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1.	Quality of Life Among Elderly People in Chitwan District, Nepal Jiwan Kumar Poudyal, Dhanendra Veer Shakya, Sumitra Parajuli, Govinda Prasad Dhungana	1-15
2.	Theoretical Investigation of the Thermodynamic Properties of Lead-free Ternary Alloys Sn-Sb-Bi and their Subsystems Sanjay Kumar Sah, Indu Shekhar Jha, Ishwar Koirala	16-30
3.	Surface Tension of Liquids (Water, Chloroform and Acetone) by Capillary Rise Method Dipak Raj Adhikari, Tek Bahadur Budha, Anup Basnet, Shesh Kant Adhikari, Shiva Pd. Baral	31-36
4.	Study of Fiber Yielding Plants of Devchuli Municipality Ward no.13, Nawalparasi Pooja Pokharel and Manoj Kumar Lal Das	37-45
5.	Study of Quality and Damping Factor at First and Second Resonance of Closed Organ Pipe S.K. Adhikari	46-54
6.	Ethnobotanical and Phytochemical Study of <i>Houttuynia cordata</i> Thunb: A Review Hari Devi Sharma, Janardan Lamichhane, Smriti Gurung and Balkumari Oliya	55-62
7.	Impact of Mandatory Corporate Social Responsibility on Beneficiary Institutions Satisfaction in Nepal Sudip Wagle	63-72
8.	University Students' Knowledge and Attitudes about Plagiarism: A Web-Based Cross-Sectional Study Hari Prasad Upadhyay, Bijay Lal Pradhan, Prativa Sedain	73-81
9.	Social Biases and Equity Investment Decisions of Individual Investors: Behavior Finance Perspective Mohan Prasad Sapkota, Shiva Bhandari	82-96
10.	Customers' Trust in E-payment : The Influence of Security and Privacy Omkar Poudel1, Pradeep Acharya and Daya Simkhada	97-112
11.	ARIMA and Exponential Smoothing Model to Forecast Average Annual	

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BMC Journal of Scientific Research

Contents

ARIMA and Exponential Smoothing Model to Forecast Average Annual Precipitation in Bharatpur, Nepal Sarad Chandra Kafle, Ekta Hooda Impact of Intellectual Capital on Firms' Performance: With Perspective of

12.	Impact of Intellectual Capital on Firms' Performance: With Perspective of	
	Commercial Banks in Chitwan	126-135
	Udaya Kumar Shrestha	

BMC	Journal of Scientific Research Volume 6	December 2023
13.	Impact of GDP and Inflation on Stock Market in India: A Case Study of BSE Index Satyendra Kushwaha, Sarad Chandra Kafle, Baburam Khanal	136-148
14.	Awareness of People on Functions of Local Government in Nepal Lila Prasad Limbu	149-161
15.	Gender Based Knowledge on the Reservation System in Nepal Purnima Shrestha	162-171
16.	'परमानन्द' महाकाव्यमा छन्दविधान दामोदर रिजाल	172-179
17.	योद्धा उपन्यासमा वर्गपक्षधरता प्रभा मरहट्ठा कोइराला	180-191
18.	विश्वेश्वरप्रसाद कोइरालाको 'सान्नानी' कथामा प्रजाति राजेन्द्र गिरी	192-200



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Surface Tension of Liquids (Water, Chloroform and Acetone) by Capillary Rise Method

Dipak Raj Adhikari^{1*}, Tek Bahadur Budha¹, Anup Basnet², Shesh Kant Adhikari³, Shiva Pd. Baral⁴

- 1. Central Department of Physical and Mathematical Sciences, Graduate School of Science and Technology, Mid-West University, Birendranagar, Surkhet Nepal
- 2. Central Department of Chemistry, Graduate School of Science and Technology, Mid- West University, Birendranagar, Surkhet Nepal
- 3. Department of Physics, Birendra Multiple Campus, Tribhuvan University, Nepal
- 4. Department of Physics, Amrit Science Campus, Tribhuvan University, Nepal
- *Corresponding author: dipak74adhikari@gmail.com

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Abstract

Surface tension is a crucial property of liquids that depends on the liquid's composition. This study aims to compare the surface tension of water, chloroform, and acetone using the capillary rise method. It involves using a capillary tube with a known radius, dipping it vertically into a liquid, and measuring the height to which the liquid rises in the tube. The surface tension of the liquid can then be measured experimentally. This relates to height of the liquid in the tube, the radius of the tube, and the surface tension of the liquid. The height of the liquid in the tube is dependent on the radius of the tube, with a smaller radius resulting in a greater height. The surface tension of the liquid is inversely related to the radius of the capillary tube.

