

NOVEL INSTRUMENT FOR MEASUREMENT OF SURFACE TENSION AND VISCOSITY OF SOLUTIONS

FIELD OF THE INVENTION:

The present invention provides a novel instrument (survismeter) capable of measuring surface tension, viscosity and dipole moment of a given solution and method of measuring the same.

BACKGROUND OF THE INVENTION:

Commercially available viscosimeters operate according to various functional principles, as described for example in Brock/Groteklaes/Mischke, Lehrbuch der Lacktechnologie, Vincentz Verlag Hanover 1998. Capillary viscosimeters, for example Ubbelohde viscosimeters, are instruments for determining the kinematic viscosity of liquids. The liquid is forced at a defined pressure through a capillary of particular length and particular radius. Either the time taken for a particular volume to flow through is measured or, conversely, the volume which flows through during a particular time is measured. The liquid may in this case be forced or sucked through the capillary. For low-viscosity liquids, the operating pressure can be generated simply by gravity with a storage vessel being placed at a raised height. The falling ball viscosimeter (Höppler viscosimeter) consists of a glass measuring tube, which holds the liquid to be tested and 6 balls. The fall time of the balls between two measuring markers is determined, and the dynamic viscosity of the liquid can be calculated from this via the density difference between the balls and the liquid and an equipment constant. Another method of determining the rheology of substances is provided by the rheometer. In this case, a layer of the liquid is placed, and sheared, between two bodies of defined geometry. Inter alia, the viscosity can be determined from the response of the liquid to shearing. Examples of conventional geometries are plate/plate, plate/tip, plate/spherical shell or concentric cylinders. Disadvantages with all the described methods are that the instruments only operate serially, the measurements sometimes last a very long time, for example rheometers, and the measuring instruments need to be cleaned after each measurement.

The shortcomings of the closed capillary techniques have been that many fluids to be tested are opaque or are not compatible with the tube materials, which would allow observation of the movement of the fluid through the tube. The use of closed capillaries also induced significant measurement errors in that measurement of movement of the fluid was only reliably possible at the point of entrance into the tube and at the point of exit. Some materials, due to incompatibilities with transparent tubes or due to the physical properties and appearance of the material to be tested, did not avail themselves readily to a closed tube capillary testing technique.

The JP Patent 62036537 discloses the method for measuring the surface tension, viscosity density measurements of solutions which has serious flaws, as density is static property of the liquids so liquid flowing method is not appropriate because electrostatic forces get disrupted during flow of the liquids. Further the viscosity and surface tension functions are fundamental and do not require interruptions during measurements but in this method the nature of viscous and surface forces is disrupted hence the method is inaccurate. It may only be a demonstrative model not a workable one where the solutions are taken in open beaker number 3 which get evaporated hence the decrease in weights has error, more over the internal pressure in tube number 5 does not remain constant. Nozzle number 4 is controlled with electric motor, which disrupts the laminar flow of liquids and will give wrong results. The major drawback of this method is that no provisions for effective temperature control are made where 2% decrease in viscosity occurs per degree temperature rise. The method is complicated and difficult to set and calibrate which is beyond the reach of the common student and the industrial worker as it is time consuming

One another US Patent US 6,941,797B2 claims to measure viscosity only, which has reservation for the horizontal use of the capillary as in majority of the cases the capillary action is permitted against some opposing force so that an effective control of the pressure is maintained. In general the opposing force is gravitation force, which for the horizontal capillary action may not be effective for pressure control. And no effective temperature control is possible with the open systems thus the methods is

not accurate and worth for working with accuracy due the lack of the experimental conditions. More over it is suitable for wetting liquids without any temperature control, and is failed for non-wetting liquids. The capillary is kept on the Teflon or polymer support that will not only absorb the temperature of the solution causing error in the results but also induction effects on the molecules as polyester clothes do so with body. In this CCD camera is used to have images of the capillary whose flashlight would give a jerk to the molecules influencing capillary action. It has another problem of using a shining light that will disrupt the natural flow of the solution as the molecules will absorb light and there flow velocity will vary.

