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Determining Surface Tension of Different Fluids with The Help of Tensiometer

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Abstract:- Current research work taken in account of surface tension of various fluids available like diesel, petrol, water. The purpose of this experiment is to determine the equivalence between surface tension and surface energy. sThis project covered the importance of surface tension of different fluids with the help of a case study from Lords Institute of Engineering & Technology.

I. INTRODUCTION

Du Noüy ring method is one of the most widely-used methods for measuring the surface tension. It is named after the French physicist who developed it in the late 1800's. The advantage of the ring method is that it is rapid, very simple and does not need to be calibrated using solutions of known surface tension. When applied to pure liquids with due precautions, the error can be reduced to ± 0.25%.
The measurement is performed by an instrument known as Tensiometer. This instrument has an accurate micro-balance and a precise mechanism to vertically move the sample liquid in a glass beaker. The modern tensiometer has a computer-controlled arrangement that can move the table holding the liquid very slowly (~100 m/s).

The ring is usually made of an alloy of platinum and iridium with well-defined geometry. The measurement procedure is as follows. The ring hanging from the hook of the balance is first immersed into the liquid and then carefully pulled up by lowering the sample vessel. snow surrounding the calorimeter which showing respiratory gas exchange is combustion, the process was similar to that of burning a candle. The micro-balance continuously records the force applied on the ring when it pulls through the air liquid interface. The surface tension is the maximum force needed to detach the ring from the liquid surface. The detachment force is equal to the surface tension multiplied by the periphery of the surface detached. Therefore, for a ring, 4 r FR where r R is the radius of the ring. The force measured by the balance includes the weight of the ring. In actual practice, the weight of the ring is first recorded before it is immersed in the liquid. Sometimes, a calibration is made with a known weight. Usually the results obtained from are in error. Harkins and Jordan (1930) derived a correction factor f such that the correct surface tension can be obtained from the following equation. sThe correction factor appears due to the weight of the liquid film immediately beneath the ring, which is also raised when the ring pulls. The correction factor depends upon the complex shape of the meniscus during the detachment of the ring, density of the liquid, radius of the ring (Rr) and the radius of the wire (wr) with which the ring is made Huh and Mason (1975) have graphically presented the variation of f with 3 r RV and rw R r .

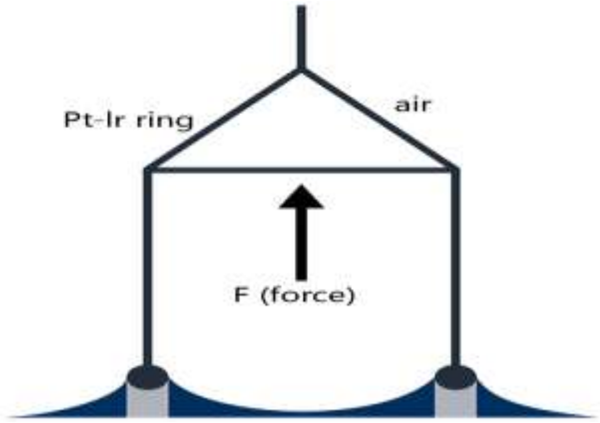


Fig.1 Du Noüy ring method

In the radii r R and w r are expressed in cm, is expressed in kg/dm3 and Expt(the experimentally measured value of surface tension) is expressed in mN/m. The Zuidema Waters correlation gives accurate results when Expt 35 mN/m and 0.1 kg/dm3. Both Huh Mason and Zuidema Waters corrections are used by the tensiometer manufacturers.

Precautions:

Assume that the contact angle is zero, i.e., the liquid should completely wet the ring. To ensure this, the latinum iridium ring is cleaned by burning it in a Bunsen burner. The ring is quite delicate and prone to distortion during use. Such distortions should be avoided, and it must be ensured that the ring lies flat on a quiescent surface. When used with the surfactant solutions, the ring must be cleaned thoroughly with pure water since the presence of small amounts of surfactant can cause a significant amount of error in the measurement. If the ring is used with viscous oils such as silicone oil or crude petroleum, it must be cleaned with a good solvent (such as acetone) to dissolve and remove the oil.

Equipment Description

Equipment Torsion dynamometer, 0.01 N 02416.00 1 Surface tension measuring ring 17547.00 1 Retort stand, h 500 mm 37692.00 heating stirrer with temp 35711.93 Support rod, l 500 mm/M10 thread 02022.05 1 Maga stirring bar 15 mm, cyl. 46299.01 1 Universal clamp 37715.00 2 Right angle clamp 37697.00 2 Right angle clamp -PASS- 02040.55 1 Crystallizing dish, boro 3.3, 1000 ml 46245.00 2 Crystallizing dish, boro 3.3, 560 ml 46244.00 2 Lab thermometer, -10..+250C 38065.00 1 Silk thread, 200 m 02412.00 1 Glass tubes, straight, 150 mm, 10 36701.64 1 Stopcock, 1-way, straight, glass 36705.00 1 Rubber tubing, i.d.7 mm 39282.00 2 Volumetric pipette, 10 ml 36578.00

