

Analysis of Radiator Coolant Mixture Using Ethylene Glycol and Di-Ethylene Glycol

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ABSTRACT: Today, the demand of automobile vehicles is on peak. So, it is a great challenge for automotive industries to provide an efficient and economical engine. The performance of an engine affects by various systems like fuel supply system, lubrication system, transmission system, cooling system etc. So, it becomes essential to account them while designing an engine for improves the engines performance. Cooling system is one of the important systems amongst all. It is responsible to carry large amount of heat waste to surroundings for efficient working of an engine. It also enhances heat transfer and fuel economy which leads to maximize the performance of an engine. Most internal combustion engines are fluid cooled using either air or a liquid coolant run through a heat exchanger (radiator) cooled by air. The heat transfer through radiator can be improved by maximizing the heat transfer area and increasing the heat transfer coefficient. The heat transfer coefficient can be increased either by using more efficient heat transfer methods or by improving the thermo physical properties of the heat transfer material i.e. coolant. Earlier, Water was widely used in radiator as a coolant for its good ability to holding heat, transfer heat and can be readily obtained. Also the mixture of water & ethylene glycol later introduced as a coolant. Both of them having certain merits & demerits. With the advancement of our new generation can use the **Di-ethylene glycol** by increasing the carbon chain of the ethylene-oxide. This comprehensive experiment on cooling system importance, coolant used in automobiles and its limitations and applications and challenges of Di-ethylene glycol as a coolant have been compiled and reviewed for automobile radiator.

I. INTRODUCTION

Glycol

Glycols are aliphatic organic compounds having two hydroxyl groups per molecule. Glycols resemble water in that they are essentially clear, colorless liquids with practically no odor. Glycols are excellent solvents for many organic compounds and are completely water-soluble. Since they can undergo chemical reactions on one or both hydroxyl groups, they are important as chemical intermediates.

Glycol are straight-chain aliphatic compounds terminated on both ends by hydroxyl group. Ethylene glycol, Di-ethylene glycol, Tri-ethylene glycol has one, two, three ethylene groups, respectively with the ethylene groups in the last two joined by an ether linkage.

Ethylene Glycol	$\text{HOCH}_2\text{CH}_2\text{OH}$
Di-ethylene glycol	$\text{HOCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$
Tri-ethylene glycol	$\text{HOCH}_2\text{CH}_2(\text{OCH}_2\text{CH}_2)_2\text{OH}$

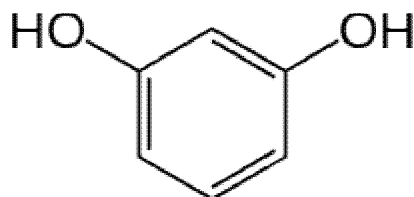
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Glycol structure:



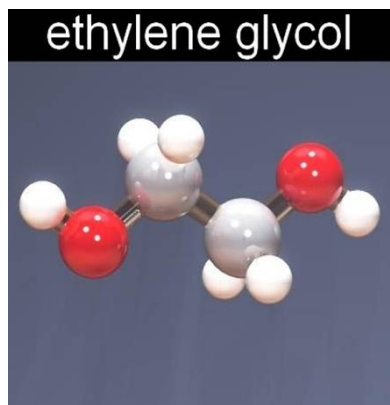
Ethylene Glycol

Ethylene glycol(IUPAC name: Ethane1,2diol) is an organic compound primarily used as a raw material in the manufacture of polyester fibres and fabric industry and large amounts of antifreeze formulation in automobile vehicles. Ethylene glycol is an odourless, colourless, syrupy, sweet tasting liquid. Ethylene glycol is moderately toxic, with children having been particularly at risk because of its sweet taste, until it became common to add bitter flavouring to consumer antifreezes containing it.

Chemical reaction of ethylene glycol:-



Ethylene glycol structure:



Di-ethylene glycol

Di-ethylene glycol is an organic compound with the formula $(\text{HOCH}_2\text{CH}_2)_2\text{O}$. It is a colourless, practically odourless, poisonous, and hygroscopic liquid with a sweetish taste. It is miscible in water, alcohol, ether, acetone, and ethylene glycol. Di-ethylene glycol is a widely used solvent. Di-ethylene glycol is produced by the partial hydrolysis of ethylene oxide. Depending on the conditions, varying amounts of Di-ethylene glycol and related glycol are produced. The resulting product is two ethylene glycol molecules joined by an ether bond.

