Politechnika Wrocławska
Wydział Podstawowych Problemów Techniki

Laboratorium Podstaw Fizyki

Physics Laboratory - Report #3

Experiment: 33C

MEASUREMENT OF SURFACE TENSION: STALAGMOMETRIC METHOD

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INTRODUCTION

Surface tension is the result of intermolecular interactions. Each molecule inside the liquid phase is evenly surrounded by other molecules and has saturated forces of mutual attraction. These forces are in all directions on average, the same, and their resultant is equal to zero.

However, particles located on the phase surface, liquid - gas, are subject to impacts of both centers. The resultant force, directed perpendicular to the surface phase, tends to pull molecules into the liquid and is called pressure surface, while tangent force to the surface is a measure of

surface tension. The stalagmometric method, which we use in this experiment, relies on determining the mass of drops detaching from the special shaped stalagmometer end.

Aim

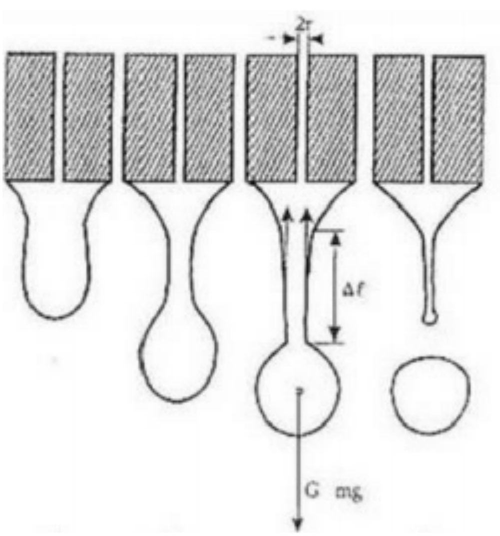
The aim of this laboratory assignment is:

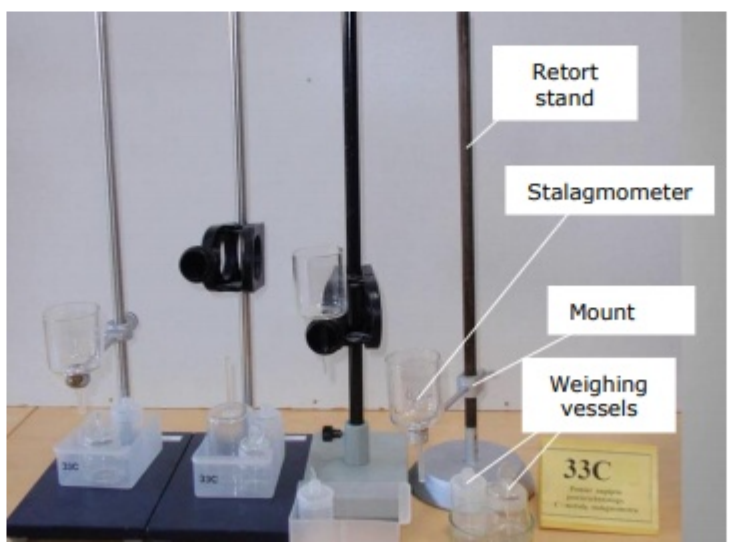
- The determination of surface tension of water and alcohol.

APPARATUS

- Stalagmometer
- Tested liquids
- Weighing vessel
- Caliper
- Thermometer

Picture representation of the measured object





Calculation Table:

Water:

lp.	n	mnw [kg]	m vessel[kg]	m drop [kg]	ρ[kg/m3]	R[m]	U	K	σ [N/m]	Temperature [C]	ρ water [kg/m3]
1	50	0.01026		0.0000706		0.0025	4.5317869	0.25472	0.0705662		
2	50	0.00999	0.00673	0.0000652	997.046	0.0025	4.185163	0.25583	0.0654528		
3	50	0.00942		0.0000538		0.0025	3.4534013	0.25892	0.0546609		
$\bar{X}$	50	0.00989	6.73	0.0000632		0.25	4.0567837		0.06356	24.8	997.046
ΔX		0.01	0.01	0.01		0.005					
$ua(X)$		0.0004952		9.90353E-06		0	0.6357041		0.009376		
$uc(X)$							0.6357303		0.0110092		

Alcohol:

lp.	n	mnw [kg]	vessel[kg]	drop [kg]	ρ[kg/m3]	R[m]	U	K	σ [N/m]	temp	ρ alcohol [kg/m3]
1	50	0,00802		2,58E-05		0.0025	2,10285	0,2645			
2	50	0,00799	0,00673	2,52E-05		0,0025	2,053947				
3	50	0,008		2,54E-05	785,22	0,0025	2,070248		0,026432		
$\bar{X}$	50	0,0080033	0,00673	2,55E-05		0,0025	2,075681			24,8	785,22
ΔX		0,00001	0,01	0,01		0,00005					
$ua(X)$		8,819E-06		1,76E-07		0					
U(x)		**0,00577**		**0,00577**				0,005782			
$uc(X)$							1,64*10^-7		2,663X10^-5		

