

Studies on Surface tension of various Alcohols

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ABSTRACT

Surface tension of various alcohols like Methanol, Propanol and iso-propanol, was measured at temperatures ranging from 30 to 70°C with intervals of 10°C. The experimental values of surface tension for these alcohols were compared with estimated values. The average percent deviation was found to be ± 1.8295 using Macleod & Sugden method.

Key words: Surface tension, Methanol and Propanol.

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INTRODUCTION

The surface tension of pure liquids is an important physical property in mass transfer process such as liquid - liquid extraction, gas absorption, distillation, and condensation. The surface tension is also a property that represents changes in molecular interaction. This physical property is needed in several chemical engineering design calculations such as interfacial area, plate spacing, slot opening, entrainment rate and liquid holdup in problems relating to two-phase flow, nucleate boiling heat transfer and the design of distillation columns. Therefore, it has been thought fit to study the effect of temperature on surface tension for some common liquids. Description of experimental work in the literature has revealed that the methods for measuring surface tension such as Capillary height method, Ring method, Drop – weight method and Bubble pressure method and among these bubble pressure method is chosen for present work.

MATERIALS AND METHODS

The apparatus is designed on the lines suggested by Sugden [1]. The arrangement of the apparatus (commonly called tensiometer) is shown in Fig.1.

Compressed air or nitrogen gas from a cylinder is passed through a drying tower loosely packed with CaCl₂ (calcium chloride), via a regulating valve and manometer to the tensiometer. Teflon needle valves provided the fine control of the flow of gas at the required flow rates. The manometer liquid used is CCl₄ (carbon tetrachloride, density = 1.570gram/cc

at 28°C). The pressure drop is measured to a precision of 0.01 mm, by means of a cathetometer mounted on a vertical pillar, provided with a vernier scale.

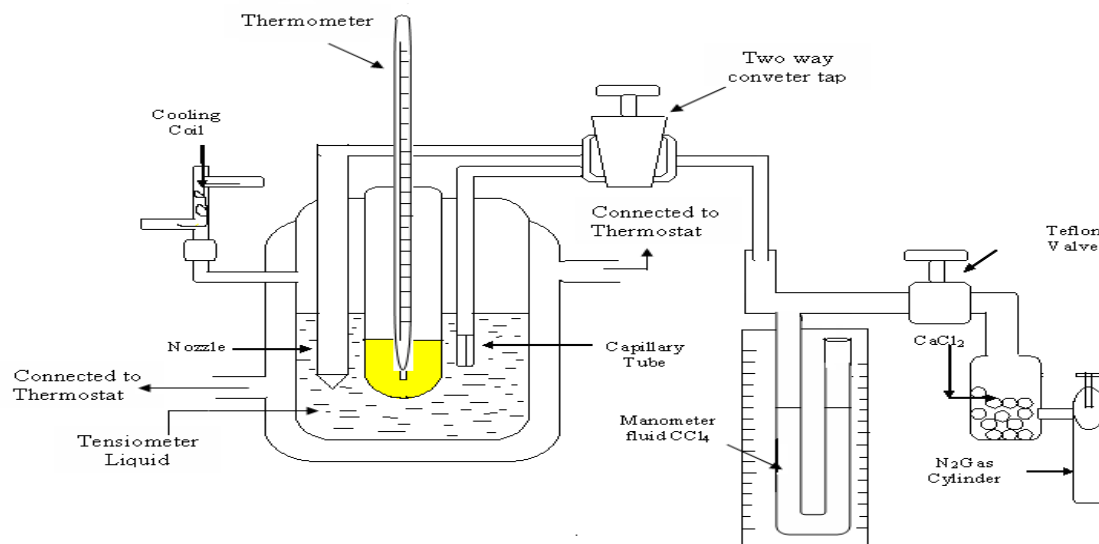


Fig1: Schematic diagram of experimental apparatus

The sample liquid is charged to the tensiometer cell until the tube tips are submerged to a depth of 1-2 cm. the tensiometer is maintained at the desired isothermal level, by circulating water from the thermostat at the required temperature. Sufficient time is allowed for the liquid to attain the desired temperature. The value is checked from time to time by means of a calibrated thermometer inserted through the top. The rate of flow of gas is so adjusted as to allow a bubble in every second. The manometer level fluctuates registering a maximum as the bubble breaks away from the tube. The maximum difference is first recorded when the gas is flowing through the capillary tube (h_1), and then when the gas is flowing through the other tube (h_2). The measurements of h_1 and h_2 are reported several times and the values are recorded only when three successive measurements of the values agreed with the limits of observation.