Thirdly the fluorescent dye is used that totally wrong as it will interact with liquid and influence the natural flow of the liquid column, these are serious gags. Again the major drawback is of temperature control nowhere it is mentioned as to how the temperature was controlled with open capillary system. It is very complicated and graduate students and industry workers cannot afford to do work with such method as it takes very longer time in multi-channel process.

The US Patent number 5,792,941 contains very serious drawbacks of temperature control and evaporation of the sample. Reproducibility of the grooves is not mentioned, several assisting tools/accessories like Dektak-8000 Profilometer and vertical scanning interferometer are used where element integrity of the measuring unit is lost. Several parameters are to be brought in coordination while self-controlled survismter is single unit. The grooves depth is not reproducible the hydrophilic material like vinyl polysiloxane suggested which do cause reflection and refraction effects and give erratic data. Further accuracy in grinding/cutting of the grooves is not maintained. The measurements involve the florescent dye coumarin and irradiated the sample with UV lamp for contrast that will definitely disrupt the surface and friction forces. The units are very expensive.

The applicants have found that until now surface tension and viscosity is measured with separate instruments which process is time consuming and is expensive. Also, the nature of biological fluids or solutions of great biophysical, physiological and

physicochemical significance do not allow their exposure for longer period for measuring such properties.

OBJECTIVES OF THE INVENTION

The primary objective of the invention is to provide single equipment for measuring the viscosity, surface tension and dipole moment with single instrument unit for a given solution.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides an instrument (survismeter), which exactly measures viscosity and surface tension and dipole moment with a single solution taken once in its reservoir and thereby reduces everything to half. The new parameter named as Friccohesity (σ/Sm^{-1} , second m^{-1}) is also derived from Fric of frictional and cohesity of cohesive forces of the liquids respectively, and denoted by rational coefficient a η/γ (σ). The values of the friccohesity are correlated to the dipole moment of liquids and their plot gives a standard calibration curve along with an equation of the curve with definite values of the coefficients, the friccohesity values are put on the calibration curve to retrieve the dipole moment values. The σ values can be measured for dimethylformamide, dimethylsulfoxide and acetonitrile solvents by plotting against their dipole moments for standard calibration curve. The range of the dipole moment values for calibration curve is pre-decided and the σ values for homogenous solutions of compositions below their saturation point can be measured with $\pm 1 \times 10^{-5} \text{ Sm}^{-1}$.

DETAIL DESCRIPTION OF FIGURES

The instrument of the invention is shown in figure 1 and 2 and described below.

The instrument is divided into three major parts like (a) the bulbs, (b) capillary limbs, and (c) capillaries.

Bulb number 8 is reservoir for holding about 20ml of solution but for measurements the 15ml of solution is taken in this bulb. Approximately 5cm^3 volume of it is left empty and maintains pressure equilibrium required for sucking and flowing of solution. It is connected to limb number 3 and bulb number 7. The bulb number 7 holds about 10ml of solution, it adjoins the lower ends of capillary numbers 1, 2 and 4 with it, and it controls the upward flow of solution being sucked to the bulb numbers 6 and 5, and 9 of capillary limb 4th and 2nd respectively. Bulb number 6 of 10ml is the important one because solution filled in is allowed to flow within the upper and lower marks made below and above it to record the flow time. The bulb number 5 stabilizes the flow by smoothening the pressure changing. Bulb 9th is of 10ml, the solution is sucked to it above its upper mark and simultaneously allowed to flow down dropwise through the vertical capillary attached to its lower tube. The drops are counted at the lower end of the capillary, which opens to the bulb 7. For this the upper end of capillary limb number 1 is kept open to control the pressure of the bulb.

The capillary limb 1, 2, 3 and 4 and their upper ends are fitted with ground glass joints of B5 (except tube number 3 with B9). Here B represents the standard glass joint and numbers along with B size of the joint. The stoppers are also used to block the upper ends of tubes. The capillary limb numbers 1 and 3 are directly attached to bulb 8th and 7th to control the pressure of the bulbs during operation and capillary limb 2nd and 4th are attached to bulb numbers 5 and 6. And the bulb number 9 and they control air pressure applied on the overhead of the top ends of capillary limbs for laminar flow of solution.

