Relative study of surface tension with the effect of impurities and temperature

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Abstract : Surface Tension is the special property associated with liquid phase of matter. Every liquid try to decrease the surface area to minimize the free surface energy. This leads to increase in stability of liquid drop. The liquid also acts as solvent for the solute. Moreover, some of the solutes are not completely soluble in a proposed solvent. The completely soluble solute in a given solvent is treated as soluble impurity and the incomplete solubility of solute in a solvent is treated as insoluble impurity. In the present work, the effect of soluble and insoluble impurity on the surface tension was studied at room temperature as well as at the washing temperature of solvent. The Jaegers method was utilized to observe the effect of impurities on the surface tension properties. Interestingly, among the different soluble and insoluble solutes (impurities) in water, the magnitude of surface tension of ubtan is observed to be least. This indicates that the spreading ability of ubtans is more and it can be utilized to make the number of applications like in body soap and liquids, for the cosmetic and washing purposes. The observed least value of surface tension to ubtan is may be due to its own ayurvedic composition of sandalwood and turmeric powder with gram flour in milk. The effect on the surface tension values of different solutes signifies their washing ability. The observed change in the values of surface tension may be due to the change in angle of contact due to the added impurities.

IndexTerms **- Surface Tension, Soluble and Insoluble impurity, Ubtan.**

I. INTRODUCTION

Surface Tension is an important property associated with the liquid phase of matter. The every drop of liquid tries to minimize surface energy to become stable one [1, 2]. The geometry of spherical surface has least area and it is responsible for the minimum free surface energy [3]. Moreover, whenever we need to use any liquid for the washing and cleaning purpose, the ability of spreading of the bubbles of liquid on the experimental surface determines the magnitude of surface tension. Water is the most useful liquid and is utilized for the washing, cleaning and number of activities in daily life. Moreover, the surface tension of water is 72 dyne/cm [1, 2]. This value affect the spreading of water on the surface and therefore the cold water is not good enough for the washing of human body and cloths. The need is to decrease the surface tension of water so that the spreading ability of water will increase and it will become useful for the washing purpose.

OUR MOTIVATION

We get fascinated by extreme beauty of soap bubbles, magic of colors and science behind such a great phenomenon. The ubtan, normally utilized for the bathing purpose and its spreading ability on the body surface of human being motivate us to study the properties of surface tension associated with it. We also got motivated to construct this framework when we saw the advertisement of washing powders about their qualities

II. LITERATURE REVIEW

The Van de Waal forces between molecules produce the Surface tension [1-5]. In case of liquid drop in air, the central molecule is attracted equally by other molecules. However, the surface molecule is attracted to its neighbors only. The surface energy always acts to try and reduce the surface for a given volume [5]. Surface-active materials are called as Surfactant and they may reduce the surface tension. A detergent is responsible to spread the water on a surface. The surface tension changes with size of bubbles. The amount of pressure in the larger bubbles will be higher than in smaller ones. Moreover, in presence of surfactant the volume of bubble increases with fast rate at the same pressure [2, 6 -7]. Ubtan is a semisolid, used for the bathing and also in cosmetics to remove the dirt particles and enhances the luster of the body [8].

III. METHODOLOGY

There are different methods for the determination of the Surface Tension. Each method has its own significance with the certain limitation [1-4]. The bubble drop method is commonly utilized due to its easiest way and the accurate measurement. The accuracy in the result of surface tension is achieved through the slow formation of fresh bubbles only one at a time (almost 10 seconds). The flow of water and the volume of the air space above water in the beaker are minimized for the stable bubble formation. Moreover, the Jaeger's method determines the surface tension at short surface. Thus the maximum pressure of each bubble is measured for spherical liquid drop surface. The Jaegers apparatus consists a long thin glass tube, with a fine bore (0.2 mm in diameter) dipped in experimental liquid (4 cm of its length) in a beaker.

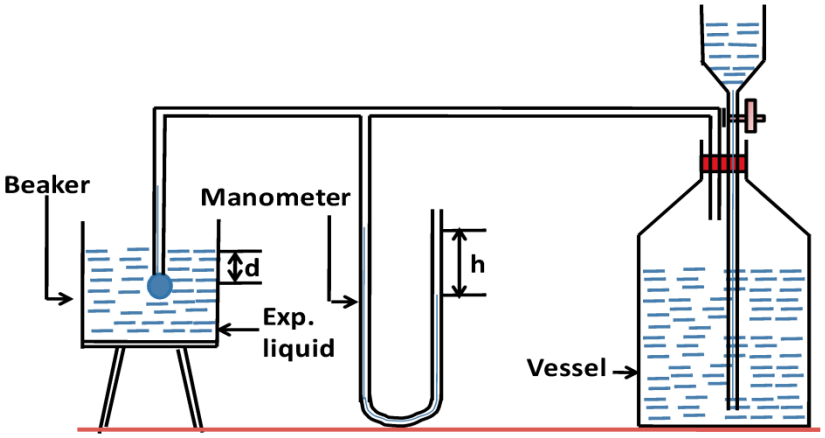

Fig. 1: Jaegers' method for the determination of Surface Tension.

