Investigation on the Effectiveness of Some Amino Acid Derivatives in Retarding NST 44 Mild Steel Corrosion in Some Agro-Fluids

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ABSTRACT: *This paper presents the report of an investigation and evaluation of the effectiveness of leucine, alanine, methionine and glutamic acid inhibitors, in retarding NST 44 mild steel corrosion, in the presence of cassava and lime fluids. This work is expected to provide useful data for the organic inhibitors capable of protecting corrosion of agro-allied equipment and machinery which had not been possible with inorganic inhibitors because of their poisonous nature. The results obtained indicate that alanine was observed to be more efficient than leucine and methione by providing corrosion inhibition at molar concentrations of 0.20M, 0.30M and 0.30M respectively. However, glutamic acid did not show a reliable inhibition. Low inhibitor concentration was found to accelerate corrosion substantially in the presence of cyanide and citric ions.*

Keywords: Inhibition, Corrosion, Mild Steel, Agro-Fluids, Leucine, Alanine Methionine and Glutamic Acid.
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INTRODUCTION

Some organic compounds containing N_2, O_2 and /or functional groups have been identified as inhibitors for aqueous corrosion of metals such as Al, Fe and Cu (Trabevelli and Carrossitti, 1970; Annard and Hurd, 1965; Alagbe, 1997). Although, a great number of materials have been reported as inhibitors for corrosion of iron and steel (Loto and Mohammed, 2000 and Alagbe, 2011), research continues to identify highly efficient inhibitors for specific applications. This is because the action exerted by a given derivative depends on its structure as well as the composition of the solution. Mild steel has been the most commonly used raw material of construction in the food processing industries. The present drive to encourage agro-based industries in Nigeria has led the government to make huge investment on the installation of machineries or plants in the rural and urban areas to process cassava, lime and their products which have now become staple diet of the people. One of the impeding factors to achieving the laudable objectives of government is the frequency with which the machineries break down due to the corrosion of the parts, resulting from the contact with the cassava juice which contains cyanic acid and lime juice which contains aggressive citric acid (Fontana and Greene, 1969). The essence of the present study being undertaken is to investigate the corrosion behaviour of mild steel in agro-fluids and effect of organic inhibitors. Because of the poisonous nature of the existing inhibitors when used in agro-based industries, it is the intention of the present study being, undertaken to identify new inhibitors among some known proteinous derivatives and also to suggest solution to corrosion damages caused by agro-fluids. The retardation of corrosion attack of machine parts will go a long way to increase the life span of the machines and this will also boost the manufacture and production of food processing equipment.

MATERIALS AND METHODS

Materials

Cassava juice was extracted with the aid of a squeezing machine, from freshly harvested cassava tubers. Lime juice was obtained from lime fruits by peeling off the outer cover and squeezing manually. The juices were stored in a freezer to prevent fermentation. Four amino acid derivations namely leucine, alanine, methionine and glutamic acid were selected for studying and varying concentrations of these were prepared in 100ml of cassava and lime fluids. The mild steel material used in the experiment was of the following chemical composition percentages: 0.14 – 0.020C, 0.18 – 0.28Si, 0.40 – 0.60Mn, 0.04S, 0.04P, 0.10Cr, 0.10Ni, 0.04Sn, 0.25Cu and 0.11N. (Oshogbo Steel Rolling Mill Handbook, 1986)

METHODS

Weight loss test specimens were from the steel samples whose compositions are given above. The original cylindrical rods were cut into short pieces having a cross section of 8mm and a gauge length of 40mm and their surfaces were given similar surfaces finishes using the same grades of emery papers for each sample. They were washed with distilled water, degreased in benzene and dried. Before weighing, the specimens were left in the desicator for 24 hours to allow the oxide film on the surface reach steady state.

Different concentrations (0.05 to 0.4M) of inhibitors were prepared and added to the two environments. Specimens were weighed in turn and their original weights recorded. They were then totally immersed in 100ml of stagnant solutions containing mixture of different concentrations of inhibitors in cassava and lime fluids respectively for container, the specimens were removed after every 24 hours and weighed after cleaning off the corrosion products, this lasted for 240 hours. The corrosion products formed on the surface of each specimen was removed by scrubbing under running water using fine emery paper. The specimens were then dried and re-weighed. The solutions were kept at room temperature throughout the duration of the experiments

RESULTS AND DISCUSSION

The relationships between corrosion rates in mils per year (mpy) and exposure time in hours are shown in figs. 1-4 in cassava fluid. The curves of figs. 1-3 show that in cassava fluid, leucine and methionine cause a loss with increase in molar concentration from 144th – 240th hour at a concentration range of 0.05 and 0.30M. After a critical inhibitor concentration of 0.30M, no appreciable decrease in corrosion rate occurs.