Keywords: capillary tube, surface tension; liquid (Water, Chloroform, Acetone)

1. Introduction

Surface tension is a fundamental property of liquids that arises from the cohesive forces between the molecules at the liquid's surface. This property is a crucial for various natural phenomena and industrial applications. In this study, the surface tension of three different liquids, namely water, chloroform, and acetone, is investigated.

Surface energy (Vikash, 2021) can be observed in the way that the surface of a liquid tends to minimize its own area, forming into a smooth, round shape when possible. The energy required to increase the surface area of a liquid by a unit of area is known as surface tension. Surface tension of given liquid is a function of temperature (Yaws, 2014). The surface tension of chloroform was found to be higher than that of water, while the surface tension of acetone was lower than that of water (Hall & Pugsley, 2020). Understanding and controlling surface tension can be crucial in a wide range of applications (Gheribi & Chartrand, 2019; Ghoufi et al., 2016; Bing et al., 2017; Khan et al., 2020 & Monko et al., 2017). Water is a common liquid with unique surface tension properties. It is known for its relatively high surface tension. This means that water

molecules at the surface tend to stick together strongly, resulting in a "skin-like" effect on the water's surface. This property allows small objects like insects to seemingly defy gravity and "walk" on the surface of water. It also causes water drops to form nearly spherical shapes due to the minimization of surface area.

Chloroform is a volatile organic compound that has a higher surface tension than water. This means that the cohesive forces between chloroform molecules at its surface are stronger than those in water. As a result, chloroform tends to form an even more rounded and elevated meniscus when placed in a capillary tube compared to water. Understanding the surface tension of chloroform is important in various chemical and biological applications.

Acetone is another organic solvent with different surface tension characteristics. In contrast to water, acetone has a lower surface tension. This means that the surface molecules of acetone do not hold together as strongly as those in water. Consequently, acetone tends to spread out more on surfaces and forms flatter menisci in capillary tubes. This property of acetone can be advantageous in certain industrial and laboratory processes.

2. Materials & experiments

In this study, a tipped pointer traveling microscope, three types of liquids (Water, Chloroform, and Acetone), two capillary tubes of different radii and a needle were used to measure the surface tension of given liquids. The capillary tubes were made of borosilicate glass and had inner radii of 0.046 cm and 0.053 cm respectively. The experimental setup consisted of three sub-systems: a PC/monitoring system, a capillary rising system, and a high-speed imaging system. To measure the surface tension, we used the capillary tube method, in which the height of rise (h) of the liquid in each capillary tube was measured and used to calculate the surface tension (T_i) of the liquids is given by

$$T_l = \frac{rh\rho g}{2cos\theta} \qquad \dots (1)$$

Where, r is the radius of the capillary tube, ρ is the density of the liquid, g is the acceleration due to gravity and θ is the contact angle between the liquid and the capillary tube.

The capillary rise method, a single capillary tube was used and the height of rise (h) and height of the liquid were measured as in Fig1 . The densities of the liquids (Water, Chloroform, and Acetone) were given.

The surface tension (T_i) of polar liquid depends on temperature and critical temperature [9]. The relation between them is given by

$$T_l = A (t_c - t)^{\frac{3}{2}}$$
 ...(2)

Where, A proportional constant t_c Critical temperature and t variation temperature.

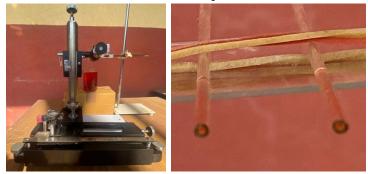


Fig. 1. Measurement of height and radii of capillary tube using travelling microscope.