The liquid surface in experimental liquid is flat due to the large diameter of beaker (8 cm) so that the liquid surface is flat. Another end of the glass tube is connected to manometer and a vessel containing water as shown in Fig. 1. Some experimental liquid rises up in the tube due to capillary action [1-4]. The small quantity of water dropped into the vessel, due to which the air get displaced from the vessel and generate pressure on the experimental liquid in a glass tube. The liquid column in a capillary slowly moves down and reaches to its minimum value. The bubble acquires a hemispherical shape with an equivalent radius of the aperture. The maximum pressure inside the bubble is referred from the height difference in manometer tube as shown in Fig.1. The same process repeats five times for the maximum accuracy

IV. RESULTS AND DISCUSSION

A molecule inside the liquid attracts the other surrounded molecules and vice versa. All molecules inside liquid are at equilibrium with neutral resultant forces [8-9]. Moreover, the surface molecules are only attracted from the liquid side and the lateral direction. Thus, the tangential force to the surface is acting due to the cohesion among the surface molecules so that the free surface of fluid behaves like an elastic membrane. Here, we did the measurement of surface tension for the water along with different soluble and insoluble impurities. The Surface tension values are obtained at room temperature and the washing temperature at 40oC. The surface tension value in each case is calculated using the formula of Jaegers method as follows:

$$\text{Surface Tension, } T = (h\rho - d\sigma)gr/2\cos\theta$$

Here h: height difference in manometer level, ρ: density of the liquid in manometer, d: depth of capillary into the experimental liquid, g is acceleration due to gravity, r: radius of the capillary bore, σ : density of the experimental liquid in beaker and ɵ is angle of contact.

1. SURFACE TENSION OF WATER WITH TEMPERATURE

The obtained results signify the decay in values of surface tension in an exponential way with the rise in temperature as shown in Fig. 2.

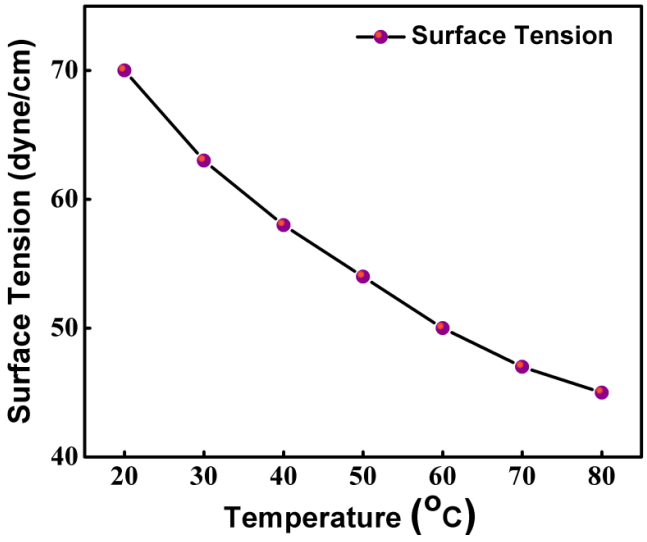

Fig. 2: Change in Surface tension with rise in temperature

The obtained value of surface tension of water at room temperature (25 oC) is 70 dyne/cm. This obtained value is similar to the standard value 72 dyne/cm at 20 oC [2-3, 7]. The decrease in values of surface tension might be due to the change in angle of contact of the water molecules with the glass surface of the capillary[4, 8-10]. This might be due to the van der waals forces and the result helps to predict the values of surface tension at the required temperature.

2. SURFACE TENSION OF INSOLUBLE IMPURITY

2.1. Soap Powder at Room temperature and Washing temperature

The surface tension of different soap powders available in market were obtained at room temperature and washing temperature. The surface tension of water is reduced to 42 dyne/cm to 54 dyne/cm for the different detergents as shown in Fig. 3 (a). This is due to the incomplete solubility of washing powder at room temperature. Moreover, the surface tension values are reduced to 31 dyne/cm to 39 dyne /cm for the same detergents at washing temperatureas shown in Fig. 3 (b). This is due to the combine effect of temperature and impurities. The increase in adhesive force due to soap powders maybe responsible for the decrease in surface tension. Moreover, the impurities and increased temperature of water changes the angle of contact and reduces the magnitude of surface tension[2, 7].The less values of surface tension with more spreading ability of the detergents can be utilized for the washing purposes. Thesolubility of detergents at washing temperature may also affectthe magnitude of the surface tension. Detergents and ingredients of soaps mainly consist either sodium lauryl sulfate or the sodium stearate or sodium oleate. This is a long hydrocarbon chains. It is attached to the hydrophilic groups like COONa. These are mainly effective in reducing the surface tension of water [2, 7].