The curve in fig. 2 shows that alanine causes a significant decrease in corrosion rate with increase in molar concentration in the test solution at a concentration range of 0.05M and 0.20M. Above 0.20M, no significant decrease in corrosion rate is observed. This shows that the effectiveness of these inhibitors depends on their concentration per hours. In fig. 4 a decrease in corrosion rates in the solution is observed as glutamic acid concentration is maintained within the range of 0.05 and 0.20M. Above 0.2M, the corrosion rates are on the increase. The relationships between the corrosion rates in mils per year (mpy) and exposure time in hours are shown in figs. 5 - 8 in lime fluid. Figs. 5-7 show that in lime fluid, a continuous drop in rate of corrosion is observed as leucine and methionine concentrations are increased at a concentration range of 0.05 and 0.3M. Above the concentration of 0.30M, no appreciable decrease in corrosion rate is noticed.

Fig. 6 also shows a significant decrease in corrosion rate as alanine concentration is increased in the test solution at a concentration range of 0.05 and 0.20M. After 0.20M, no appreciable decrease in corrosion rate is noticed. This also shows that the effectiveness of these inhibitors depends on their concentrations. In fig. 8, a decrease in corrosion rate in the solution occurs as glutamic acid concentration is maintained within the range of 0.05 and 0.10M.

Above 0.10M, corrosion rate is on the increase. Examination of the curves in figs. 9-12 shows that the inhibitive power in cassava declines from alanine through leucine, methionine to glutamic acid and in lime from alanine through methionine, leucine to glutamic acid in that order. It also observed from data that alanine, leucine and methionine are more effective in lime medium than in cassava medium. The reason for this is that lime is an example of organic acid which contains citric acid that contains the carboxyl functional group (COO^-). This is quite different from the cyanide contained in cassava. The result also indicates that the presence of alanine influences the tendency towards passivation of metal surface only after the concentration of 0.20M, while leucine and methionine are active above 0.30M. Hence, it could be deduced that the ease with which alanine influences ferrous corrosion inhibition relative to leucine and methionine is high. Glutamic acid does not provide a reliable corrosion inhibition. The reason for this is probably because glutamic acid contains two carboxyl groups and only one amino group; their aqueous solutions are therefore acidic (Data and Ottaway, 1976).

This may be ascribed to the dissolution of the film formed on the surface of the metal. The increase in corrosion in figs. 1-8 for leucine, alanine and methionine at low concentration and glutamic acid at all concentrations can be explained as being due to the inability of the inhibitors to effectively plug all corrosion sites (Rollason, 1984). This leads to an increase in corrosion rate, since large amount of oxygen is supplied to the cathodic site thereby speeding up the cathodic reaction (oxygen reduction). In response to this, the anodic reaction (metal dissolution) increases. The curves of figs. 1-3 and 5-7 show that leucine, alanine and methionine in cassava and lime fluids respectively cause a sharp drop in corrosion rate at critical inhibitor concentrations, because the presence of these inhibitors tends to influence the ease of passivation on the metal surface.

In figs. 9 and 10, alanine gave the least corrosion rates for specimens immersed in cassava fluid followed by leucine, methionine and glutamic acid throughout the 240 hours of the experiment for the same concentration. Figs. 11 and 12 showed that there seem to be a gradual decline in inhibitive power in lime from alanine through methionine, leucine to glutamic acid in that order throughout the 240 hours of the experiment for the same concentration. Alanine, leuicine and methionone are more inhibitive than glutamic acid in the two environments because they belong to neutral group of the amino acid derivations which contain one-NH_2 and one-COOH in the molecule. This is quite different from glutamic acid which belongs to acidic group that contains one-NH_2 and two-COOH in the molecule.

CONCLUSIONS

The corrosion behaviour of mild steel in cassava (HCN ion) and lime (citric acid) solutions is determined by the reactions taking place on the metal-oxide layer interface where alanine, leucine and methionine have displayed the tendency towards corrosion inhibition of ferrous materials. Glutamic acid does not provide a reliable corrosion inhibition. This may be ascribed to the dissolution of the film formed on the surface of the metal. Cassava solution is more corrosive than lime solution. Higher concentrations of inhibitors will be required for protection in the former solution. The inhibitive power in cassava solution has been shown to be in the order: alanine > leucine > methionine > glutamic acid and in lime to be the order: alanine > methionine > leucine > glutamic acid.

