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WATER TOLERANCE OF MOTOR FUEL GRADE GASOLINE/ALCOHOL BLENDS

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A comparison is made between ethanol and methanol's ability to improve the water tolerance of gasoline blends. It is shown that ethanol is about 18 times more effective than methanol in improving the water tolerance of the alcohol/gasoline blends. The effect of cyclohexane, and p-xylene on the water tolerance of ethanol/gasoline blends has been studied. It is shown that these additives produce negative effect on the water tolerance of the blends. Whereas acetone, butanone-2 and ethyl acetate additives improved the water tolerance of the ethanol/gasoline blend by 18% mass. Butanol-1 is considered as the most effective additives, since it improved the water tolerance of the ethanol/gasoline blend by 43% mass.

Key words : Water tolerance, Motor fuel, Grade gasoline, Alcohol blends.

Introduction

Its only recently, that man has realized how precious and important the naturally occurring petroleum is, and how fast its reserves are shrinking. Therefore, desperate attempts are being made all over the globe to cut down its consumption and find the alternative sources of energy. One way to meet this goal is to use alcohols as motor fuel either straight or blended with gasoline.

The process has already been started in petroleum poor countries to mix alcohol (frequently absolute) in gasoline in order to conserve the petroleum oil. Blends containing upto 20% v of alcohol in gasoline are known to make satisfactory motor fuel [1]. For such mixtures, if the alcohol is not anhydrous a blending agent is needed. Otherwise, losses of the alcohol to the water can be very high and have a considerable impact on the economics of this material as blending component in motor gasoline.

Recently the author [2,9] carried out detailed study of the phase instability problems of methanol/gasoline blends. It is reported that by adding 5% v/v butanol-1, water tolerance of the 20% v/v methanol in gasoline blends can be increased from 0.15 to 0.6% mass at 0° without causing phase separation of the blend. Karmarker [3] also reported an improvement in the water tolerance of methanol/ gasoline blend upto 0.4% mass by adding 9.1% v of aliphatic ketones. Ingamalls *et. al.* [4] studied over 150 water solubilizing additives, none produced sufficient improvement in water tolerance of methanol/gasoline blends. Halstead [5] while investigating methanol/gasoline blends reported that aliphatic alcohols are better water stabilizing agents than aromatic hydrocarbons. Valencia-Chaves *et. al.* [6] have reported that by adding 5% v benzyl alcohol, water tolerance of the methanol blends can be increased from 0.3 to 0.4% mass.

A little data is reported regarding the phase separation of ethanol/gasoline blends. Scheller [7] has observed that an addition of 10% v ethanol to unleaded gasoline increased water tolerance to 0.25% mass and the fuel consumption is reduced by 5%. Scheller *et. al.* [8] tested the performance of 10% v ethanol/gasoline blends on many automobiles. After driving over 2 million miles they reported no difference in fuel consumption, cylinder wear, vapour lock or corrosion problems associated with the use of ethanol/gasoline blends.

In the present work, the results of phase separation studies of 25/75 v/v ethanol unleaded gasoline blends in the presence of various hydrocarbon additives and water are reported.

Behaviour of alcohols as motor fuel. The alcohols are attractive as motor fuel or as gasoline blending component because of the following reasons:

(i) The alcohols have an excellent octane number, about 130.
(ii) The inflammability limits (lower 4.0% and upper 13.7%) for alcohols are higher than for gasoline, so the easier starting is obtained.
(iii) The cooling effect of the high latent heat of alcohols is responsible for their excellent anti-knock properties when used alone or as gasoline blend.
(iv) Carburettor icing is reduced by the use of alcohol.
(v) Exhaust emission can be improved since the alcohols effectively causes the engine to operate at a leaner fuel/air ratio.
(vi) For blends of upto about 20% alcohol, the lower calorific value of the alcohol is off set to some extent by the improved volumetric efficiency resulting from the denser charge.
(vii) Alcohols are excellent solvents for gums formed in engines from petroleum spirits and they do not form gums and carbon during combustion.
(viii) They can be synthesized from cheap sources like natural gases, molasses, starch and coal.

