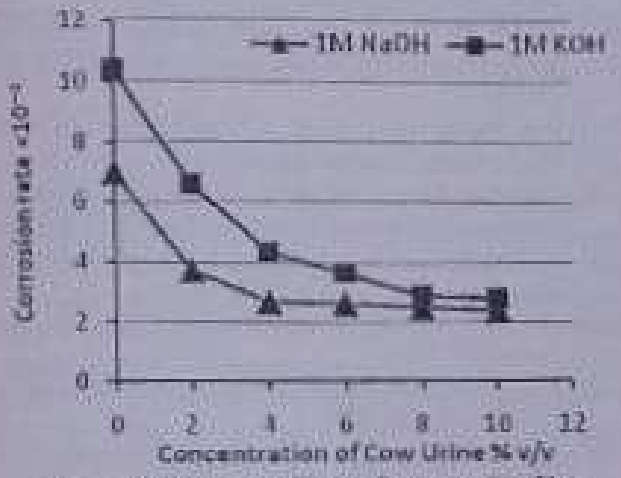

Fig. 1: Corrosion rate Versus Concentration Plot

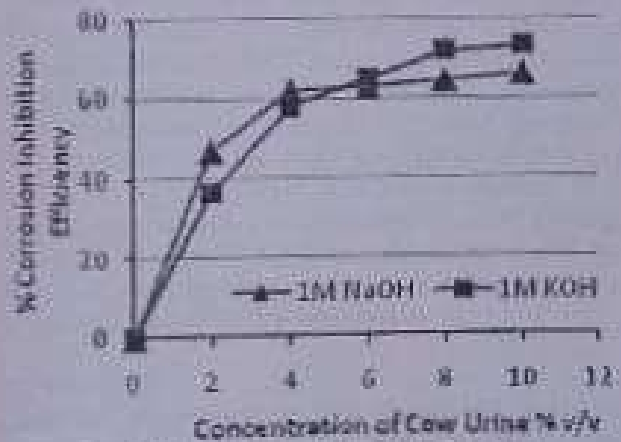

Fig. 2: % Inhibition v/s Concentration Plot

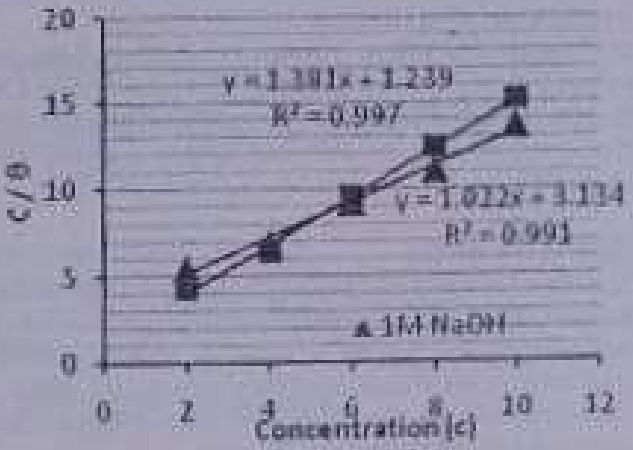

Fig. 3: Langmuir Adsorption Isotherm

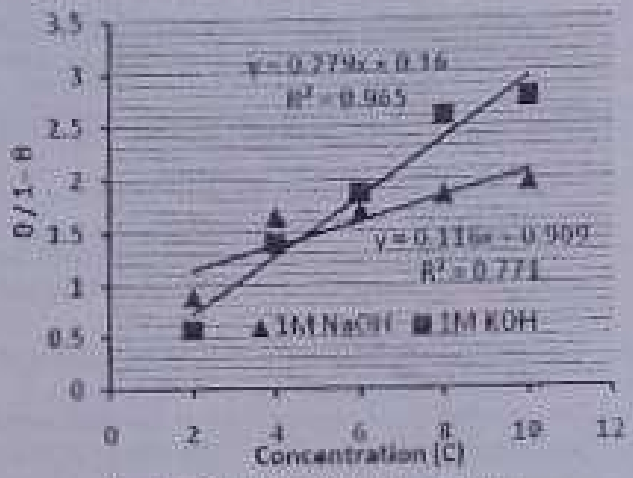

Fig. 4: Freundlich Adsorption Isotherm

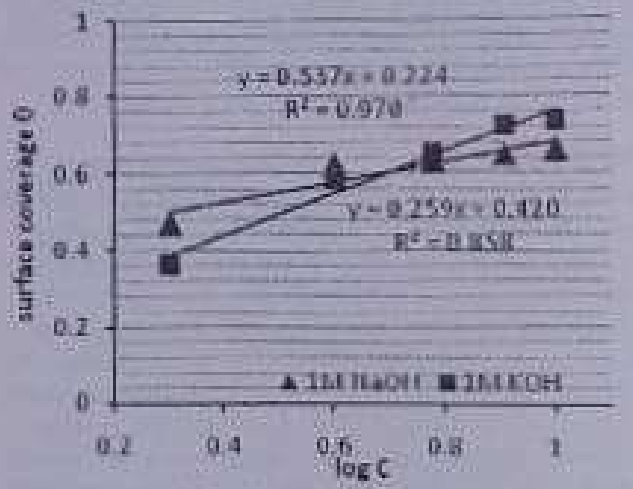

Fig. 5: Temkin Adsorption Isotherm

obtained with R^2=0.965 for KOH and 0.771 for NaOH indicating the adsorption followed the Freundlich isotherm (Figure-4).

Temkin Adsorption Isotherm

The Temkin adsorption isotherm was plotted between surface coverage θ and log of conc. of inhibitor (log C), a straight line with R² values 0.970 and 0.858 for KOH and NaOH respectively revealed that Temkin isotherm was obeyed (Figure-5).

SYNERGISTIC EFFECT

The corrosion inhibition property of cow urine may further be investigated with the reference of synergistic effect of other constituents present in the urine such as carbolic acid, calcium, magnesium, chlorides, sulfates, uric acid etc. These constituents may also have some effect on the corrosion rate and inhibition efficiency.

CONCLUSIONS

1. Cow urine was found to act as a corrosion inhibitor for aluminium metal in alkaline medium of NaOH and KOH reactions.
2. Corrosion rates were decreased in presence of cow urine.
3. Percent inhibition efficiency increased with increasing the concentration of cow urine addition.
4. Inhibition efficiency was found higher (73.44 %) in case of 1M KOH as compared to 1M NaOH (66.21%) at 10% concentration of cow urine.
5. The corrosion inhibition was supposed to be due to the adsorption of urine on metal surface.
6. The adsorption phenomena were found to obey Langmuir, Freundlich and Temkin adsorption isotherms