SOLUTION / SUGGESTION

In the manufacturing of food processing machines such as grinders, graters, mixers, fryers etc. mild steel and other metals are normally used. These materials corrode easily when in contact with corrosive fluids such as cassava juice, lemon juice, etc. This leads to malfunctioning and breakdown of the machines. In many cases the processed food is contaminated with the products of corrosion.

In order to control this effect of corrosion menace a serious attention should be given to the application of inhibitors as described in my technical report. The amount of wastages due to negligence over the effect of cassava and lime fluids on food processing machine have been very devastating. Since amino acid is nutritious to human body its determined quantity can be added to cassava or lime food when been processed to act as inhibitor to the corrosion of component of the machine. This suggestion is very applicable to machineries and plants used in processing lemon and tomatoes juices.

The seven point agenda adopted by the nation for social technological advancement is very laudable. The area of agriculture and health cannot be adequately taken care of if the effect of corrosion on facilities for food production and quality of food therewith produce is not properly addressed. Therefore for realization of the seven point agenda especially in the area of agriculture and health more research work on corrosion inhibitors should be carried out with the aim of preventing corrosion effect on food processing machineries. It also necessary to carry out adequate research work to find out inhibitors for eliminating corrosion in facilities in other aspect of economy such as in petrochemical, pharmaceutical and building industries. This will enhance high performance and durability of machines which will lead to techno-economical development of our society.

REFERENCES

Adepoju, O. T. and Balogun, S. A. (1985): Influence of inhibitors on the corrosion behaviour of mild steel in chloride and nitrate solutions. In proceedings 6th European symposium on corrosion inhibitors, p.627 – 631.

Alagbe, M. (1997): "Inhibition of corrosion of mild steel in some agro-fluids by some amino acid derivatives". Unpublished M.Sc. Research Thesis, Department of metallurgical and materials engineering, OAU, Ile-Ife pp.4 - 6.

Alagbe, M. (2011): "Effectiveness of corrosion inhibitors and their influence on behaviour of NST 44 mild steel in chloride and sulphate solutions. Inter-world journal of science and technology, vol. 4 no. 2 www.rdursonassociates.com, p. 89-99.

Annard, R. R. and Hurd, R. M., (1965): The inhibitions of corrosion and hydrogen embrittlement of AISI 410 stainless steel. Journal of

Electrochemical Society. P.112, 1438 - 1444.

ASTM (1985): "Annual Books of Standards", Section 3, Vol. 3.02, Designation G.I. 81. American Standard of Testing and Materials. P 112 – 113

Datta, S. P. and Ottaway, J. H. (1976): Biochemistry 3rd Edition, Bailliere Trindall, London, p.51- 52.

Fontanan, M.G. and Greene, N.D. (1967): Corrosion Engineering 2nd Edition, McGraw-Hill. New York. p.129.

Loto, A. and Mohammed, A. I. (2000): The effect of cashew juice extract on corrosion inhibition of mild steel in HCl Journal of corrosion prevention and control NACE international. P. 50 – 56 Oshogbo Steel Rolling Mill Handbook, (1986).

Rollason, E. C. (1984): Metallurgy for Engineers. 4th Edition, Edward Arnold Publishers Ltd., London, p.451-456.

Trabevelli, G. and Carrossitti (1970): Advances in Corrosion Science and Technology, Plenum, New York, p.147 - 148.

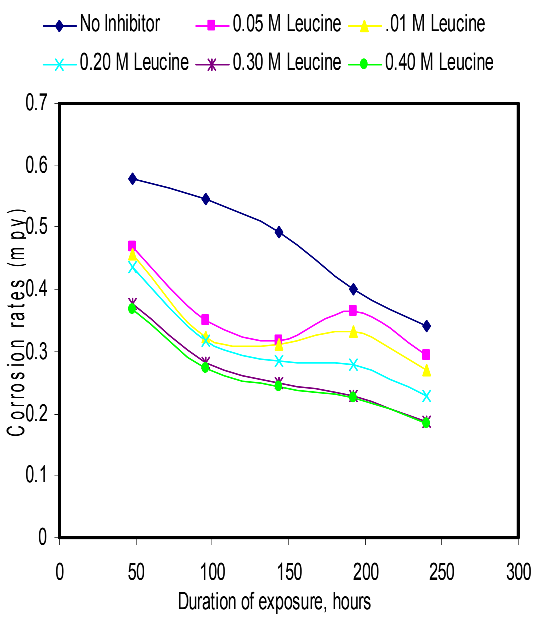

Figure 1: Effect of leucine as a suitable inhibitor of mild steel corrosion in cassava fluid