The followings are the disadvantages associated with the alcohols when used as motor fuel or gasoline blending component.

(i) Alcohols differ from gasoline in their higher latentheat (gasoline 140 Btu/lb, ethanol 370 Btu/lb) and this results in a cooler fuel/air in take to the engine.

(ii) Alcohols have low calorific value (ethanol 12,800 Btu/lb and gasoline about 19,500 Btu/ lb). Because of the low calorific value the high output is achieved by a higher fuel con sumption than with gasoline.

(iii) Alcohol blends are more liable to vapour lock than straight gasoline.

(iv) The more serious objection to the alcohol/ gasoline blends is that the mixtures are un stable and the phase separation occurs even in the presence of small amount of water
or with change in temperature.

Experimental

The ethanol/gasoline blends were made on percentage volume basis. The unleaded gasoline was used for experiments the composition of which is mentioned in Table 1. The water was taken on percentage mass basis in order to eliminate any error due to temperature change. The samples were made by mixing 5% v/v of additive and 95% v of 25/75 v/v ethanol/gasoline blends. Due to the hygroscopic nature of the mixture, exposure to the atmosphere was minimized. All the glasswares were washed first with distilled water, than in acetone and dried in an oven at 100° and cooled in a desicator.

TABLE-1. COMPOSITION OF GASOLINE

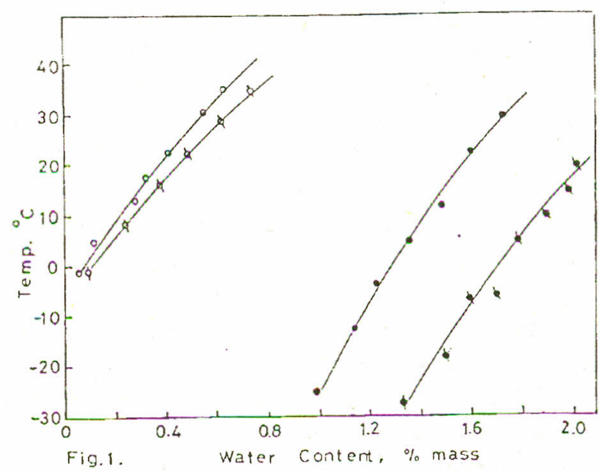
1.	Maximum percentage evaporated at temperature °F		
	10%	=	133
	50%	=	230
	90%	=	342
	E.P.	=	407
2.	Gum mg/100 ml	=	2.1
3.	Reid vapour pressure	=	8.3
4.	Sulphur %	=	0.092

To measure the phase separation temperatures of the blends, 25 ml of the mixture was transferred to a 50 ml capacity flask, fitted with an air tight cork and thermometer. The weight of the solution was measured with an accuracy of +0 .01 mg, before adding predetermined amount of distilled water. It was made sure that the thermometer bulb was completely immersed in the solution. The flask was cooled in a heavy duty deep freezer. The temperature at which the clean mixture turned cloudy on cooling and clear on heating was noticed as phase separation temperature of the blend. The reported temperature are accurate to ± 0.5° over the range studied. The chemicals used were supplied by E. Merck Darmstad of Germany, and were of 99.9% purity.

Results and Discussions

In Fig. 1 is shown a plot of phase separation tem peratures versus percentage water content at two different concentrations of ethanol and methanol blends in gasoline. The two concentrations (20% v and 25% v) of ethanol and methanol are selected because these concentrations are more commonly used and are known to make satisfactory fuel when blended with gasoline [1]. It is clear from the results that ethanol is much more effective water stabilizing agent than methanol at a given temperature and concentration. For example, the water that can be tolerated by the 25/75 v/v ethanol/gasoline blend is 1.78% mass at 0° compared with 0.1% mass tolerated at the same temperature and concentration by methanol/gasoline blend. This means that ethanol is about 18 times more effective than methanol in stabilizing the water content of the alcohol/gasoline blends. This is also true for 20/80 v/v ethanol and methanol concentration in gasoline. For this very reason it was decided to select ethanol/gasoline blends for further investigation.