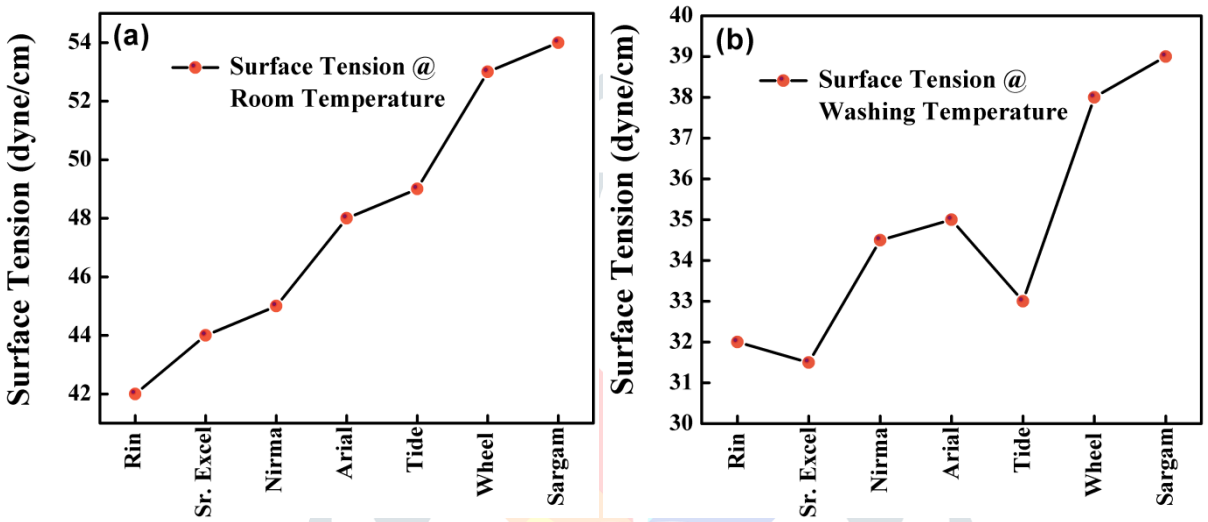

Fig. 3: Surface Tension of detergents at a) Room temperature and b) Washing temperature.

2.2. Vim bar and Dettol

The surface tension of vim bar, utilized for the pot cleaning is 40 dyne/cm and the dettol used for the cleaning of hands having surface tension of 33 dyne/cm in cold water. These are the significant results for the washing purpose. This result signifies the requirement of the values of surface tension for washing in cold water [2].

2.3. Ubtan

The calculated value of the surface tension for ubtan is 25 dyne/cm in a hot water at 40oC. This is the lowest recorded magnitude of surface tension among the different values obtained in the present study. The obtained lowest value is due to the ayurvedic composition of ubtan. Ubtan basically consist sandalwood and turmeric powder. The homogenous mixture of with gram flour in milk reduces the magnitude of surface tension [8].

3. SURFACE TENSION OF SOLUBLE IMPURITY

The recorded value of Surface Tension for the soluble impurity of NaCl and Sugar are 90 dynes/cm and 95 dynes/cm respectively. The solubility of NaCl is less as compeer to Sugar. This result supports the phenomenon of rise in surface tension due to the soluble impurity.

V. CONCLUSION

The objective of the present work is to obtain the values of surface tension for the different soluble and insoluble impurities relative with the water. The nature of decay in the magnitude of surface tension is an exponential way with the rise in temperature for the water. The insoluble impurities of different detergents decrease the surface tension of water to 42 dyne/cm to 54 dyne/cm and the same values decrease further in a hot water at washing temperature to 31 dyne/cm to 39 dyne/cm. The vim bar and the dettol liquid report the surface tension of 40 dyne/cm to 33 dyne/cm. The soluble impurity of salt and sugar increases the surface tension to 90 dyne/cm to 95 dyne/cm. The fascinating results were obtained for the ubtan and it shows the least surface tension of 25 dyne/cm in a hot water at 40oC. The obtained results are helpful to understand the washing ability of the soluble and insoluble impurities and their effect on the property of surface tension. It will help to generate new idea to decrease the surface tension of water with the addition of different surfactant.

REFERENCES

[1] Demonstrating Science With Surface Tension by John Hudson
[2] The Science Of Soap Films And Soap Bubbles by Cyril Isenberg
[3] Mechanics And General Properties Of Matter by P.K. Chakrabarti
[4] Surface Tension by Drew Hant
[5] Special Adjuncts to Treatment by Ian Y. Wong and David Wong, in Retina, 2013
[6] Avery's Diseases of the Newborn by J. Craig Jackson, 2012
[7] Fundamentals of Materials Science, In Craig's Restorative Dental Materials, 2012
[8] Rajarshi Biswas, Pulok K. Mukherjee, Amit Kar, Shiv Bahadur, Ranjit K. Harwansh, Sayan Biswas, Naif Abdullah Al-Dhabi and V. Duraipandiyan 2016, Evaluation of Ubtan - A traditional indian skin care formulation ; Journal of Ethnopharmacology, 192, 283–291.
[9] Ines M. Hauner, Antoine Deblais, James K. Beattie, Hamid Kellay, and Daniel Bonn 2017, Dynamic Surface Tension of Water by, J Phys Chem Lett. , 8(7), 1599–1603
[10] Md. Alamgir and J. H. Lienhard1978, The Temperature Dependence of Surface Tension of Pure Fluids by, J. Heat Transfer 100(2), 324-329.