The capillaries adjoining bulb numbers 6 and 7, adjoining bulb numbers 9 and 7th may be vertical or horizontal placed. The inner diameter of the both is 0.5mm to 1.0 mm. The U form capillary cancels out the effect of gravitational force on the downward flow of solution.

DETAIL DESCRIPTION OF THE INVENTION:

Accordingly, the present invention relates to an instrument for determining the viscosity, surface tension and dipole moment of liquids, said instrument comprising: one or more capillary tube being connected with chambers/bulbs such as herein described wherein

a first capillary is vertically connected to bulb (7),

a second capillary is vertically or horizontal connected to bulb (7) through bulb (9),

a third capillary provided in the 'U' form and connected to bulb (7) at bottom through bulb (8),

a fourth capillary is connected to bulb (7) through bulbs (6) and bulb (5), such that the said fourth capillary is vertically or horizontally placed between bulbs (6) and (7).

In the instrument the capillary tube which adjoins bulbs (6) and (7) having inner concentric tubes.

In the said instrument the capillary tube which adjoins bulbs (9) and (7) having inner concentric tubes.

In the said instrument the ratio of inner tube to outer tube diameter is in the range of 0.5 mm to 1.5 mm.

In the said instrument the capillary tube (1) is directly connected to atmosphere in order to maintain pressure inside the bulb (7).

In the said instrument the bulbs are in the spherical, circular, cylindrical, square and rectangular shape.

In the said instrument the bulb (5) is connected to bulb (6) for stabilizing the flow by smoothening the pressure change.

A further embodiment of the present invention relates to a method for determining the viscosity, surface tension and dipole moment of liquids with the said instrument, said method comprising the steps of:

- a) allowing solution (L) of known viscosity value in bulb (8) through capillary capillary limb (3), while keeping other ends of capillaries are open;
- b) sucking the said solution from bulb (8) through U form capillary adjoining bulbs (6) and (7) in order to collect the solution in bulb (5), while said sucking is carried out upper end of capillary (4) is kept open while upper end of capillary (2) and (1) are blocked with stopper;
- c) allowing down flow of said solution by removing stopper of capillary (1) and measuring time while solution flow between upper and lower marks of bulb (6);
- d) repeat the steps (a) to (c) several times;
- e) measuring time data for test solution (V) and calculating the viscosity data with formula (1)

$$1. \quad \eta_{\text{soln}} = (\rho_{\text{soln}} \cdot t_{\text{soln}} / \rho_{\text{solv}} \cdot t_{\text{solv}}) \cdot \eta_{\text{solv}}$$

wherein η_{soln} =viscosity of solution, η_{solv} =viscosity of solvent

t_{soln} = flow time for solution, t_{solv} =flow time for solvent

ρ_{soln} = densities of solution, ρ_{solv} =densities of solvent

- f) sucking the solution (a) of known surface tension in bulb (8) through capillary (2) to bulb (9), while blocking the socket of capillary limb (4) and (1) by stopper,
- g) allowing drop wise flow of solution from bulb (9) and counting numbers of drops in bulb (7),
- h) repeating step (f) to (g) several times for solution as well as solvent (b) and calculating surface tension with formula

$$i. \quad \gamma_{\text{soln}} / \gamma_{\text{solv}} = \eta_{\text{solv}} \cdot \rho_{\text{soln}} / \eta_{\text{soln}} \cdot \rho_{\text{solv}}$$

wherein

$\gamma_{\text{soln}}, \gamma_{\text{solv}}$ = surface tension, $\eta_{\text{solv}}, \eta_{\text{soln}}$ = number of drops for solution and solvent

$\rho_{\text{solv}}, \rho_{\text{soln}}$ = density of solution and solvent at desired TK

- (i) obtaining flow time in step (e) and number of drops in step (g) for solution (L) & (V) and calculating the dipole moment with formula

$$\mu = 4.20141 - 25.02689\sigma + 385.37892\sigma^2$$

wherein σ is friccohesity

$$\sigma = \sigma_0[(t/t_0 \pm B/t)((n/n_0)+0.0012(1-w/w_0))]$$

wherein B/t is kinetic energy correction to viscous flow, $0.0012 \times 10^3 \text{ kg m}^{-3}$ air density and the $(1-w/w_0)$ is buoyancy correction to w and w_0 the weights of solution and solvent, respectively.

