Daehan Hwahak Hwoejee
Volume 9, Number 2, 1965
Printed in Republic of Korea.

The Surface Tension of Liquid Iodine

by

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(Received June 25, 1965)

액체 요오도의 표면장력

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(1965. 6. 25 受理)

요 약

액체 요오드의 표면장력을 측정하기 위하여 새로운 장치를 고안하고 differential capillary rise method를 써서 125.0°, 135.0°, 145.0°, 및 155.0°C 에서 각각 36.88, 35.87, 34.83 및 34.04 dyne/cm 의 값들을 얻었다.

이 측정된 값들로부터 Eötvös 상수를 구해 본 결과, 각 온도에서 비슷한 값을 보여주고 있음을 알았다.

Abstract

The surface tension of liquid iodine was measured by differential capillary rise method at various temperatures above the melting point.

A paraffin bath with mercury regulator was used to maintain constant temperature. The height of the meniscus of liquid iodine in the capillary tube was measured by a travelling microscope.

The measured values of surface tensions at 125.0°, 135.0°, 145.0° and 155.0°C were 36.88, 35.87, 34.83 and 34.04 dyne/cm, respectively.

Calculated Eötvös constant from the surface tension data, experimentally obtained, were consistent through the temperature range.

Introduction

For the measurement of surface tension of liquids, various methods, such as, capillary rise method, drop weight method, ring method, etc. have been used. The surface tension data of various liquids, obtained by means of the above methods are readily available in literatures.

However, the determination of surface tension of liquid iodine suffers many difficulties. The high melting point and deep color of iodine vapor are the serious difficulties for determining the surface tension of liquid iodine.

For this work, an apparatus was specially designed, using two capillary tubes of different diameters[1]. In designing the apparatus, a special care was taken to eliminate the dense iodine vapor contamination within the apparatus, which makes the reading of capillary rise extremely difficult.

Experimental

The essential part of the apparatus is shown in Fig. 1. Two capillary tubes of different radii (one, 0.002406 cm, and the other, 0.006872 cm) are mounted within a Pyrex glass tube of 3.5 cm in diameter and 20 cm in height, through holes of a plate A, which is tightly fixed to the Pyrex tube. The plate A supports the two capillary tubes and at the same time it prevents the dense iodine vapor filling the upper parts of the column. Through a tube, C, attached to the column just beneath the plate A, the iodine sample is introduced. The tube C is opened to the air so that the vapor pressure of the liquid is maintained at the atmospheric pressure. Another tube D is attached to the upper part of the column in order to prevent the direct contact of the cold air.

As iodine sample Resublimado Iode first class, produced by Merck Co., was used.

Capillary tubes are drawn from Corex glass tube.

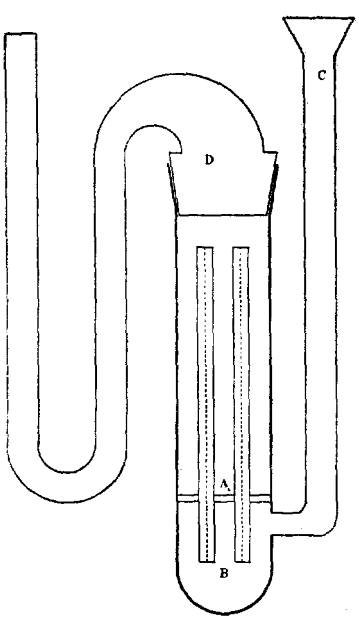

Fig. 1 The cell of the surface tension measurement of liquid iodine.

Among them, the tubes of uniform capillary diameter are selected, and they are cleaned with cleaning solution, distilled water, and steam.

Then pure mercury is introduced into capillary. The length of the mercury in the capillary is measured by the use of a comparator and the amount of iodine introduced into the capillary is weighed by a microbalance. From these measurements the radius of the capillary tubes are obtained by the use of the following relationship[2]:

$$r=\sqrt{\frac{\text{Weight of mercury}}{\text{Density}\times\pi\times\text{height of mercury}}}$$

The radii of the capillaries are found to be $(2.406\pm 0.004)\times 10^{-3}$ cm and $(6.872\pm 0.006)\times 10^{-3}$ cm respectively.