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REFERENCES

[1]. N. Santhini and T. Jeyaraj, Atchives of Applied Science Research, 4(5), 2213-2222, 2012.

[2]. D A Jones, Principle and Prevention of corrosion of metal, (1992)25.

[3]. J Talwar, Vijaya Alva, Indian Journal of chemical technology (2009), vol. 16, 228-232.

[4]. M. A. Quraishi, M. A. W. Khan and M. Ajmal, Anti-Corros. Methods and Materials, 43, 5, 1996.

[5]. B. Hammouti, A. Aouniti, M. Taleb, M. Brighli and S. Kertit, Corrosion, 51, 641, 1995.

[6]. A. A. El-Meligi, Corrosion Science, 2, 22-23, 2010.

[7]. H P Schan, M H Moinuddin Khan, S. raghvendra and N S Beojang, Open Electrochemistry Journal, 1, 13-18, 2009

[8]. P.C. Okafor, E. E. Ebenso and U. J. Ekpe, Int. J. Electrochem. Sci., 5(2010) 978-993, (2010).

[9]. K. and Vasudha V.G., E-Journal of Chem., 7(3), 673-684, 2010.

[10]. S. Ananda Louise Sathyanathan, M. Selvanayagam, S. Mahanin, and N. Palaniswamy, Indian Journal of Chemical Tech., 12:356-360, 2005

[11]. S. Khalid Hasan and Pinky Sisodia, Rasayan J. Chem., Vol.4, No.3, 548-553, (2011).

[12]. S. Khalid Hasan and Salem Edrah, J. Industrial Research and Technology, Vol.1, No.2, p 110-113, (2011)

[13]. S A Mandavgane, Ashis K Ramteke and Naresh K Mudu, Natural Product Radiance, vol 4(5), 2005.

[14]. Christian Vargel, Mickel Jacques, and Martin P Schmidt, Corrosion of Aluminium, Elsevier, UK, 2004.

[15]. Prabhu, R.A., T.V. Venkatesha and A.V. Shanbhag, J. Iran. Chem. Soc., 6(2): 353-363, 2009.

[16]. Chauhan, L.R. and G. Gunasekaran, Corros. Sci., 49: 1143-1161, 2007.

[17]. K C Emregul, A a akay and O Atakol, Mater. Che. Phy.93, 325-329, 2005.

[18]. Y. K. Agrawal, J. D. Shah, M. N. Desai, and N. K Shah, Corrosion Sci, 46: 633-65, 2003.