Also, the present invention provides an instrument (survismeter), which exactly measures these parameters with a single solution taken once in its reservoir and thereby reduces everything to half.

The survismeter was fabricated based on 2 in 1 technique for surface tension and viscosity data measurement. As the innovations keep going on for betterment in experimental techniques for reducing the consumptions of the time, efforts and materials used in, hence two different survismeter type I and II are developed for academic, and research and development laboratories. In general the biological, biochemical solutions and biofluids are very expensive and get spoiled on exposure for longer period of time hence it is difficult to measure both the properties separately with indusial instruments which takes much time and materials. Thus the survismeters resolve such hurdles for obtaining such data on biological solutions for the study of the atherosclerosis with minimum operational steps. Even school and graduate students can deal with type I, it is simplest and handy with minimum sophistication while type II has certain degree of sophistication meant for high accuracy work like determination of molecular weights of polymers and critical micellar concentration [CMC] of surfactants and detergents. The U-capillary between the bulbs 6 and 7 of the type I (Figure 1) is reduced to straight and an additional U-capillary between the bulbs 9 and 7 of the survismeter II (fig. 2) is incorporated for nullifying an effect of gravitational force, g , on dropwise flow. The survismeter I is for introducing the concept of 2 in 1 as important step towards green chemistry instrumentation but the type II is fundamentally for ultra accuracy for academic and Research and Development laboratories with certain degree of sophistication for accurate determination of molecular weights of polymers and CMC (critical micellar

concentration) of surfactants and detergents. They can measure the surface tension, viscosities and friccohesity data of the sols, gels, colloidal solutions of 0.0005 to 0.800 mol kg⁻¹ and solutions of polymeric materials of concentrations from 0.0005 to 0.550%. The survismeter would be very useful to produce highly accurate data of surface tension, viscosities and friccohesity data for nano-particle solutions.

The instruments are a step forward in the field of solution engineering to produce fundamental information. Apart from frictional and cohesive forces, a vacancy has been felt to derive new property known as friccohesity (σ), which has never been noticed for liquid mixtures, as no mixing is ideal. Thus a new equation is formulated for calculation of the σ values for insight of a state of intermolecular forces.

The values of the friccohesity have been used to measure the dipole moment of the solutions instead of capacitor. If the rough range of the μ (dipole moment) values of the unknown liquid solutions is estimated then by measuring the σ values for the liquids whose dipole moment values are known a standard equation and calibration curve are obtained. The μ value is the function of the electrostatic forces of the liquids and hence the solvents of the μ values of similar range are used for calibration curve. The friccohesity values are assumed to effectively illustrate the rheological behavior of the biological fluids, as to how the diffusion of the biocompatible ions- Na⁺, K⁺ and Mg²⁺ and others, and molecular ions-zwitterions (amino acids) and globular polyvalent protein ions get transported along with bio-fluids in the blood capillaries. It can decide the category of the viscous flow of the biochemical solutions whether they belong to Newtonian flow or the Brownian. In general, the biological solutions are very expensive and get spoiled with time hence survismeters are very useful techniques to measure both the CMC and intrinsic viscosity in minimum time, efforts and exposure of the solution. The survismeters do not permit any restriction for measuring both the properties of Newtonian liquid solutions below their saturation compositions even it is suitable for very dilute colloidal solutions of nano-molar compositions. The important condition of the liquid solutions is that they must respond to viscous flow. However the γ and η data for 0.0005 to 0.800 mol kg⁻¹

colloidal liquid solutions and similar concentrations of the polymers can be measured by using the capillaries of the 0.5 to 1.0 mm inner diameter, thus the desired inner diameter of the capillaries must be incorporated in the instruments. Basically the inner diameter of the capillary decides the viscous and drops wise flows of the liquids of desired strength.

Operation: It is divided into various sections.

a) Washing: A standard procedure is used for cleaning and drying in oven at 393.15TK.