Calculations:

a) **Calculate U and K**

$U = \frac{m}{p * R^3}$ => $U_1 = \frac{0.0000706}{997.046 * 0.0025^3}$ = 4.5317869 ~ 4.53

We calculate:

U_1 = 4.5317869 ~ 4.53
U_2 = 4.185163 ~ 4.19
U_3 = 3.4534013 ~ 3.45

$\sigma = \frac{m*g}{R}$* K => $\sigma_1 = \frac{0.0000706*9.81}{0.0025}$*0.25472 = 0.0705662 ~ 0.07

Similarly we calculate:
σ_1 = 0.0705662 ~ 0.07
σ_2 = 0.0654528 ~ 0.07
σ_3 = 0.0546609 ~ 0.05

b) **Mean value**

$$\overline{\boldsymbol{mnw}} = \frac{\boldsymbol{mnw1+mnw2+mnw3}}{\mathbf{3}} = \frac{\mathbf{0.01026+0.00999+0.00942}}{\mathbf{3}} = \mathbf{0.00989}$$

$$\overline{\boldsymbol{m\ drop}} = \frac{\boldsymbol{mdrop1+mdrop2+mdrop3}}{\mathbf{3}} = \frac{\mathbf{0.0000706+0.0000652+0.0000538}}{\mathbf{3}} = \mathbf{0.0000632}$$

Similarly we calculate the mean values of U and σ:
$\overline{U}$ = 4.0567837
$\bar{\sigma}$ = 0.06356

c) **Calculating the uncertainties of measured unites (Uncertainties type A)**

$$u_a(\bar{X}) = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n(n-1)}}$$

$u_a(mnw)$=
$$\sqrt{\frac{(0.01026-0.00989)^2 + (0.00999-0.00989)^2 + (0.00942-0.00989)^2}{6}} = 0.0004952$$

Uncertainties of the type A for the following were calculated using the same formula:

$u_a(mnw)$=*0.0004952*
$u_a(m\ drop)$= *9,90353E-06*

$$u_a(U)=0.6357041$$
$$u_a(\sigma)= 0.009376$$

d) **Calculating the uncertainties of type B**

$u_b(m)=\frac{0.01}{\sqrt[3]{3}}= 0.00577g$

e) **Calculating the total uncertainty**

$$U(x) = \sqrt{u_a^2(\bar{X}) + u_b^2(X)}$$

Total uncertainties for the following were calculated using the same formula:

$$u_c(U) = 0.6357303 \sim 0.64$$

$$u_c(\sigma) = 0.0110092 \sim 0.01$$

CONCLUSION

Not including the exact temperature of the liquid and the exact pressure in the room makes it impossible to check the results with tabular results. In addition, the accuracy of the measurement is affected by the imperfection of the instrument we use. When dripping liquid into the vial, we do not know how much during this time the liquid has evaporated, which makes it impossible to accurately determine the weight of a single drop. Despite this, we have obtained an optimal result of the tension surface.

Results

Water**:**

	mnw	**m drop**	**U_1**	**U_2**	**U_3**	**σ_1**	**σ_2**	**σ_3**
Unit	kg	kg				N/m	N/m	N/m
Value			4.5317869 ~ 4.53	4.185163 ~ 4.19	3.453401 3 ~ 3.45	0.070 5662 ~ 0.07	0.065 4528 ~ 0.07	0.054 6609 ~0.05
$\bar{X}$	0.00989 ~ 0	0.0000632 ~ 0	4.0567837 ~ 4.06			0.06356 ~ 0.06		
$u_a(\bar{X})$	*0.00049 52~ 0*	*9,90353E-06*	0.6357041 ~ 0.64			0.009376 ~ 0		
$u_b(X)$	*0.00577*							
$u(\bar{X})$			0.6357303 ~ 0.64			0.0110092 ~ 0.01		

Alchol

	mnw	**m drop**	**U_1**	**U_2**	**U_3**	**σ_1**	**σ_2**	**σ_3**
Unit	kg	kg				N/m	N/m	N/m
Value			2.10285 ~ 2.1	2.053947 ~ 2.05	2.070248 ~ 2.07			
$\bar{X}$	0.00800 33 ~ 0	*2.55E-05*	2.075681 ~ 2.08					
$u_a(\bar{X})$	*8.819E-06*	1.76E-07						
$u_b(X)$	*0.00577*							
$u(\bar{X})$			1.67*10^-7			2.66*10^-5		