The chloroform is an organic solvent having density 1.4832 g/cm³ at 20 °C. The density of Acetone is 0.7857 g/cm³.

3. Calculations and analysis

Observation:

Least count of main scale (L.C) = 0.05 cm

Least count of vernier scale (V.C) = 0.001 cm

In this experiment, we can be measured the surface tension by the help of given value of h and r for two capillary tubes separately. Now the value of h and r can be obtained with the help of table 1 and 2 respectively.

Liquid	Tubes	H	Height of liquid (cm)			Rises height of liquid (<i>h</i>) (cm)
		Total Reading	Total Reading	h_1	h_2	$h = h_1 h_2$
Water	1	7.075	3.955	4.46	1.602	2.862
	2	6.559				
Chloreform	1	6.323	6.256	1.36	5 0.68	0.68
Chloroform	2	6.282	0.230			
A	1	6.217	6.274	2.05	.05 1.025	1.025
Acetone	2	6.289	0.274	2.05		

Table	1:	Height	of	liquid	(<i>h</i>)
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Table 2: Radii of capillary tubes (r)

C N	Microscope reading for position of inner right wall of the tubes			
S.N Total reading Total reading		Total reading	Radius of the capillary tube (<i>r</i>)	
1	16.607	16.614	0.046	
2	2.855	2.908	0.053	

	Table 5. Surface tension of the liquid (T_1)						
S.N.	Liquid	Height of the liquid, h(cm)	Radius of the capillary tube, r (cm)	Surface tension of the liquid (dyne/cm)			
1	W. () 0.00		0.046				
1 Water		2.862	0.053	69.42			
2 Chloroform		0.69	0.046	24.575			
		0.68	0.053	24.373			
3	Acetone	0.046		19.505			
J A	Acetone	1.025	0.053	17.303			

Table 3: Surface tension of the liquid (T_{i})

Table 4: Comparing standard and experimental value of surface tension ofdifferent liquids

S.N.	Liquids	Experimental Values (dyne/cm)	$\bar{x} \pm S.E$	Standard values (dyne/cm)	Temperature (°C)
1	Water	69.42	6.817±0.364867	72	23
2	Chloroform	24.575	6.3025±0.028991	27.16	23
3	Acetone	19.505	6.253±0.050912	23.32	23

Calculation of the surface tension of the different liquid (Water, Chloroform, and Acetone) by using the above equation (1).

Radius of capillary tube 1 (r_1) = 0.046 cm

Radius of capillary tube 2 $(r_2) = 0.053$ cm

For Water, the density of water (ρ) = 1 g/cm³

The measured and standard value of surface tension of the liquids (Water, Chloroform, and Acetone) are predicted in table 3 and 4 respectively and those values are close agreement with the standard results.

4. Results and disscussion

The results of the study showed that the surface tension of water and organic liquids like Chloroform and Acetone can be measured using the capillary rise method. The values of surface tension obtained were all positive, indicating that the surface tension acts in an upward direction. The surface tension of chloroform was found to be higher than that of water, while the surface tension of acetone was lower than that of water.

These results suggest that the surface tension of a liquid is influenced by its molecular structure and intermolecular forces. Water, being a polar molecule, has a higher surface tension than non-polar molecules like chloroform and acetone. Additionally, the fact that the surface tension of acetone is lower than that of water could be due to the presence of a carbonyl group in its molecular structure, which can disrupt the intermolecular forces between acetone molecules.

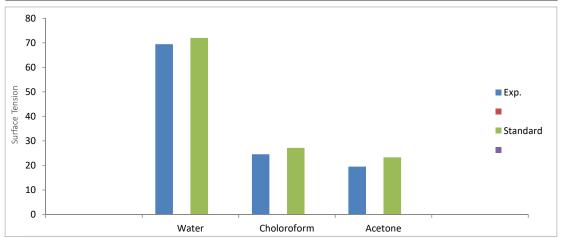


Fig. 2. Bar diagram of different liquids (Water, Chloroform and Acetone)

The surface tensions of the different liquids (Water, Chloroform and Acetone) are compared by Fig. 2 column picture. In this diagram, the surface tension of water is greater than chloroform and acetone because the effect of temperature on the surface tension i.e. the decrease in surface tension with increase of temperature and intermolecular force of attraction also decreases.

