Correlation between the Arrhenius viscosity parameters and the boiling temperature of some engineering fluids

N. Ouerfelli [a,b,*], A.A. Al-Zahrani [a], T.A. Al-Jabran [a], W.T. Azzoni [a], A.M. Al-Amari [a], W.H. Al-Ghamdi [a].
[a)] University of Dammam, Saudi Arabia; [b)] University of Tunis El Manar, Tunisia.

Abstract

Knowledge and estimation of transport properties of fluids are necessary for mass flow and heat transfer. Viscosity is one of the main properties which are sensitive to temperature and pressure variation. In the present work, based on the use of statistical techniques for regression analysis and correlation tests, we propose an original equation modeling the relationship between the two parameters of viscosity Arrhenius-type equation ($\ln\eta = \ln As + Ea/RT$). Empirical validation using 90 data set of fluids provided from the literature and studied at different temperature ranges gives excellent statistical results which allow us to redefine the Arrhenius-type equation using a single parameter instead of two ones ($E_a = \lambda \cdot R \times (-lnA_s)^{\alpha_0}$). More, causal correlation between these parameters and the normal boiling temperature (T_b) of the corresponding fluids leads us to propose two predictive empirical equations one with the activation energy ($T_b(E_a) = -\frac{E_a}{68 - 4.05 \times Ea^{0.34}}$) and one with the logarithm of pre-exponential factor ($T_b(lnA_s) = \frac{(-lnA_s)^{2.933}}{8.2 + lnA_s}$). We conclude that the boiling temperature is in causal correlation with the two Arrhenius parameters, but with other physical and chemical properties implicitly for which there are some ones are common for the two Arrhenius parameters while others are in relationship only for a single parameter ($\ln As$) or (Ea). To correct this observation, we will try to suggest in future works, an expression both explicit, the two viscosity Arrhenius parameters $T_b(Ea, \ln As)$ alternatively in the numerator and in the denominator. Note that this equation is tested to some heavy oils with reliable agreement for which we can conclude that it can be useful for petroleum chemistry.

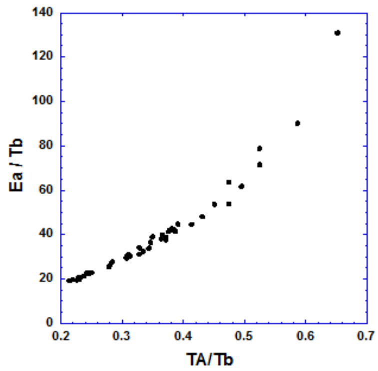

Figure 1 : Correlation between the ratios and Arrhenius activation energy-boiling point (Ea/Tb) and the Arrhenius temperature-boiling point (TA /Tb) for some pure solvents.

Where T_A / (K) is the Arrhenius temperature for each pure solvents defined by the following equation:

$$T_A = \frac{-E_a}{R\ln(A_s)} \tag{1}$$

Recent Publications

1. Das D, Salhi H, Dallel M, Trabelsi Z, Al-Arfaj AA, Ouerfelli N. Viscosity Arrhenius activation energy and derived partial molar properties in isobutyric acid + water binary mixtures near and far away from critical temperature from 302.15 K to 313.15 K. J. Solution Chem. 2015;44:54–66.
2. Messaâdi, A, Salhi, H, Das, D, Alzamil, NO, Alkhaldi, MA, Ouerfelli, N, Hamzaoui AH. A novel approach to discuss the viscosity Arrhenius behavior and to derive the partial molar properties in binary mixtures of N,N-dimethylacetamide with 2-methoxyethanol in the temperature interval (from 298.15 to 318.15) K. Phys. Chem. Liq. 2015;53:506–517..
3. Ben Haj-Kacem R, Ouerfelli N, Herráez JV, Guettari M, Hamda H, Dallel M. Contribution to modeling the viscosity Arrhenius type-equation for some solvents by statistical correlation analysis. Fluid Phase Equilibr, 2014;383:11–20.
4. Ben Haj-Kacem R, Ouerfelli N, Herráez JV. Viscosity Arrhenius Parameters Correlation: Extension from Pure to Binary Liquid Mixtures. Phys. Chem. Liq. 2015;53:776–784.
5. Messaâdi A, Dhouibi N, Hamda H, Belgacem FBM, Adbelkader YH, Ouerfelli N, Hamzaoui AH. A novel equation correlating the viscosity Arrhenius temperature and the activation energy for some classical solvents. Journal of Chemistry, vol. 2015, Article ID 163262, 12 pages, 2015. doi:10.1155/2015/163262.

Biography

Noureddine Ouerfelli has a PhD and Habilitation Diploma in Chemistry; he is a head of research project in the Laboratory of Biophysics and Medical technologies. He has published more than 45 papers in reputed journals on modeling of physicochemical properties in solution. (http://www.researchgate.net/profile/Noureddine_Ouerfelli/). Email: nouerfelli@yahoo.fr