A01-691P-Y51

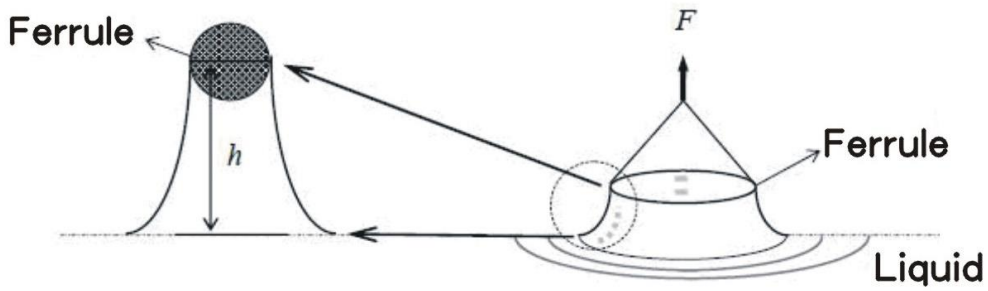
Dunouy's Surface Tension

Purpose

Observe and measure the surface tension of liquid.

Theory

Surface tension is the attraction between water modules or between water modules and other substances. The attraction of modules is molecular force which can be classified into two types: cohesion and adhesion. The attraction of similar modules is cohesion. The attraction of dissimilar modules is adhesion.



Due to the attraction between modules at the surface, modules cohere with each other and consequently minimize the surface. The force minimizing the surface is called surface tension which is the result of cohesion between modules.

Suppose the length of the ring is ℓ, the distance for the surface film to break is h. Since a surface film has two layers, so the actual surface is 2ℓ. The work W is

$$W = F \times h = 2\ell hT \tag{1}$$

Surface tension is defined as the pulling force of every unit length at the surface. Its symbol is T and unit is N/m.

$$T = \frac{F}{2L} \tag{2}$$

Suppose the water surface tension is T_1. The relative pulling force of water and unknown liquid are F_1 and F_2. The surface tension T_2 of unknown liquid can be expressed as

$$T_2 = T_1 \frac{F_2}{F_1} \tag{3}$$

The experiment uses the torsion of metal wire as upward pulling force of the ring. The strength of pulling force changes with the rotation of metal wire. The relationship between the pulling force and the rotation angle of metal wire can be measured from the weight of mass. By comparing the rotation angle to the pulling force F, we can measure the surface tension T.

Factors influence the surface tension: 1. Liquid type 2. Temperature 3. Impurities

Normally, surface tension decreases with the rise of temperature, as shown in **Figure 1**. When the temperature rises, the average kinetic energy of modules increases which will decrease the attraction between modules.

