**International Journal of Current Advanced Research**
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 6; Issue 10; October 2017; Page No. 6657-6659
DOI: http://dx.doi.org/10.24327/ijcar.2017.6659.0990

Research Article

# DENSITY AND EXCESS MOLAR VOLUMES OF WATER-METHANOL BINARY MIXTURES AT (293.15 TO 313.15) K

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**A R T I C L E I N F O**

***Article History:***

Received 15th July, 2017
Received in revised form 19th August, 2017 Accepted 25th September, 2017
Published online 28th October, 2017

***Key words:***

Binary mixtures, Density, Excess molar volume, Methanol, Water.

**A B S T R A C T**

In this study Densities of pure methanol, water and its binary mixtures were measured at temperatures from 293.15 to 313.15 K over the whole composition range. Excess molar volume was found to be negative with large magnitude. Density and excess molar volumes plotted against mole fraction $X_1$.



## INTRODUCTION

Alcohols, either pure or mixed with water are widely used in the pharmaceutical industry, in cosmetics, enology & as a source of energy [1-3].

Interactions between water & alcohols are extremely complex. Both alcohols & water are self associated liquids through H-bonding. Alcohol possesses hydrophilic OH group as well as hydrophobic group. The mode of interaction of these two groups towards water is completely different. The hydrophilic OH group of an alcohol forms H-bond with water through hydrophilic interactions and disturbs normal water structures, while the alkyl group promotes the structure of water molecule surrounding this group through hydrophobic hydration. A better understanding of water-alcohol interaction is of considerable importance on the field of solution chemistry. It can provide important information regarding hydrophilic and hydrophobic interactions. It is believed that both these effects, hydrophilic and hydrophobic take place in the water rich region of aqueous alcohol solutions [4].

In these paper, the result of excess molar volume & density of binary mixture formed by water with methanol at (293.15 to 313.15) K are reported.

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### *Experimental Section*

In all experiment, triple distilled water was used. Methanol was supplied by fisher scientific with purity (GC) 99.5%.

Binary mixture was prepared by knowing masses of each liquid in airtight stoppered glass bottles. The densities of pure liquid and binary mixture of liquids were measured in 15 $cm^3$ double arm pycnometer [5-8].

This pycnometer was calibrated using conductivity water with 0.9970 $cm^{-3}$ at $25^0$C its density. The pycnometer filled with air bubble free experimental liquid was kept in a transparent walled water bath in which the temperature was maintained to attained thermal equilibrium. The position of the liquid level in the two arms was recorded with travelling microscope which read correctly to ± 0.01 mm. the density values were reproducible within 5 X $10^{-5}$ g $cm^{-3}$ [9].

## RESULT AND DISCUSSION

The excess molar volume & densities of water with methanol at (293.15 to 313.15) K are reported in table 2 & shown graphically in fig. 1 & 2.

The excess molar volume $V^E$ were calculated using the following equation [10]

$$V^E = \frac{(X_1M_1 + X_2M_2)}{\rho_{12}} - \left(\frac{X_1M_1}{\rho_1}\right) - \left(\frac{X_2M_2}{\rho_2}\right)$$

Where, $M_1$, $X_1$, $\rho_1$ & $M_2$, $X_2$, $\rho_2$ are molecular weight, mole fraction & density of components 1 & 2 respectively of binary

mixtures, $\rho_{12}$ the mixtures density. Densities of water with methanol were determined at temperatures of 293.15 to 313.15 K. the densities of the pure components are shown in table 1 along with the literature values. From table 1 it is seen that experimental values and literature values are found to be close; the results has been satisfactory. The density and corresponding $V^E$ data of the binary systems is shown in table 2 at various temperatures. Fig.1 shows the plots of densities as a function of mole fraction of methanol in water. There is continuous decrease in density at the same rate on addition of methanol in water a show a little variation. Excess molar volumes, $V^E$ for methanol in water have been plotted in fig. 2 from this fig. $V^E$ Found to be negative with large magnitude.

**Table 1** Densities (ρ) of pure liquids at various temperatures (T/K)

| Temp. (T/K) | Density ($\rho \cdot 10^{-3}$ (kg·m$^{-3}$) | | | |
|---|---|---|---|---|
| | Water | | Methanol | |
| | Expt. | Lit. | Expt. | Lit. |
| 293.15 | 0.9975 | 0.0081(11) | 0.7902 | - |
| 295.15 | 0.9970 | - | 0.7884 | - |
| 298.15 | 0.9963 | 0.9970(12) | 0.7857 | 0.7866(12) |
| 300.15 | 0.9958 | - | 0.7840 | - |
| 303.15 | 0.9950 | 0.9956(11) | 0.7811 | 0.7812(14) |
| 305.15 | 0.9944 | - | 0.7794 | - |
| 308.15 | 0.9934 | 0.9940(13) | 0.7767 | 0.7261(13) |
| 310.15 | 0.9927 | - | 0.7749 | - |
| 313.15 | 0.9916 | 0.9921(13) | 0.7721 | - |