Di-ethylene glycol is one of several glycols derived from ethylene oxide. Glycols related to and coproduced with Di-ethylene glycol and have the formula $\text{HOCH}_2(\text{OCH}_2\text{CH}_2)_n\text{OH}$.

Since $n=0$ Ethylene glycol

$n=1$ Di-ethylene glycol

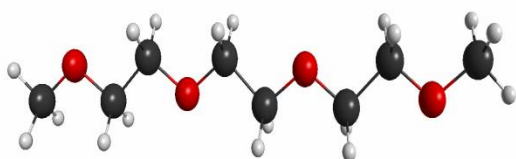
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Di-ethylene glycol Structure:



II. EXPERIMENTAL SETUP

Materials

- Ethylene Glycol
- Di-ethylene Glycol
- corrosion inhibitor (phosphates)
- De-ionized water

According to the application of the project selected the following tests to conduct on different mixing composition ratios.

- **Mixing Composition Ratio**
- **Boiling point**
- **Viscosity**

III. EXPERIMENTAL PROCEDURE

Mixing Composition Ratio

The above material are mixed with different compositions and based upon this the testing process are obtained.

1. Ethylene glycol + Deionised Water + Corrosion Inhibitor (phosphate)
2. Di-ethylene glycol + Deionised water + Corrosion Inhibitor (phosphate)

S.NO.	Mixing Solution	Ratio - 1	Ratio-2	Ratio-3
1.	Ethylene glycol	50:49:1	40:59:1	60:39:1
2.	Diethylene glycol	50:49:1	40:59:1	60:39:1

Boiling Point

The boiling point of a substance is the temperature at which the vapor pressure of the liquid equals the pressure surrounding the liquid and the liquid changes into a vapor.

The boiling point of a liquid varies depending upon the surrounding environmental pressure. A liquid in a partial vacuum has a lower boiling point than when that liquid is at atmospheric pressure. A liquid at high pressure has a higher boiling point than when that liquid is at atmospheric pressure. For a given pressure, different liquids boil at different temperatures.

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Fig.1 Boiling Point Apparatus

Viscosity

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal concept of "thickness". For example, honey has a much higher viscosity than water. Viscosity is a property arising from collisions between neighboring particles in a fluid that are moving at different velocities. When the fluid is forced through a tube, the particles which compose the fluid generally move more quickly near the tube's axis and more slowly near its walls: therefore some stress, (such as a pressure difference between the two ends of the tube), is needed to overcome the friction between particle layers to keep the fluid moving.

Redwood Viscometer

These viscometers are designed for viscosity tests of petroleum Products. They conform to requirements of IP 70. Two adaption of Red Wood viscometer are available No. 1 for liquids having Red Wood flow 20 seconds to 2000 seconds and No. II for liquids whose flow time exceeds 2000 seconds. The complete outfit comprises Stainless steel bath with electrical heating arrangement suitable to operate at 220 Volts AC Mains with tap, silver plated oil cup with precision stainless steel jet, cup cover, ball valve, thermometer-clip. Stirrer and M.S. Sheet stand with levelling screws.



Fig.2 Redwood Viscometer Apparatus

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IV. RESULTS AND DISCUSSION

Boiling point

1. Determination of boiling point of ethylene glycol mixing solutions:-

S.No.	Ethylene glycol	Deionised water	Corrosion inhibitor (phosphate)	Boiling point
1	50ml	49ml	1mls	108°C
2	40ml	59ml	1ml	106°C
3	60ml	39ml	1ml	113°C

2. Determination of boiling point of Di-ethylene glycol mixing solution:-

S.No.	Di-ethylene glycol	Deionised water	Corrosion inhibitor (phosphate)	Boil-ing point
1	50ml	49ml	1ml	154.8 °C
2	40ml	59ml	1ml	152.4 °C
3	60ml	39ml	1ml	159 °C