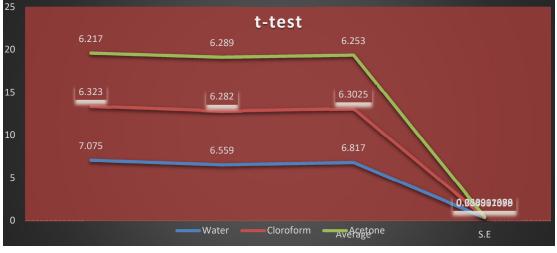


Fig. 3. The graph by the t-test (S.E. =0.600927)

Fig.3. shows that the liquids are slowly increasing and then going on a straight line. This is plotted by the statistical data of different liquids (Water, Chloroform and Acetone). We have calculated the average value and standard deviation of different liquids using by the given statistical data, The standard errors of the surface tension (mean \pm standard error) of the different liquids were calculated by using the T-test.

5. Conclusion

In conclusion, the capillary rise method was found to be an effective method for determining the surface tension of the different liquids, including water, chloroform, and acetone. The

experimental values of surface tension were compared with standard literature values. The experimental values were found to be reasonably close to the literature values for all three liquids: water, chloroform, and acetone. Water, being a polar molecule, had a higher surface tension than non-polar molecules like chloroform and acetone. The surface tension of acetone was found to be lower than that of water, possibly due to the presence of a carbonyl group in its molecular structure, which can disrupt the intermolecular forces between acetone molecules. The standard error of the surface tension measurements was found to be 0.600927. These findings provide a better understanding of the factors that influence surface tension and may be useful in a range of applications where surface tension plays a role, including in the design of microfluidic devices, the development of new surfactants, and the optimization of industrial processes. It's important to note that the capillary rise method assumes ideal conditions, and real-world factors such as impurities in the liquids or imperfections in the glass capillary tubes may introduce errors. **References**

- Bing, H., Yang, S., Qin, Z., Wen, B. and Zhang, C. (2017). The roles of wettability and surface tension in droplet formation during inkjet printing, *Sci. Rep.* 7:11841, https://doi.org/10.1038/ s41598-017-12189-7
- Gheribi, A. and Chartrand, P. (2019). Temperature and oxygen adsorption coupling effects upon the surface tension of liquid metals, *Sci. Rep.*, 9(1):7113, https://doi.org/10.1038/ s41598-019-43500-3
- Ghoufi, A., Malfreyt, P. and Tildesley, D. J. (2016). Computer modelling of the surface tension of the gas–liquid and liquid–liquid interface, *Chem. Soc. Rev.*, 45:1387–1409, https://doi.org/10.1039/C5CS00736D
- Hall, C., Pugsley, V. (2020). Spontaneous Capillary Imbibition of Water and Nonaqueous Liquids into Dry Quarry Limestones, *Transp Porous Med* 135, 619–631, https://doi. org/10.1007/s11242-020-01489-8
- Kalová, J. and Mareš, R. (2018). The temperature dependence of the surface tension of water, *AIP Conference Proceedings* 2047, 020007, https://doi.org/10.1063/1.5081640
- Khan, M., Adil, A.W., Ismail, T., Bhat, S.A., Sofi, F.A. and Bhat, M.A. (2020). Eureka Moment: An Archimedean Alternative for the Determination of *cmc* of Surfactants *via* Weight Measurements, ACSOmega, 5, 49, 31640–31643, https://doi.org/10.1021/acsomega.0c04029
- Mańko, D., Zdziennicka, A. and Jańczuk, B. (2017). Surface tension of polytetrafluoroethylene and its wetting by aqueous solution of some surfactants and their mixtures, *Appl. Surf. Sci.*, 392(15):117–125, https://doi.org/10.1016/j.apsusc.2016.09.020
- Neelakandan, V. Tech. Identification number: T19000388 (2020/2021) Study programme: Master Thesis, N0723A270002, Department of Nonwovens and Nano fibrous materials
- Yaws, C. L. (2014). Thermophysical Properties of Chemicals and Hydrocarbons, 842-847, Science Direct