**Table 2** Density (ρ), Excess molar volume ($V^E$) for various mole fractions ($X_1$) of methanol at (293.15 to 313.15) K

| Temp. (T/K) | $X_1$ | $\rho \cdot 10^{-3}$ (kg·m$^{-3}$) | $V^E.10^6$ (m$^3$·mol$^{-1}$) |
|---|---|---|---|
| 293.15 | 0.0000 | 0.9975 | 0.0000 |
| | 0.0588 | 0.9806 | -0.1713 |
| | 0.1232 | 0.9655 | -0.3829 |
| | 0.1942 | 0.9506 | -0.6120 |
| | 0.2726 | 0.9335 | -0.7976 |
| | 0.3599 | 0.9141 | -0.9247 |
| | 0.4575 | 0.8936 | -1.0102 |
| | 0.5675 | 0.8706 | -0.9886 |
| | 0.6922 | 0.8456 | -0.8409 |
| | 0.8350 | 0.8190 | -0.5432 |
| | 1.0000 | 0.7902 | 0.0000 |
| 295.15 | 0.0000 | 0.9970 | 0.0000 |
| | 0.0588 | 0.9801 | -0.1731 |
| | 0.1232 | 0.9647 | -0.3851 |
| | 0.1942 | 0.9497 | -0.6146 |
| | 0.2726 | 0.9324 | -0.8002 |
| | 0.3599 | 0.9128 | -0.9270 |
| | 0.4575 | 0.8922 | -1.0120 |
| | 0.5675 | 0.8691 | -0.9913 |
| | 0.6922 | 0.8440 | -0.8466 |
| | 0.8350 | 0.8173 | -0.5442 |
| | 1.0000 | 0.7884 | 0.0000 |
| 298.15 | 0.0000 | 0.9963 | 0.0000 |
| | 0.0588 | 0.9793 | -0.1769 |
| | 0.1232 | 0.9636 | -0.3887 |
| | 0.1942 | 0.9482 | -0.6162 |
| | 0.2726 | 0.9306 | -0.8026 |
| | 0.3599 | 0.9108 | -0.9278 |
| | 0.4575 | 0.8900 | -1.0144 |
| | 0.5675 | 0.8668 | -0.9948 |
| | 0.6922 | 0.8416 | -0.8487 |
| | 0.8350 | 0.8147 | -0.5458 |
| | 1.0000 | 0.7857 | 0.0000 |
| 300.15 | 0.0000 | 0.9958 | 0.0000 |
| | 0.0588 | 0.9788 | -0.1500 |
| | 0.1232 | 0.9628 | -0.3501 |
| | 0.1942 | 0.9472 | -0.5644 |
| | 0.2726 | 0.9295 | -0.7377 |
| | 0.3599 | 0.9095 | -0.8496 |
| | 0.4575 | 0.8886 | -0.9212 |
| | 0.5675 | 0.8652 | -0.8801 |
| | 0.6922 | 0.8399 | -0.7136 |
| | 0.8350 | 0.8130 | -0.3892 |
| | 1.0000 | 0.7840 | 0.0000 |
| 303.15 | 0.0000 | 0.9950 | 0.0000 |
| | 0.0588 | 0.9778 | -0.1867 |
| | 0.1232 | 0.9616 | -0.3990 |
| | 0.1942 | 0.9456 | -0.6236 |
| | 0.2726 | 0.9276 | -0.8095 |
| | 0.3599 | 0.9074 | -0.9365 |
| | 0.4575 | 0.8864 | -1.0265 |
| | 0.5675 | 0.8628 | -1.0034 |
| | 0.6922 | 0.8374 | -0.8613 |
| | 0.8350 | 0.8104 | -0.5588 |
| | 1.0000 | 0.7811 | 0.0000 |
| 305.15 | 0.0000 | 0.9944 | 0.0000 |
| | 0.0588 | 0.9771 | -0.1868 |
| | 0.1232 | 0.9608 | -0.4005 |
| | 0.1942 | 0.9445 | -0.6251 |
| | 0.2726 | 0.9264 | -0.8107 |
| | 0.3599 | 0.9061 | -0.9387 |
| | 0.4575 | 0.8848 | -1.0239 |
| | 0.5675 | 0.8612 | -1.0050 |
| | 0.6922 | 0.8358 | -0.8632 |
| | 0.8350 | 0.8087 | -0.5575 |
| | 1.0000 | 0.7794 | 0.0000 |
| 308.15 | 0.0000 | 0.9934 | 0.0000 |
| | 0.0588 | 0.9761 | -0.1929 |
| | 0.1232 | 0.9595 | -0.4076 |
| | 0.1942 | 0.9429 | -0.6299 |
| | 0.2726 | 0.9245 | -0.8160 |
| | 0.3599 | 0.9039 | -0.9402 |
| | 0.4575 | 0.8826 | -1.0304 |
| | 0.5675 | 0.8589 | -1.0125 |
| | 0.6922 | 0.8333 | -0.8688 |
| | 0.8350 | 0.8062 | -0.5650 |
| | 1.0000 | 0.7767 | 0.0000 |
| 310.15 | 0.0000 | 0.9927 | 0.0000 |
| | 0.0588 | 0.9752 | -0.1932 |
| | 0.1232 | 0.9586 | -0.4095 |
| | 0.1942 | 0.9417 | -0.6304 |
| | 0.2726 | 0.9232 | -0.8163 |
| | 0.3599 | 0.9025 | -0.9435 |
| | 0.4575 | 0.8810 | -1.0311 |
| | 0.5675 | 0.8573 | -1.0158 |
| | 0.6922 | 0.8317 | -0.8727 |
| | 0.8350 | 0.8044 | -0.5662 |
| | 1.0000 | 0.7749 | 0.0000 |
| 313.15 | 0.0000 | 0.9916 | 0.0000 |
| | 0.0588 | 0.9740 | -0.1971 |
| | 0.1232 | 0.9570 | -0.4130 |
| | 0.1942 | 0.9400 | -0.6364 |
| | 0.2726 | 0.9212 | -0.8216 |
| | 0.3599 | 0.9003 | -0.9490 |
| | 0.4575 | 0.8787 | -1.0384 |
| | 0.5675 | 0.8548 | -1.0203 |
| | 0.6922 | 0.8217 | -0.8780 |
| | 0.8350 | 0.8017 | -0.5709 |
| | 1.0000 | 0.7721 | 0.0000 |

