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A Simple Instrument for Measuring the Surface Tension and Viscosity of Liquids

Man Singh

Chemistry Research Lab, Deshbandhu College,
University of Delhi, New Delhi, 1100019 India
e-mail: mansingh50@hotmail.com

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Abstract—The surface tension and viscosity of liquids are usually measured using different instruments, which increases the measurement time. This time is often too long for certain biological liquids and solutions. The instrument proposed allows both quantities to be measured quickly with fewer manipulations of the liquid.

The instrument is a survismeter made of glass; a schematic drawing of it is shown in the figure. Before measurements, the instrument must be rinsed in the conventional manner and dried in a desiccator at 120°C for 12 h. Both calibration and measurements are performed in succession using the same technique; calibration is performed using a liquid with known values of its viscosity and surface tension.

To measure the viscosity, ±15 ml of the liquid is poured into bulb *8* through tube *3* with the other tubes kept open. The survismeter is then mounted in a stainless-steel support in a thermostat at the desired temperature. After this, the liquid from bulb *8* is sucked upward through a U-shaped capillary using a 50-ml syringe with an airtight plunger. The syringe is connected to a Teflon or polyvinyl chloride tube with a stopper at its end, which is inserted into tube *4*. The liquid is sucked into bulb *5* at open tube *3* and tubes *1* and *2* are closed with stoppers. After bulb *5* is filled, tubes *1* and *4* are opened and a backflow of the liquid is initiated. The time of the flow between the upper and lower marks of bulb *6* is counted by an electronic timer with a resolution of 0.01 s. The measurements are repeated several times in order to ensure reproducibility of the results. The liquid viscosity is calculated from the conventional formula

$$\eta = (\rho t/\rho_r t_r)\eta_r,$$

where η and η_r are the viscosities, t and t_r are the flow times, and ρ and ρ_r are the densities of the measured and reference liquids at the given temperature, respectively.

To measure the surface tension, the liquid is sucked in a similar manner into bulb *9* above the upper mark at tubes *1* and *4*, which are closed with stoppers. After this, the stoppers are removed, the syringe is disconnected, and the number of drops falling into bulb *7* are counted for as long as the liquid flows between the marks. The air pressure in tube *2* can be controlled by closing the flexible tube with a screw clamp.

The surface tension coefficient is calculated using the standard formula

$$\gamma/\gamma_r = (n_r\rho/n\rho_r),$$

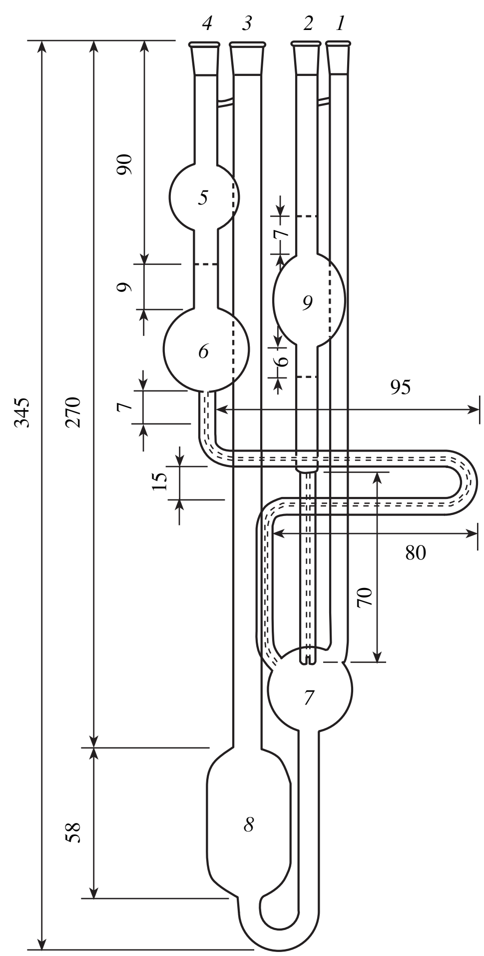

Figure.

Data on surface tension and viscosity (Δ is the difference between the experimental and reference data), as measured by the described survismeter (exp.) and from the literature [1, 2] (ref.)

Liquid	T, K	Surface tension, dyn/cm			Viscosity, mP		
		ref.	exp.	Δ	ref.	exp.	Δ
Carbon tetrachloride	298.15	26.15	26.76	0.61	0.88	0.881	0.001
Methanol	298.15	22.28	22.51	0.23	0.547	0.545	–0.002
	298.13	22.55	22.98	0.43			
Ethyl ester	298.15	16.50	16.26	–0.24	0.222	0.224	0.002
Benzene	298.15	27.50	27.40	0.10			
	293.15	28.87	27.85	–1.02	0.601	0.602	0.001
Cyclohexane	298.15	23.82	24.12	0.30	0.98	0.979	–0.001
Acetic acid	293.15	27.42	27.16	–0.26			
Ethanol	293.15	22.40	22.75	0.35	1.06	1.061	0.001
Glycerin	298.15	64.00	64.01	0.01	1.49	1.489	–0.001

where γ and γ_r are the surface tension coefficients, n and n_r are the number of drops, and ρ and ρ_r are the densities of the measured and reference liquids at the given temperature, respectively.

Using this instrument, surface tension and viscosity measurements can also be performed during, e.g., hydrolysis and polymerization reactions. The measured values of the surface tension and viscosity coefficients of such substances as benzene, acetic acid, glycerin, ethanol, etc., agree with the reference data to within 0.2 dyn/cm and 0.001 mP.

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