After introducing iodine sample, the apparatus is submerged into the paraffin thermostat. When the entire system reaches a thermal equilibrium at the desired experimental temperature, the capillary rises in the two tubes are read by travelling microscope of 1/1000 cm precision.

Before reading the capillary rise, the verticality of the capillary tubes is tested by moving the travelling microscope upward and downward from various directions.

Results and Calculations

Let h_1, and h_2 be the capillary rises of the tube of radius r_1 and of the tube of radius r_2, respectively. Since the height of the capillary rise is inversely proportional to the radius of the tube, the ratio of the capillary rises, G, can be expressed as follows; assuming same contact angles at the two capillaries;

$$G=h_2/h_1=r_1/r_2$$

The difference of the height, H, is

$$H=h_1-h_2=h_1-h_1G$$

Then, from the above equation, h_1 can be expressed

$$h_1=H/(1-G)$$

If the radius of the capillary is very small, the contact angle is negligible; then, the surface tension can be expressed,

$$\gamma=1/2h_1r_1gd=KHd$$

where, d, g, and K are the density of liquid, the gravitational acceleration and the capillary constant which is equal to $r_1 g/2(1-G)$, respectively.

The heights of capillary rises, experimentally measured at the temperatures, 125.0°, 135.0°, 145.0° and 155.0°C, and the calculated surface tension data are tabulated in Table I.

Table I Densities and Surface Tensions at Various Temperatures.

Temperature (°C)	Density [3] (gr/cm³)	H(cm)	γ(dynes/cm)
125.0	3.941*	5.086	36.88±0.08
135.0	3.914*	4.981	35.87±0.08
145.0	3.884*	4.874	34.83±0.07
155.0	3.859*	4.794	34.04±0.07
$\gamma=KHd$	$K=1.840\pm0.002$		

* These data are interpolated values.

Utilizing, the Ramsay-Shield's Equation, $\gamma=(MV)^{2/3}=k(t_c-t-6)$, Eötvös constant is calculated for each temperature, and tubulated in Table II. Where, γ and V are the surface tension and the specific volume of the liquid at temperature t, M, k and t_c are the molecular weight, Eötvös constant and the critical temperature of the liquid, respectively.

Table II Eötvös Constants at Various Temperatures.

Temperature (°C)	125.0	135.0	145.0	155.0
Eötvös constant	1.53	1.53	1.54	1.50

As shown in the Table, Eötvös constant is consistent through the experimental temperature range.

Discussion

The coefficient of linear thermal expansion of Corex glass is only 6.1×10^{-6}/°C; therefore, the effect of temperature to the radius of the capillary tube is negligible.

The capillary rise method is the most accurate one for the determination of surface tension of liquids. However, usually the meniscus is not spherical, and the radius of the curvature is different from the radius of the capillary tube, and proper correction is necessary for the precise determination of surface tension. By using differential capillary rise method, this error is corrected to the required accuracy.

If Poisson's mathematical correction terms[4],

$$h_1=h+r_1/3-0.1288r_1^2/h$$

$$h_2=h'+r_2/3-0.1288r_2^2/h'$$

(h and h' are the readings of heights) are introduced to the differential rise equation, H is expressed,

$$H=(h-h')+(r_1-r_2)/3-0.1288(r_1^2/h-r_2^2/h')$$

since $(r_1-r_2)/3$ is very small, this correction is also negligible.

It is noteworthy that in this experiment, the inconvenience of reading the capillary rise due to the dense vapor is eliminated, and that the error in the calculated surface tension data to the experimental error in the determination of capillary radius is minimized.

Acknowledgement: The authors wish to thank the Government of Republic of Korea for support of this work.

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