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Viscosity

1. Determination of Viscosity of Ethylene glycol mixture solution:-

S.No	Mixing Ratio	Temperature (°C)	Time Taken (sec)	Density (g/cm ³)	Kinematic Viscosity (centistoke)	Dynamic Viscosity (NS/m ²)
1	50:49:1	60	88	0.8857	0.209	0.185
		70	70	0.8207	0.157	0.129
2	60:39:1	60	75	0.8857	0.172	0.157
		70	55	0.8207	0.111	0.110
3	40:59:1	60	82	0.8857	0.192	0.17
		70	60	0.8207	0.127	0.09

Determination of Viscosity of Di-ethylene glycol mixture solution:-

S.No	Mixing Ratio	Temperature (°C)	Time taken (sec)	Density (g/cm ³)	Kinematic Viscosity (centistoke)	Dynamic Viscosity (NS/m ²)
1	50:49:1	60	85	0.95	0.200	0.19
		70	75	0.88	0.172	0.15
2	60:39:1	60	80	0.95	0.186	0.17
		70	60	0.88	0.127	0.11
3	40:59:1	60	75	0.95	0.172	0.15
		70	55	0.88	0.111	0.09

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Graphical Representation:-

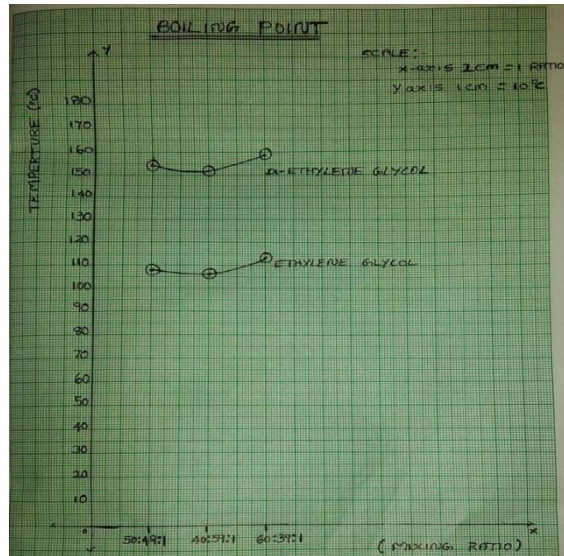


Fig.3 Variation of Temperature Vs Boiling point

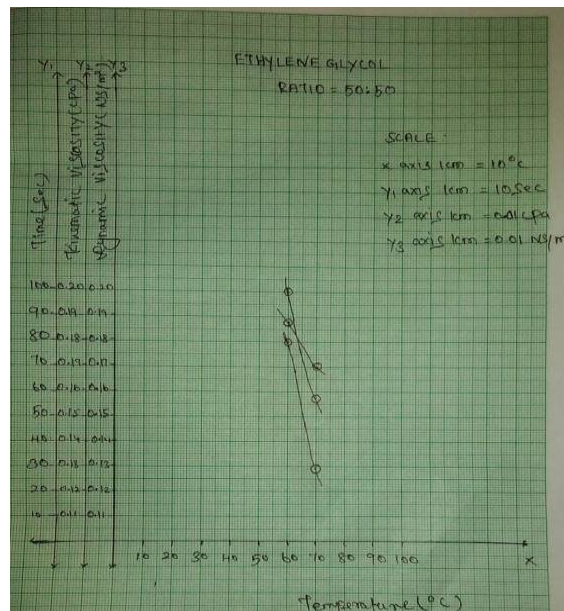


Fig.4 Variation of Temperature Vs Time, Kinematic Viscosity, Dynamic Viscosity (50:50)