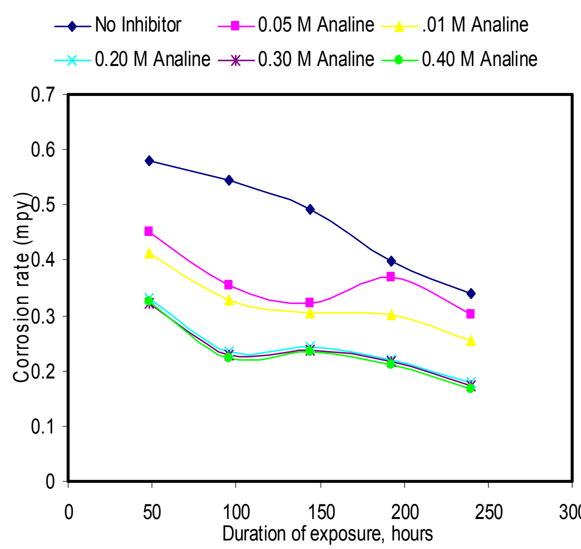

Figure 2: Effect of alanine as a suitable inhibitor of mild steel corrosion in cassava fluid

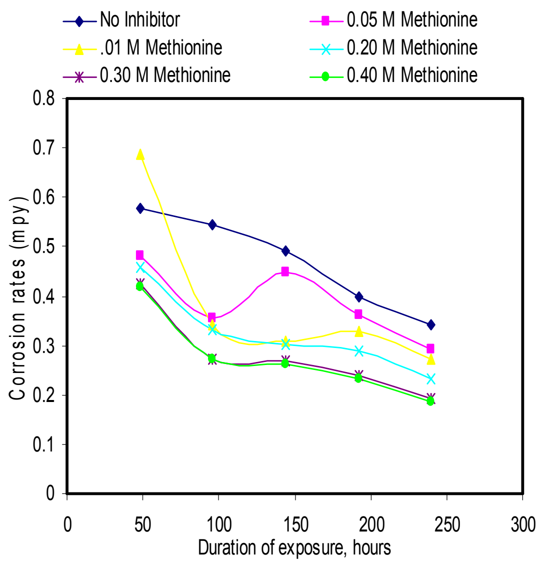

Figure 3: Effect of methaionine as a suitable inhibitor of mild steel corrosion in cassava fluid

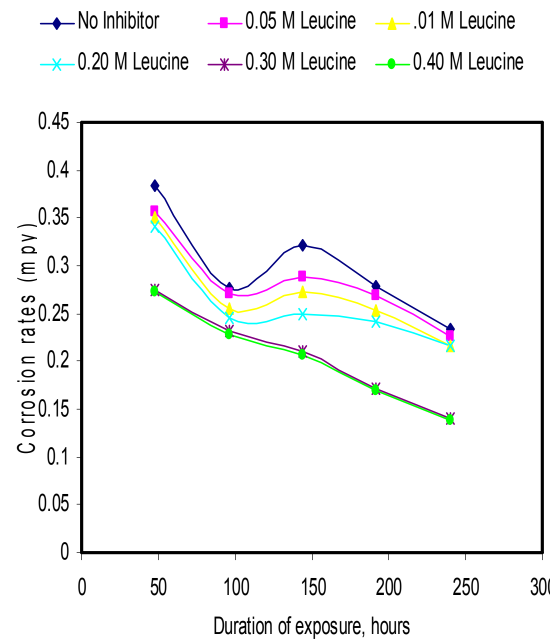

Figure 5: Effect of leucine as a suitable inhibitor of mild steel corrosion in lime fluid