The effect of various hydrocarbons on the water tolerance of 25/75 v/v ethanol/gasoline blends was studied. The samples were made by mixing 5% v of hydrocarbon additives and 95% v of ethanol/gasoline blend. The additives studied were cyclohexane, n- hexane, p-xylene,



Water Content, % mass

Fig. 1. The effect of ethanol and methanol concentrations on the water tolerance of the gasoline blends.; 0 20/80 v/v methanol/gasoline blend.; ∅ 25/75 v/v methanol/gasoline blend.; ● 20/80 v/v ethanol/ gasoline blend. ; ● 25/75 v/v ethanol/gasoline blend.

acetone, butanone-2, ethyl acetate and butanol-1. The results are plotted in Fig. 2. An examination of the data reveals that cyclohexane, n-hexane and p-xylene fail to improve the water tolerance of the 25/75 v/v ethanol/ gasoline blends. On the contrary, produced a negative effect. Therefore it may be concluded that the above mentioned additives should not be used as water stabili zing agents.

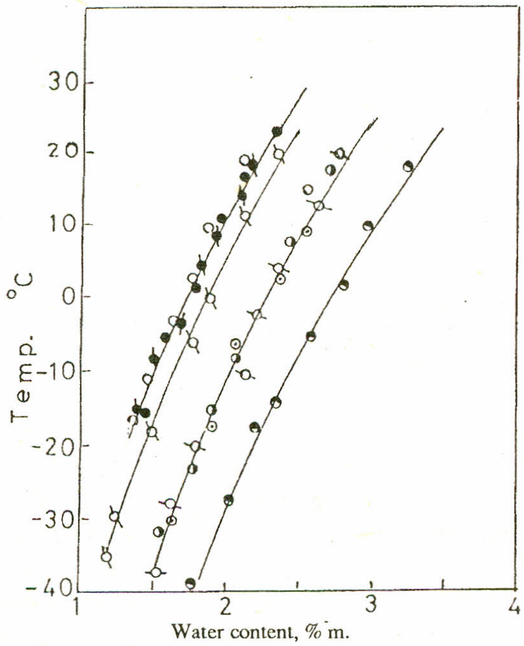


Fig. 2. The effect of various additives on the 25/75 v/v ethanol/ gasoline blends. 25/75 v/v ethanol/gasoline blend without any additive.; 0 5% cyclohexane.; 5% n-hexane. ; 5% p-xylene.; 5% ethyl acetate.; 5% acetone.; 5% butanon-2.; 5% butanol-1.

The effect of other additives namely, ethyl acetate, acetone, butanone-2 and n-hexane when used 5% v as additives is also shown in Fig. 2. The water tolerance of the 25/75 v/v ethanol/gasoline blend at 0° was improved from 1.88% to 2.26% mass i.e. an increase of 20% mass. These additives produced virtually identical improvement in the water tolerance of the ethanol blend with the exception of n-hexane. The effect on the improvement of water tolerance of the blend is greatest due to butanol-1 additive. For example, the water that can be tolerated by the ethanol blend without causing phase separation increased from 1.88% to 2.7% mass at 0° i.e. an increase of 43% mass. These results can not be compared because of paucity of data reported in the literature.

Conclusions

The following conclusions can be drawn from the present study.

(a) Ethanol is about 18 times more effective than methanol in increasing the water tolerance of the alcohol/gasoline blends.

(b) Cyclohexane, n-hexane and p-xylene should not be used as water stabilizing agents as they fail to improve the water tolerance of the blend.

(c) Other additives like ethyl acetate, acetone and butanone-2 are effective as they improved the water tolerance of the ethanol blend by 18% mass.

(d Butanol-1 is the most effective additive and the water tolerance of the blend was improved by 43% mass by the use of butanol-1 additive.

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