Procedure

Set-up and procedure Perform the experimental set-up according to the measuring ring is carefully degreased with alcohol, rinsed in distilled water and dried. The ring is attached to the left arm of the torsion dynamometer using a silk thread. The torsion dynamometer’s indicator is set to “0” and the weight of the ring compensated using the rear adjusting knob so that the lever arm is in the white area between the marks. The liquid under investigation is poured into a carefully cleaned 900 ml crystalallization dish and the ring is completely submerged. In the experiment the liquid is warmed using the heating unit of the magnetic stirrer and stirred. As soon as the required temperature has been nearly reached, switch off the heating and allow the temperature to stabilise (residual heat of heating plate). Now switch off the stirrer and allow the liquid to come to rest. Then let liquid slowly allowed to runoff through the immersion tube (Fig. 1) from the dish on the magnetic stirrer into the dish located adjacent to the stirrer. To achieve this, open the one-way stopcock which is connected to the immersion tube via a rubber hose. Fill the immersion tube (siphon) with liquid before beginning the measurement by briefly applying suction with the filter pump. Continuously readjust the torsion dynamometer while the liquid runs out to keep the lever arm in the white area between the two marks. Stop the measurement at that moment when the liquid film tears from the ring, and read off the last value set on the torsion dyna- mometer. Record this value together with the temperature of the liquid. Throughout the entire measurement procedure, ensure that the apparatus is not subject to vibration. The liquid collected in the second crystallization dish is poured back into the dish on the heating plate and the measurement is repeated for other temperatures in the same manner. Perform the experiment in a temperature range of 20° to 130°C at intervals of 5°C. Perform another series of experiments to determine the surface tension of various ethanol water mixtures (using the same method as above) at room temperature. Starting with pure ethanol, successively add water to make up the following mixtures:

II. OBSERVATION

Methanol/ml	Water/ml	Ethanol/%
90	-	100
90	+10	90
90	+20	75
90	+20	64.3
90	+20	56.3
90	+20	50

III. CALCULATION

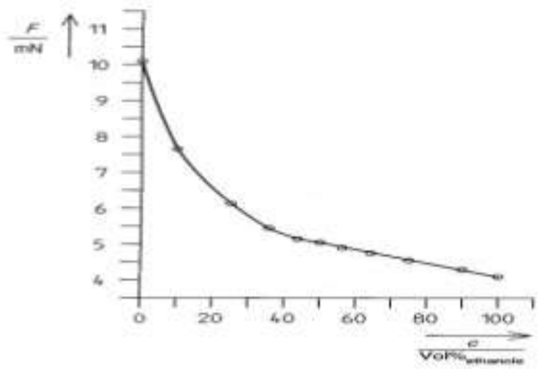
Theory and evaluation A molecule in a liquid is subject to forces exerted by all molecules surrounding it; pressure p is isotropic. The resultant force acting on a molecule in a boundary layer of a liquid surface is not zero but is directed towards the interior of the liquid. In order to enlarge the surface of a liquid by an amount DA, a certain amount of work DE must be performed.
« = (1)
« is the specific surface energy. It is identical with the surface tension
g
= (2)

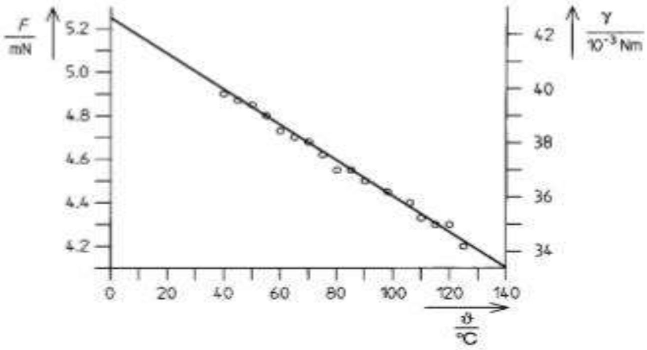
where force F acts along the edge of length I, tangential to the surface in order to maintain the liquid film. When a ring of radius ris used, the length of the edge is
/ = 2 · 2 p r (3)

The diameter of the measuring ring employed is 2r = 19.65 mm. There is no need to correct the measured force to compensate for the weight of the liquid lifted because the ring has a sharp bottom edge.
The surface tension of almost all liquids drops linearly with increasing temperature.
g = g’ (T_k’– T) (4)
where T_k’ is a temperature near the critical temperature Tk. The molar surface tension can be defined with reference to the molar volume V_m
gm = g · V_m 2/3 (5)

which together with equation (4) results in
gm = g’ · V_m 2/3 (T_k’–T) (6)
The temperature coefficient
kg = g’V_m 2/3 (7)
is equal for almost all liquids (Eötvös’ equation):
kg = 2.1 · 10^{-7} J/K (8)
Values below this indicate association in the molecules in the liquid, larger values indicates, dissociation. The measurement results obtained for olive oil have an inverse linear relationship to temperature. From Fig. 2:
(20°C) = 41.3 · 10^{-3} Nm^{-1} (9) (1200C) 411and= 6.7 · 10-5$Nm^{-1}K^{-1}$ (10)

GRAPHS





IV. RESULTS

From the data collected it is calculated that the surface tension are:
Data and results Literature values:
Water = 72.8 mN · m^{-1} g
Ethanol = 21.97 mN · m^{-1}
Experimental values:
water = 82 mN · m^{-1} g
Ethanol = 33 mN · m-^{1} g
OIive oil = 40 mN ·m^{-1}

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