Chemicals used are Methanol (99.8%), Propanol (99.9%), and iso - propanol (99.9%), which are AR grade, purchased from S.D.Chemicals Ltd., pure liquids used in the present work are prepared from the AnalaR/Guaranteed reagent grade, further purified according to the methods described by Weissberger and Reddick and Bunger [2].

The empirical relation given by Sugden [1] is accurate to 1 part in 1000 for the surface tension (dyne/cm). Provided $0.2 > r_2 > 0.1$ and $r_1 < 0.001$. The Sugden[1] equation is

$$\sigma = \rho A g (h_1 - h_2) \left[1 + \frac{0.69 r_2 D}{\rho (h_1 - h_2)} \right]$$

Where A = apparatus constant, determined by calibration, r_2 = radius of larger capillary tube a(cm), D = density of liquid sample (gram/cc) and ρ = density of manometer liquid (gram/cc) and $g = 981$ (cm/sec²). The apparatus constant (A) is determined by using chemicals for which surface tension data is known, eg: toluene, o-xylene, methanol. From Macleod [3]

$$\sigma^{1/4} \text{ (dyne / cm)} = \{ [P] (\rho_l - \rho_v) \}$$

Where ρ_l is density of the liquid, ρ_v is density of the vapour and [P] is the Parachore and it is called as the temperature independent parameter. Sugden [5, 6] indicated how it might be estimated from the structure of the molecule.

RESULTS AND DISCUSSION

Based on the closeness of the agreement of the physical property data given in Table1, with selected values from the literature [3], and on the accuracy of the calibration charts and tables prepared and the pure liquids are estimated to be of purity better than 99.5%.

Table 1. Comparison of refractive index and density of the pure liquids used in the present study with selected values from the literature at 20 + 0.05° C.

S.No.	Compound	Density(lit[3])(gram/ml)	Density(observed) (gram/ml)	Refractive index (lit[2])	Refractive index (exp)
1	Methanol	0.7910	0.7911	1.3284	1.3280
2	Propanol	0.8036	0.8003	1.3855	1.3854
3	iso-propanol	0.7854	0.7823	1.3772	1.3770
4	Butanol	0.8095	0.8094	1.3979	1.3977
5	iso-butanol	0.8065	0.8064	1.3953	1.3950
6	tert-butanol	0.7812	0.7813	1.3877	1.3876
7	o-xylene	0.8801	0.8800	1.5054	1.5052
8	Toluene	0.8668	0.8666	1.4969	1.4967

The experimental values of surface tension of pure liquids are compared with the predictions from Macleod & Sugden[4], given in the table 2.

Table2. Comparison of experimental and estimated surface tension values of alcohols

Compound	Temp ⁰ C	σ exp (dyne /cm)	σ Macleod[4] (dyne /cm)	Percentage deviation
Methanol	30	21.2485	18.5884	14.290
	40	20.4994	18.1167	13.1519
	50	19.9997	17.2003	16.2752
	60	18.9987	16.3191	16.420
propanol	30	22.7483	22.8642	0.5094
	40	21.9993	21.7355	-1.1991

To be continued....

	50	21.2494	20.6492	-2.8245
	60	20.2473	19.6041	-3.1767
	70	19.4921	18.5992	-4.5808
iso-propanol	30	20.4983	20.6841	0.9064
	40	19.9984	19.6041	-1.9716
	50	19.2482	18.5992	-3.3717
	60	18.4988	17.6300	-4.6965
	70	17.7486	16.7024	-5.8945

On the overall basis the percent average deviations are ± 1.8295 for Macleod & Sugden.

CONCLUSIONS

- The effect of temperature on surface tension for pure compounds was studied. As the temperature increases and surface tension decreases.
- The surface tension of pure liquids was found to vary linearly with temperature.
- The experimental values compared with the values estimated by using Macleod & Sugden method, the average percent deviation was found to be ± 1.8295 .

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REFERENCES

- [1] Sugden.S, J.Chem.Soc, 121,858 (1922); 125,27,1924.
- [2] Riddick,J.A., Bunger,W.B., Sanako, T.K., Physical properties and Methods of purification in Techniques of Chemistry, 4th Eddition, Bernasconi, C.F, Edition, Wiley – Interscience, New York, 1986.
- [3] Gallant Robert W, Physical properties of hydro carbons, The Dow Chemical Company,1, 1968.
- [4] Maleod,D.B.,Trans.paraday Soc.19,38,1923.
- [5]Sugden,S.,J.Chem.Soc.,32,1924.
- [6] Sugden. S., J.Chem.Soc., 1177,1924.