An Executive Summary of The Final Report of Work Done on The Minor Research Project

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INVESTIGATION OF THE CORROSION BEHAVIOR OF MILD STEEL IN FUEL ETHANOL FOR AUTOMOBILE INDUSTRY

Submitted to UGC by

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EXECUTIVE SUMMARY

There is an alarming concern about the depleting petroleum reserves of the world. This has led to a global search for alternative fuels viz. biofuels as substitutes for fossil based fuels. Biofuels are derived from renewable sources (biomass). Liquid biofuels are classified into bioalcohols and biodiesel; which are used as separate fuels or as additives in conventional fuels(blends) - bioalcohols in petrol and biodiesel in diesel fuel. These alternative fuels are being developed and brought to market but with many new feed stocks and manufacturing processes. Examples of new alternative fuel sources include: Ethanol, methanol, butanol, biodiesel, etc. Feedstock sources for these fuels include: corn, sugar beets, sugar cane, brewing wastes, soy beans, animal fat, algae, etc.

The experience we have with conventional fuels is based on years of research, testing, and manufacturing and service. The interest in the investigation of materials compatibility in ethanol is top priority due to the increased demand for ethanol caused by its growing application as a fuel and a fuel additive for automobiles. Many countries including India have already mandated use of ethanol blended petrol. During production, transportation and usage, ethanol comes in contact with various materials. Therefore it is important to understand the influence of ethanol on materials as well as the influence of materials on ethanol so that the design and construction of systems handling biofuels can be carried out in a cost-effective manner. Pipelines made up of Mild Steel(MS) are essential to the fuel infrastructure which offer the most economical solution for widely distributed, large-scale transport of ethanol. A variety of corrosion effects can occur in metals in contact with ethanol solutions; these include dry, wet, galvanic, and electrolytic corrosion, stress corrosion cracking, erosion corrosion, and other effects from time, temperature, and contaminants/additives.

Literature from more than 120 related research papers was reviewed to collect the data on ethanol sources, corrosion, production and application for this project and data listed in Tables. About ten papers based on this project were presented in National and International conferences. Brief summary of the project findings is presented as follows.

Corrosion Behaviour: Experiments on the corrosion behavior of mild steel in fuel ethanol for three compositions: i. E100 [100%. Ethanol], ii. E5[5% ethanol+95% Petrol] & iii. E10[10% ethanol+90% Petrol] were conducted by weight loss method. The results revealed that corrosion rate (C.R) increases with increase in ethanol composition.

Role of Water: The corrosion rate and conductivity of E100, Petrol, E5 and E10 in the absence and presence of 1% water was determined to understand the role of water and conductivity on the materials compatibility of ethanol. The results reveal that conductivity increases in presence of water in ethanol which leads to an increase in corrosion rate of Mild Steel. Further E100 being highly soluble and hygroscopic shows maximum increase in conductivity on addition of water There is no change in the conductivity value of petrol on addition of water since water is insoluble in petrol. The conductivity values of E5 and E10 are relatively higher than petrol owing to the presence of ethanol. And in presence of 1% water the conductivity values of E5 and E10 show slight increase compared to E100. Since the percentage of ethanol in E5 and E10 is relatively less and petrol has least solubility of water. In all case corrosion rate appears to be directly dependent on the percentage of water, alcohol as reflected by the conductivity values & it implies that corrosivity of ethanolic solutions depends on solubility of oxygen, pH and conductivity**.** Results reveal that:

a. **Conductivity of Petrol < E5 < E10 < E100**
b. **Corrosion rate of Petrol < E5 < E10 < E100**
c. **pH of Petrol > E10 < E5 < E100 before immersion test.**

d. **pH of E10 > Petrol > E5 >E100after immersion test.**

Role of pH: Comparison of the pH values before and after immersion tests for all the solutions show a marked decrease indicating an increase in acidic character evidently due to the formation of acetic acid which could be an additional factor in increase of corrosion rate observed.

Role of Inhibitors for corrosion prevention: The Inhibition Efficiency (IE) of two plant based inhibitors A[ethanolic extract of rhizome of *zingiberaceae* family] & B[ethanolic extract of leaves of *fabaceae* family] in controlling corrosion of mild steel immersed in 40ml each of E100, E5 and E10 was determined by weight loss method. The results reveal that:

1. The %IE in each of the solutions for both inhibitors A & B increases with increase in inhibitor concentration.
2. Even though both A & B exhibit high %IE of above 80; Inhibitor A exhibits maximum %IE > 90.
3. The % IE achieved with A in E100, E5 & E10 is almost same ie. 91-92.
4. The % IE achieved with B in E100E5& E10increases with the percentage of ethanol and is maximum for E100. %IE of E100(90), > E5(83) > E10(85)
5. The values of %IE imply that A is better inhibitor than B.
6. Since both A & B exhibit high %IE at concentrations as low as 50ppm, they have potential for commercial exploitation.

Role of Conductance and pH values of of ethanol, water & Petrol: in varying composition was evaluated to predict corrosion rate of M.S and the results are summarized below. Increasing amounts of water/ethanol increases conductivity and increases the potential for corrosion.

Properties investigated	**%composition Range**	**Variation of pH**	**Variation of Conductance μS/cm**	**Predicting Corrosion of M.S**
Effect of water on on conductivity and pH of ethanol	0.25-66.66% of water in ethanol	Increases from 4.92-6.88	Increases from 0.66-30	C.R increases
Effect of ethanol on on the conductance and pH of unleaded petrol	0-50 %of ethanol in petrol	a)Increases between 0-14% from 12.2-17.15 b)Decreases between 15-50% from 10.6 to 6.3	Increases from 0.01-0.5	C.R increases
Effect of water on on conductance and pH of 1:1 mixture of ethanol and petrol	0-27% of water in 1:1 mixture of alcohol and petrol	Increases from 6.06-6.22	Increases from 0.49-12	C.R increases
Effect of petrol on the conductance and pH of ethanol	0-50% of petrol in ethanol	Decreases from 5.6-5.23	a)Increases between 0-9% from 0.68-0.73 b)Decreases between 10-50% from 0.68-0.38	C.R may Increase upto 9% and decreases above 9%
Effect of water on the conductance and pH of 1:1 mixture of ethanol and petrol	0.125-4.191% of water in 1:1 mixture of alcohol and petrol	Increases from 5.53-6.12	Increases from 0.42-4.4	C.R increases
Effect of addition of ethanol on conductance of water	0-21% of alcohol in water	-	Decreases from 64-33	C.R decreases

Environmental assessment of the inhibitors: was done by evaluating toxicity, bioaccumulation and biodegradability. The inhibitors were found to exhibit low toxicity, easily biodegradable and possess low bioaccumulation hence qualify as environmentally friendly inhibitors.

Morphology Studies by SEM: SEM images of mild steel immersed in E100, E10 for 25 hours in the absence of inhibitors reveals that mild steel surface appears to be corroded when immersed in E100 and E10 Where as in the presence of both inhibitors A & B mild steel surface appears to be covered with film which may be the reason for decrease in corrosion rate of mild steel. However investigations should be conducted for longer duration of immersion tests to get a better understanding of corrosion protection of inhibitors used.