(b). Material and methods: The survismeters are made of borosil glass with simple glass blowing units, the borosil glass syringe with needle and with plunger is used to suck the solutions from the bulb number 8th to the corresponding survismeter bulbs through the flexible Teflon tube. The survismeters are cleaned with freshly prepared chromic acid, ordinary and distilled water and finally with aqueous acetone.

(c). Stainless steel stand: It mounts the survismeters with reversible nut and bolts fitted clips at a vertical position. An electronic timer of 1×10^{-2} second accuracy is used to record the flow times for the prescribed volume of the liquid. The stand keeps the survismeter at fairly vertical and reproducible position and inhibits the jerks, which affect the viscous and drop wise flows.

(d). Handling and operation: The vertical position is made with the help of mercury leveling instrument. The reference liquid and solutions were separately filled in the bulb number 8 of both the survismeters with utmost care and sucking of the liquids from the bulb number 8th to the bulbs 7, 6 and 5 for flow times and bulbs number 7th and 9th for drops numbers can be made cautiously. The attention was paid to avoid the formation of the air bubble in the liquid at any step during sucking operation as it disrupts the smooth flow. The sucking was made with syringe connecting the needle of the syringe and the respective upper end of the survismeter capillary limb.

Advantages: The survismeters-type I and II have almost similar structures except few changes, their schematic drawings are shown in Figures 1 and 2. The type I is a very handy and simple in operation and most suitable for academic work for school and graduate students with minimum delicacy in designing and handling. Its exposure to the students can develop the concept of simultaneous measurements of surface tension and viscosity, which are never been done with single instrumental unit.

The type II is an advance version of the 2 in 1 technique and is most appropriate for research and developmental work having high level of delicacy and needs utmost attention for handling and operation with high resolution. Basically it allows the slow flow as fast viscous flow causes higher disruptions in the hydrodynamics of the liquids. The survismeter are most suitable to measure surface tension and viscosity of surfactants, sols and gels, paints, pigments, textile, paper pulps and petroleum products. Both of the instruments consist bulbs, capillary limbs and capillaries for solution, pressure and liquid flow control with almost similar in structural designing and operational methods.

Fundamental difference: The type I survismeter differs from the II due to the shape of the capillaries. The capillaries of type I adjoining the bulbs 9th to 7th (for drops counts) and 6th to 7th (for flow times) are vertical in shape and shorter in length, almost 1/3 times to that of the type II. Such kinds of shape of capillaries facilitates an easy handling of the instruments; the inner diameter of the capillaries in both the cases is 0.5 mm. Contrary to the design of capillaries of type I, the type II consists the U shaped capillaries adjoining the bulbs 9th to 7th and 6th to 7th, respectively. The length of the capillaries is three times of the type I, thus the shape and length of the capillaries of the type II introduce certain complications and sophistication in the instrument for operation and handling. The purpose of the U capillaries is to nullify an effect of gravitational force on the viscous and dropwise flows of the solutions for clearer picture of the structural interactions.

Common features: The bulb number 8th of both the instruments holds about $20 \times 10^{-3} \text{ dm}^3$ but in general about $15 \times 10^{-3} \text{ dm}^3$ of solution is preferred for measurements with approximately $5 \times 10^{-3} \text{ dm}^3$ empty volume left unoccupied for pressure equilibrium.

The bulb number 8th is connected to capillary limb number 3 and bulb number 7, respectively. The bulb number 7th holds about $10 \times 10^{-3} \text{ dm}^3$ of solution, and adjoins the lower ends of capillary limb numbers 1, 2 and 4, respectively, and it controls an upward flow of solution being sucked to the bulb numbers 6 and 5, and 9 of capillary limb 4th and 2nd, respectively. The bulb number 6th of $10 \times 10^{-3} \text{ dm}^3$ is an important one as solution filled in is allowed to flow within the upper and lower marks made on the capillaries below and above it (Figs.1 and 2). The bulb number 5 stabilizes the flow by equilibrating a pressure and thermal stability. The bulb 9th is of $10 \times 10^{-3} \text{ dm}^3$, the solution is sucked above its upper mark and simultaneously allowed for down flow dropwise through vertical (type I) and the U (type II) capillaries attached to its lower tube. The drops were counted at the lower end of the capillary, which opens to the bulb number 7th and the upper end of capillary limb number 1 was kept open for pressure control of the bulb. The tubes 1, 2, 3 and 4, respectively, are the capillary limbs whose upper ends are fitted with ground glass joints of B5 (except tube number 3 with B 9). Here the B is standard glass joint along with size of the B, the stoppers are also used to block the upper ends of tubes. The capillary limb numbers 1 and 3 are directly attached to bulb 8th and 7th for pressure control of the bulbs during operation and the capillary limb 2nd and 4th are attached to the bulb numbers 5 and 6. And along with bulb number 9th, they control air pressure applied overhead of the top ends of capillary limbs for laminar flow of solution.