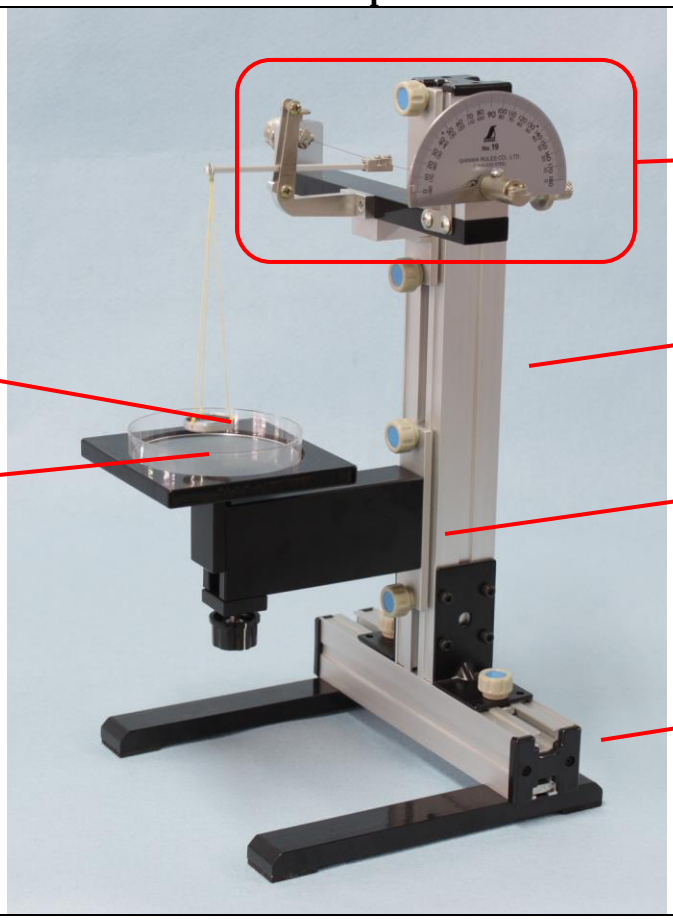
Figure1. Surface Tension of Liquid

	Surface Tension of Liquid (mN/m)					
Temperature (℃)	Water	Alcohol	Ether	Glycerol	Petroleum	Mercury
5	74.92					
10	74.22					
15	73.49					
20	72.75	22.3	16.5	63.4	26.0	476.0
25	71.97					
30	71.18					
40	69.59					
60	66.59					
80	62.61					

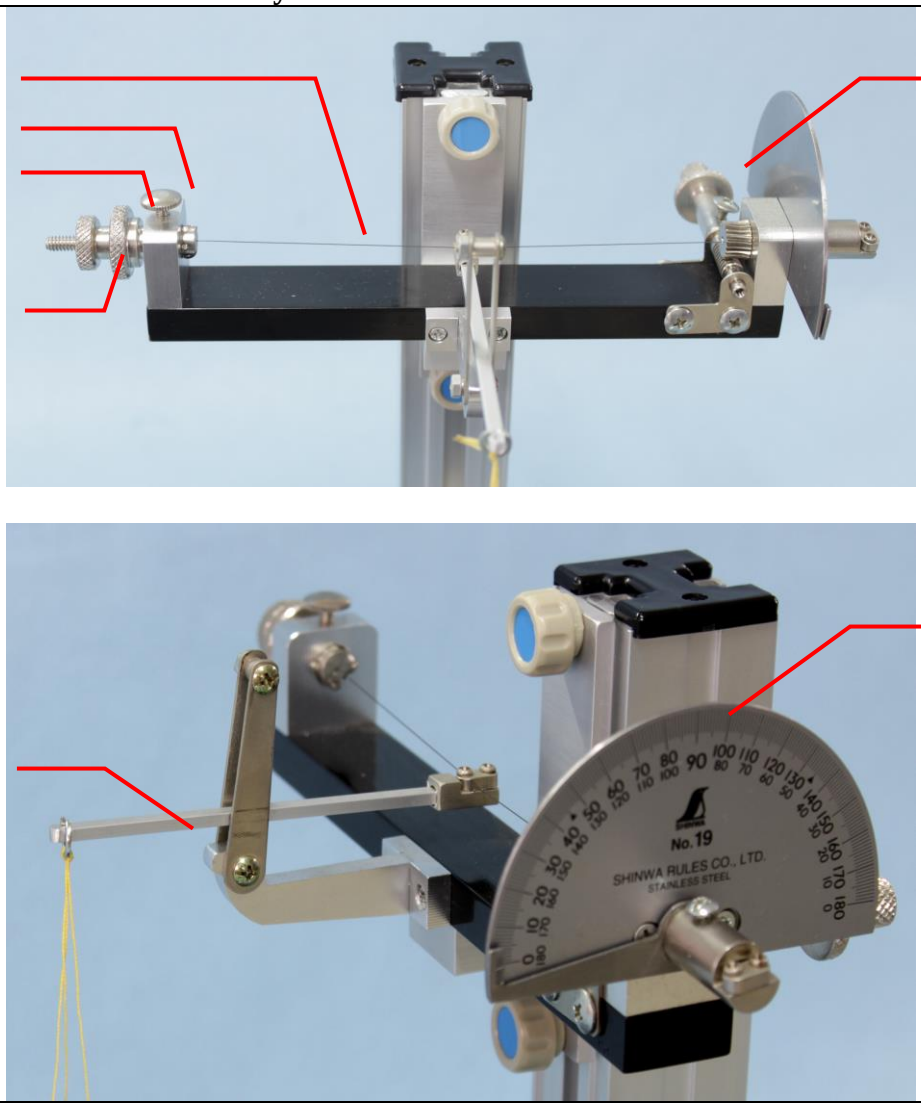
Instruments

Instrument list					
No.	**Accessory**	**Qty.**	**No.**	**Accessory**	**Qty.**
1	Aluminum base	1	2	Aluminum stand	1
3	Micro-adjustable stage	1	4	Movable system of surface tension measurement	1
5	Dish	1	6	Ring	2
7	Mass	1pack	Pre-preparation	Heater	1
Pre-preparation	Thermometer	1	Pre-preparation	Liquid to be measured	1