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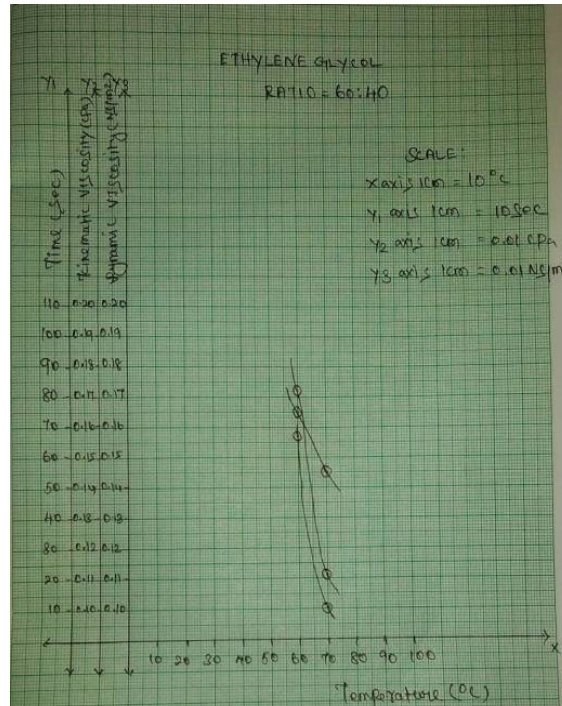


Fig.5 Variation of Temperature Vs Time, Kinematic Viscosity, Dynamic Viscosity (60:40)

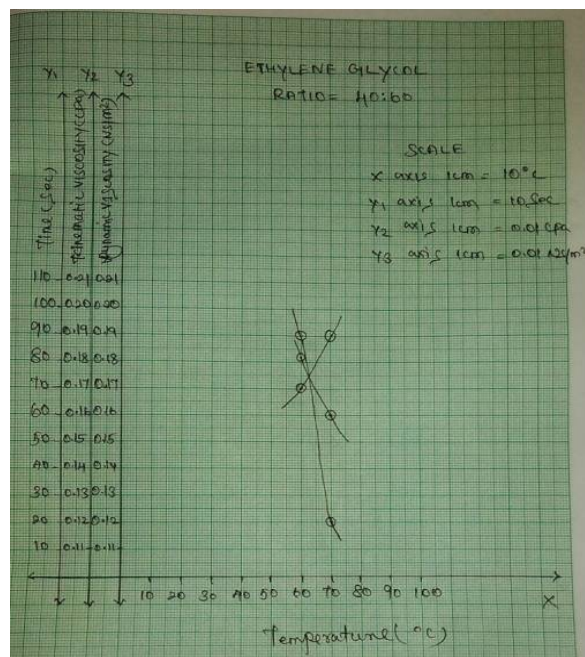


Fig.6 Variation of Temperature Vs Time, Kinematic Viscosity, Dynamic Viscosity (40:60)

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V. FUTURE WORK

Ethylene glycol disrupts hydrogen bonding when dissolved in water. Pure ethylene glycol freezes at about -12°C (10.4°F), but when mixed with water, the mixture does not readily crystallize, and therefore the freezing point of the mixture is depressed. Specifically, a mixture of 60% ethylene glycol and 40% water freezes at -45°C (-49°F). Di-ethylene glycol behaves similarly. It is used as a de-icing fluid for windshields and aircraft. The antifreeze capabilities of ethylene glycol have made it a component of anti-crystallization mixtures for low-temperature preservation of biological tissues and organs. Mixture of ethylene glycol and water can also be chemically termed as Glycol Concentrate/ Compound/ Mixture/ Solution.

However, the boiling point for aqueous ethylene glycol increases monotonically with increasing ethylene glycol percentage. Thus, the use of ethylene glycol not only depresses the freezing point, but also elevates the boiling point such that the operating range for the heat transfer fluid is broadened on both ends of the temperature scale. The increase in boiling temperature is due to pure ethylene glycol having a much higher boiling point and lower vapor pressure than pure water; there is no chemical stabilization against boiling of the liquid phase at intermediate compositions, as there is against freezing.

Hence by determining the freezing point, specific heat, vapour pressure of the Di-ethylene glycol solution will remain more useful than the ethylene glycol solutions.

VI. CONCLUSION

From the experimental result, the antifreeze coolant solutions can vary with their boiling point and freezing point depression. By increasing the mixing ratio of glycol with deionised water the boiling point are also get increased. Similarly the freezing point of the mixture is also get decreases. The boiling point variation and viscosity variation of Ethylene glycol mixture and Di-ethylene glycol mixture is get calculated and proved successfully. Hence comparing these two solutions the boiling point and flow of fluids that is viscosity get differs. The Di-ethylene glycol has high boiling point and more viscosity so it is more benefit than ethylene glycol.

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