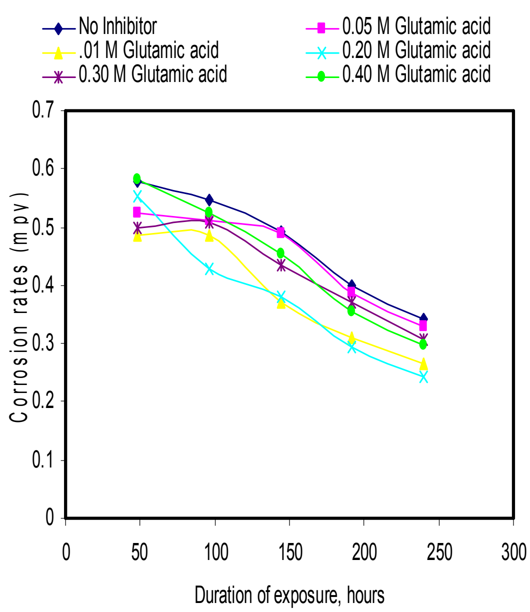

Figure 4: Effect of glutamic acid as a suitable inhibitor of mild steel corrosion in cassava fluid

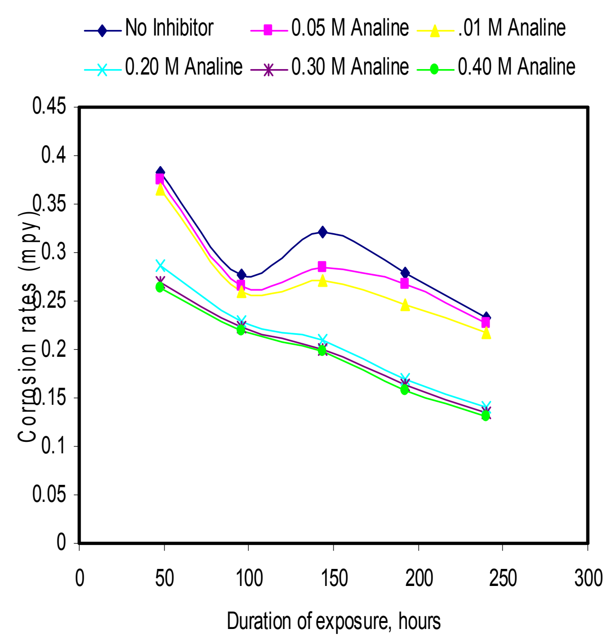

Figure 6: Effect of alanine as a suitable inhibitor of mild steel corrosion in lime fluid

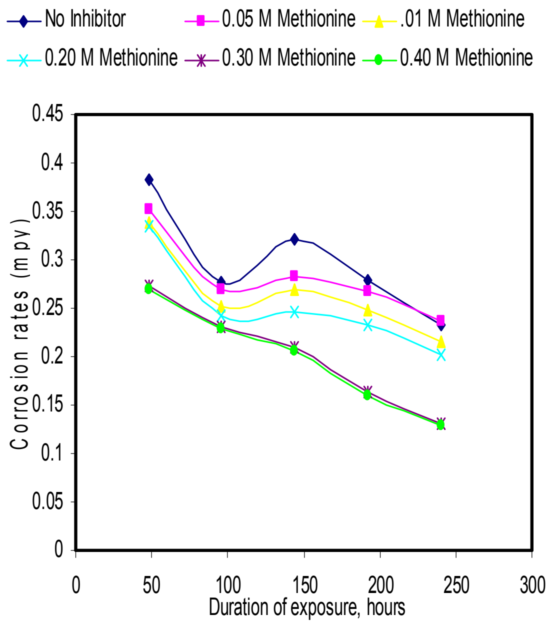

Figure 7: Effect of methionine as a suitable inhibitor of mild steel corrosion in lime fluid

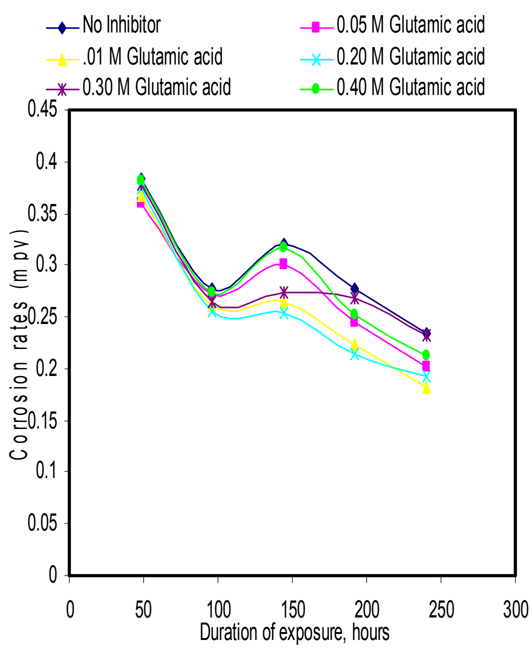

Figure 8: Effect of glutamic acid as a suitable inhibitor of mild steel corrosion in lime fluid