Instrument picture



Movable System of Surface Tension Measurement



a. Metal wire: Stainless steel wire

b. Tension control knob: Control the tightness of metal wire.

c. Correction knob: Control the tightness of metal wire. Use the scale to reset the correction knob.

d. Lock correction knob: Lock the correction button when it is reset to zero.

e. Lever: Hang the ring

f. Angle knob: Control the upward force and rotation angle of metal wire.

g. Scale: For the use of recording rotation angle

Procedure

I. Correction and preparation before experiment

1. Adjust the angle knob and reset the scale to zero.
2. Adjust the tension knob so the metal wire is straight.
3. Hang the ring on the lever and adjust the scale correction knob to keep the lever in the horizontal.
4. Use pencil to mark on the level and use the mark as reset position, as shown in **Figure 4-1**.

Figure 4-1

II. According to the experimental recording sheet I, record the relationship between the mass and the angle.

5. Hang masses and adjust the angle knob so the level is balanced. Record the weight of mass and the angle of lever in balance.
6. Analyze the functional relationship of mass weight and rotation angle of metal wire.

III. Use experimental recording sheet II to measure the surface tension.

7. Adjust the ring to keep it in the horizontal. Make sure the scale is zero.
8. Fill the dish with liquid and place it on the stage. Move the stage to the ring slowly and gently so the ring touches the surface of the liquid.
9. Adjust the angle knob. Observe the phenomenon of surface tension from the contact moment till the ring separates from the liquid surface and record its angle.

10. Keep the ring dry and repeat the procedure.

11. Calculate the results based on equations on theory section.

12. Measure different types of liquid on experiment recording sheet III.

Experimental records

Experiment recording sheet I. Relationship between mass and angle								
Trail	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mass								
Angle								

Analyze above data and use above data to draw a figures.

Experiment recording sheet II. Surface tension of water

Chart		Measurement	Calculation	
Water temperature (℃)	Surface tension T1(mN/m)	Ring radius r(m)	Circumference L(m)	Upward pulling force F1(mN/m)

Liquid to be measured	Calculation according to the experiment records		T2=F2/2L	T2=T1(F2/F1)	Chart	
Rotation angle	Pulling force of metal wire	Upward pulling force F2	Surface tension T2	Surface tension T2	_____ Surface tension	Error
deg	g	mN	(mN/m)	(mN/m)	(mN/m)	%

Experiment recording sheet III. Surface tension measurement of _____

Liquid to be measured		Measurement	Calculation	
____(℃)	Surface tension T1(mN/m)	Ring radius r(m)	Circumference L(m)	Upward pulling force F1(mN/m)

Liquid to be measured	Calculation according to the experiment records		T2=F2/2L	T2=T1(F2/F1)	Chart	
Rotation angle	Pulling force of metal wire	Upward pulling force F2	Surface tension T2	Surface tension T2		Error
deg	g	mN	(mN/m)	(mN/m)	(mN/m)	%

Questions and discussions

1. In the definition of surface tension, the unit is energy / surface. The unit in our experiment is force/ length. Please explain whether energy / surface equals to force/ length.

2. If we can accurately measure F, is the T in equation (1) accurate? Is the value of T larger or smaller than the actual surface tension? Discuss the accuracy of this experiment.

Atis Scientific Instruments Co.,Ltd
Address：1F., No.18, Nanming St., South Dist.,
Tainan City 702, Taiwan (R.O.C.)
E-mail:atis@atissi.com.tw
Tel: (886) -6-2925201
Fax: (886)-6- 2611476
Mobile:+886-9-8006-1128
Website: www.atis.com.tw