

A Review on Thermodynamic and Transport Properties of Liquid and Liquid Mixture

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Abstract

The study of thermodynamic characteristics of liquids and liquid mixtures is crucial to comprehending the nature of molecular interactions in the system. Excess thermodynamic characteristics in multicomponent fluid mixtures give important information on intermolecular interactions. However, phase equilibria are frequently employed to assess the correctness of any theory or chemical model defining the thermodynamic behaviour of a solution. The current work is based on a review of thermodynamic and transport characteristics of liquids and liquid mixtures.

Keywords: Density, velocity, fluid, thermodynamic, viscosity, surface tension.

I. INTRODUCTION

The thermodynamic and transport characteristics of liquids and liquid mixes are used to understand engineering applications such as heat transmission, mass transfer, and fluid movement, as well as to research the molecular interactions between the various components of the mixtures. The physical, chemical, and transport characteristics of fluids are important in chemical process industries because materials are often handled in fluid form. As a result, information on certain of the characteristics of liquids and liquid mixtures, such as density and viscosity, is widely used in solution theory and molecular dynamics. The interpretation of data acquired from thermochemical, electrochemical, biochemical, and kinetic research requires such outcomes.

Understanding molecular interactions requires the study of thermophysical characteristics of fluids, and it aids the design of many industrial chemical processes involving heat, mass, and fluid movement. Owing to interactions between the solute-solute, solvent-solvent, and solute-solvent, as well as interstitial accommodation due to structural factors, the variations in thermodynamic and transport parameters are quite complicated. To design mass transfer procedures, a quantitative assessment of liquid mixes is necessary.

More sophisticated treatments [3-4] of liquid mixtures derived their conceptual basis from-

- (a) the cell model for liquids and (or) from –
- (b) the postulations of a universal form for the intermolecular potential expressed by

$$\epsilon_{ij} = \epsilon_{ij}^* \phi(r_{ij}/r_{ij}^*)$$

where, r_{ij} is the distance between centres of molecules i & j , ϵ_{ij}^* & r_{ij}^* are characteristic parameter for the pair, and $\phi(r/r^*)$ is the universal function of its agreement.

The intermolecular energy is usually discussed on the basis of the familiar Lennard-Jones potential operating between the molecular centres. Even in comparatively simple polyatomic molecules, the acentric distribution of polarizable electrons necessitates fairly drastic modification of this potential. Kihara[3], Hamann and Lambert[4] and Pitzer[5,6] have offered modified intermolecular potentials for polyatomic (globular) molecules, especially those approximating spherical symmetry in form.

An extension [7] of these considerations which suggests itself, as a basis for treating the intermolecular energy in liquid consists in integrating the interactions of elements of the core of one molecule with the elements of all surrounding molecules, these latter being treated as occupying the space outside the cavity reserved for the molecule in questions.

The result obtained departs markedly from the form of the intermolecular energy according to the theory of Lennard-Jones and Devonshire.

In the limit of very large particles such that the range of intermolecular interactions, attractive as well as repulsive, is small compared to the molecular diameter and to the distance between boundaries of the domains of neighbouring molecules, the intermolecular energy can then be treated as arising effectively from interactions between the surfaces of adjoining molecules. The calculations support an account of the intermolecular energy on this basis, and they indicate further that this manifestly approximation should be satisfactory even for small polyatomic molecules. Certainly, this approximation, which has a long history of usage in solution theory, is preferable to central force potentials, the Lennard-Jones type of virtually all molecules. It offers the additional advantage to treatment of nonspherical molecules and of mixtures of molecules differing in size. Numerous theories have been developed in past to study the properties of and interactions in liquid solutions are discussed in the section below.

II. LITERATURE REVIEW

Density and viscosity of saturated liquid dimethoxymethane were measured at various temperatures by J. Wu et al¹. P. Jain and M. Singh² measured density, viscosity and excess properties of binary liquid mixtures of propylene with polar and non-polar solvents. G. Cruz-Reyes et al³ established a correlation of viscosities of pure gases and liquids with the use of significant structure theory. R. J. Martins⁴ interpreted the viscosity of pure liquids at elevated pressures. L. T. Novok⁵ proposed modeling of viscosity of liquid mixtures of polymer solvent systems. Calculations of viscosity of ternary and quaternary liquid mixtures were carried out by several workers⁶.

Excess Gibbs free energy model for calculating the viscosity of binary liquid mixtures is given by R. J. Martins et.al.⁷. Generic van der Waals equation of state, modified free volume theory of diffused viscosity of simple liquids were determined by, Laghaei et. al⁸, J. Wu⁹

experimentally determined the viscosity of saturated liquid dimethylether at elevated temperatures. Viscosity of the homologous series of n-(trans-4-n-alkyl cyclohexyl) isothioganate was studied by J. Jadzyn¹⁰. Excess molar enthalpies of dimethylcarbonate and (methanol, ethanol, 1- propanol) at various temperatures and pressures were studied by S. Li and H. Dong¹¹.

Excess molar enthalpies and excess molar volumes of ternary system 1, 2-dichloro benzene + benzene + hexane was studied by M. M. Mato et al¹² at 25°C. G. C. Shekhar and M. V. P. Rao¹³ studied excess molar volumes and speeds of sound of N, N-dimethylacetamide with chloroethane at 303.15 K.

Valles¹⁴ measured the excess enthalpy, density, speed of sound and viscosity of 2-methyl tetrahydrobutanol at different temperatures. Generalized correlation for the viscosity of hydrocarbons based on corresponding principles and molar refraction was studied by M. Riazi et al¹⁵. Y.-Y. Duan et al¹⁶ measured the saturated liquid viscosity of cyclopentane and isopentane. A. E. Nasrabad¹⁷ modified the free volume theory of self-diffusion and molecular theory of shear viscosity of liquid CO₂.