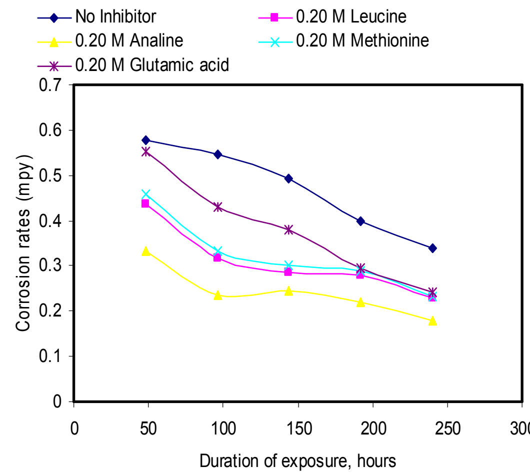

Figure 9: Relationship between corrosion rates and duration of exposure in cassava fluid containing different inhibitors of 0.20M concentration

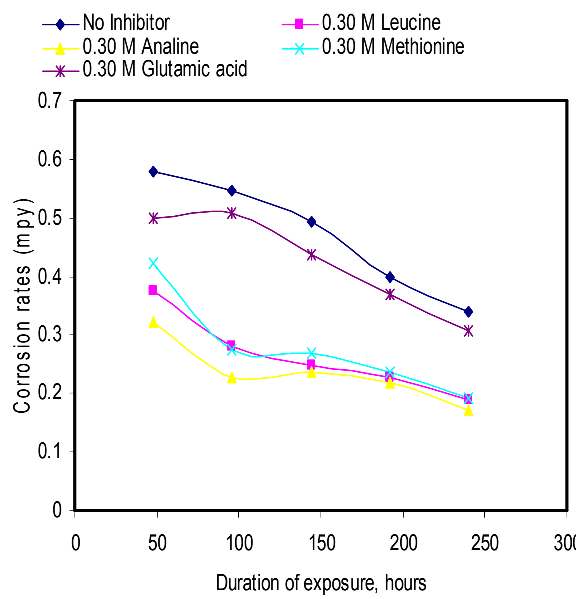

Figure 10: Relationship between corrosion rates and duration of exposure in cassava fluid containing different inhibitors of 0.30M concentration

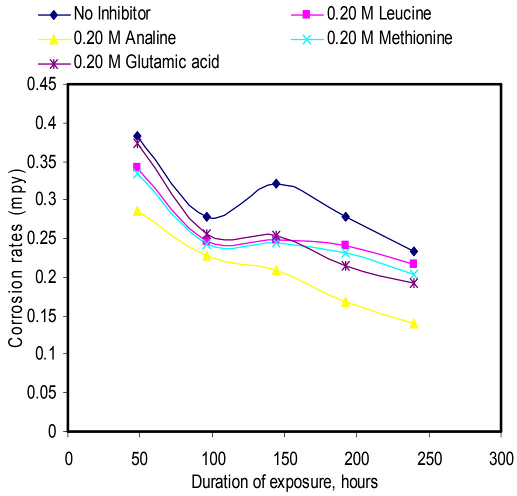

Figure 11: Relationship between corrosion rates and duration of exposure in lime fluid containing different inhibitors of 0.20M concentration

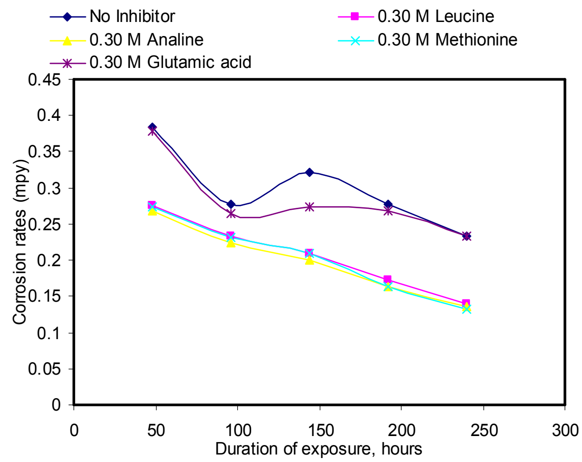

Figure 12: Relationship between corrosion rates and duration of exposure in lime fluid containing different inhibitors of 0.30M concentration

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