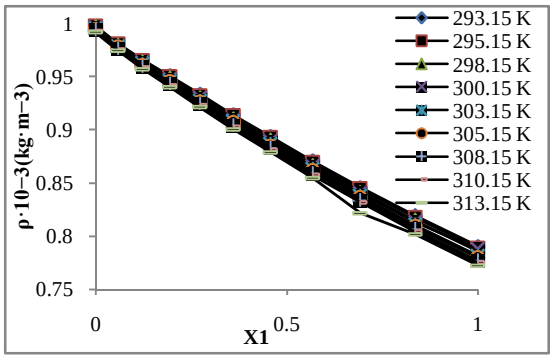


**Fig 1** Plot of density (ρ) vs. mole fraction ($X_1$) for methanol in water system at 293.15 to 313.15 K.

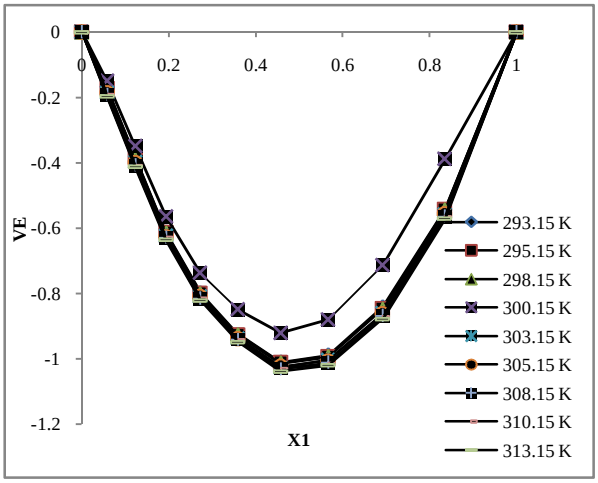


**Fig 2** Plot of Excess molar volume ($V^E$) vs. $X_1$ for methanol in water at 293.15 to 313.15 K.

## CONCLUSION

Densities and Excess molar volume of pure methanol, water and in water-methanol binary mixtures were measured at temperatures from 293.15 to 313.15 K Over the whole composition range. There is continuous decrease in density at the same rate on addition of methanol in water and excess molar volume was found to be negative with large magnitude.

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**How to cite this article:**

Ramesh R. Pawar *et al* (2017) 'Density And Excess Molar Volumes of Water-Methanol Binary Mixtures At (293.15 To 313.15) K', *International Journal of Current Advanced Research*, 06(10), pp. 6657-6659.
DOI: http://dx.doi.org/10.24327/ijcar.2017.6659.0990

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