Determination of viscosity and density of di- (2-ethylhexyl) phosphoric acid + kerosene were carried out by L. R. Koekemoer et al¹⁸. I. Johnson¹⁹ experimentally determined density, viscosity and speed of sound in the ternary mixture of 2-ethoxyethane + dimethylformamide + N, N-dimethylacetamide and 2- ethoxyethanol + dimethylformamide + N, N-dimethylacetamide at 308.15 K.

III. CONCLUSION

Following a review of the literature, the study discovered that there is intermolecular interaction between the components in the binary combination. Many volumetric characteristics may be determined using thermodynamics. Temperature and pressure have a significant impact on the thermodynamic and volumetric characteristics. There are many properties of a mixture that have thermodynamic significance, including “thermal expansion coefficients, excess thermal expansion coefficients, isothermal coefficients of pressure excess molar enthalpy, partial molar volumes, partial molar volumes at infinite dilution, partial excess molar volumes, and partial excess molar volumes at infinite dilution.”

References

1. “Ivona R. Radovia, Mirjana Lj. Kijevöceanin, Aleksandar A, Tasia, Bojan D. Djordjevia And Slobodan P. A Erbanoviä ,Erived, Thermodynamic Properties Of Alcohol + Cyclohexylamine Mixtures”, J. Serb. Chem. Soc., 2010, 75 (2), 283-293..
2. “P. P. Patil, S. R. Patil, A. U. Borse And D. G. Hundiwale, Density, Excess Molar Volume And Apparent Molar Volume Of Binary Liquid Mixtures”, RasayanJ.Chem., 2011, 4(3), 599-604.
3. “Matej Hus, Gasper Zakelj And TomaUrbic, Properties Of Methanol Water Mixtures In A Coarse-Grained Model”, ActaChim. Slov., 2015, 62, 524-530.

4. "G. J. Maximo , M. C. Costa And A. J. A. Meirelles, Solid-Liquid Equilibrium Of Triolein With Fatty Alcohols", Brazilian Journal Of Chemical Engineering, 2013, 30(1), 33-43.
5. "Denis S. Abrams And John M. Prausnitz, Statistical Thermodynamics Of Liquid Mixtures: A New Texpression For The Excess Gibbs Energy Of Partly Or Completely Miscible Systems", Alche Journal, 1975, 21(1), 116-128.
6. N. Shankar Ganesh And T. Srinivas, "Evaluation Of Thermodynamic Properties Of Ammonia-Water Mixture Up To 100 Bar For Power Application Systems", Journal Of Mechanical Engineering Research, 2011, 3(1), 25- 39.
7. Mohamed Ibrahim A , GeirSkaugen B , Ivar S. Ertesva G, "Modelling CO₂ - Water Thermodynamics Using SPUNG Equation Of State (Eos) Concept With Various Reference Fluids", Energy Procedia, 2014, 51, 353 - 362.
8. RavindraDhar, R S Pandey,V K Agrawal, "Optical And Thermodynamic Studies Of Binary Mixtures Of Nematic Liquid Crystals From Homologous Members Of Alkyloxybenzoic Acid", Indi An J Pure & A PplPhys, 2002, 40, 901-907.
9. N. Shankar Ganesh And T. Srinivas, "Thermodynamic Properties Of Binary Mixture For Power Generation Systems", Arpn Journal Of Engineering And Applied Sciences, 2010, 5(10), 11- 24.
10. Privat, J.-N. Jaubert, And M. Moliere, "The Thermodynamics Of Alcohols-Hydrocarbons Mixtures", MATEC Web Of Conferences 3 , 2013, ,1-10.
11. Andreas Heintz, "Recent Developments In Thermodynamics And Thermophysics Of Non-Aqueous Mixtures Containing Ionic Liquids- A Review", J. Chem. Thermodynamics, 2005, 37, 525-535.
12. T Karunakar A, ChSrinivasu B , K Narendra, "Thermo Acoustic And Infrared Study Of Molecular Interactions In Binary Mixture Aniline+1-Butanol", Research And Reviews: Journal Of Pure And Applied Physics, 2013, 1(1), 5-10.
13. Rita Mehra, MeenakshiPancholi And Avneesh K Gaur, "Ultrasonic And Thermodynamic Studies In Ternary Liquid System Of Toluene+1- Dodecanol+Cyclohexane At 298, 308 And 318k", Archives Of Applied Science Research, 2013, 5 (1),124-133.
- 14.C. Valles, E. Perez, A. M. Mainar, J. Santafe and M. Dominguez, J. Chem. Eng. Data, 51(3), 1105(2006).
- 15.M. R. Riazi, K. A. Mandi and M. Alquallaf, J. Chem. Eng. Data, 50(1), 1(2005).
- 16.R.-F. Ma, L. Shi, Y.-Y. Duan, L.-Z. Han and N.-X. Liu, J. Chem. Eng. Data, 48(6), 1418(2003).
- 17.A. B. Nasrabad, R. Laghaei and B.C. Eu, J. Phys. Chem. B., 109(16), 8171(2005).

18.L. R. Koekemoer, M. J. G. Badenhorst and R. C. Everson, J. Chem. Eng. Data, 50(2), 587(2005).

19.I. Johnson, M. Kalidoss and R. Srinivasmoorthy, J. Chem. Eng. Data, 47(6), 1388(2002).

20.X.-X. Li, Y.-X. Liu and X.-H., J. Chem. Eng Data, 49(4), 1043(2004).