Handling: Usually, surfismeters are calibrated with any solution of known surface tension and viscosity but ultra pure water is preferred. Unit numbers 4th and 2nd are calibrated separately for viscosity and surface tension measurements, respectively as under-

For viscosity measurements: About 15ml solution of known viscosity value is taken in the 8th bulb through 3rd capillary limb keeping other ends of the capillary limbs

open. The Survismeter is mounted on the stainless steel stand and kept in thermostat at desired temperature. The solution is sucked upward from bulb number 8th through U form capillary by 50ml capacity syringe (for example Dispo Van) fitted with airtight plunger. With needle of syringe, one end of Teflon or high quality PVC tube is attached and another end is attached to a movable stopper with hole. The stopper is fixed in the socket of 4th capillary limb and pulling out the plunger sucks up solution till the bulb number 5th is filled up, and afterward the stopper is removed. During suck the socket of capillary limb 3rd is kept open while of 2nd and 1st are blocked with stopper and for down flow of solution the syringe and stopper of capillary limb number 1st is taken back. The flow time between upper and lower marks of the bulb number 6th is counted. The flow time with 0.01second was recorded with electronic racer for several times to ensure the reproducibility in values. Similarly the time data are collected for solutions in question and viscosity (η) data are calculated with usual relation.

$$\eta_{\text{soln}} = (\rho_{\text{soln}} \cdot t_{\text{soln}} / \rho_{\text{solv}} \cdot t_{\text{solv}}) \cdot \eta_{\text{solv}}$$

The η_{soln} and η_{solv} viscosities, t_{soln} and t_{solv} flow times, and ρ_{soln} and ρ_{solv} densities of solution and solvent respectively at desired temperature.

Surface tension: After flow time data were obtained the solution is sucked to the bulb number 9th above its upper mark similarly with the blocked socket of the capillary limbs 4th and 1st by stoppers. For the dropwise flow of solution from the bulb number 9th the stoppers are removed followed by syringe and the number of drops are counted in the bulb 7th. The measurements were repeated several times for reproducibility. A nut bolt fitted clip is used to control the air pressure applied on overhead of the capillary limb number 2nd and usual mathematical relations are applied for surface tension data as.

$$\gamma_{\text{soln}} / \gamma_{\text{solv}} = (n_{\text{solv}} \cdot \rho_{\text{soln}}) / (n_{\text{soln}} \cdot \rho_{\text{solv}})$$

The γ_{soln} and γ_{solv} surface tensions, n_{solv} and n_{soln} number of drops, and ρ_{soln} and ρ_{solv} densities of the solution and solvent respectively at desired TK.

Result and discussion: The coefficients surface tension and viscosity of benzene, acetic acid ethylacetate, glycerol are measured and given along with literature data in table 1 and are found in close agreement with $\pm 0.05 \text{ dyne cm}^{-1}$ and ± 0.0001 milipoise deviation in values. The surface tension and viscosity data of binary and ternary aqueous and non-aqueous solution systems of lower to higher concentration ranges have been obtained to a very high reproducibility. The densities were measured with pyknometer with 0.01mg Dhona balance model 100DS.

Friccohesity: Data of the η and γ functions are fitted in the following equation.

$$(\eta/\gamma) = (\eta_0/\gamma_0)(t_0/n_0) \quad (1)$$

The function $(\eta/\gamma) = \sigma/S \text{ m}^{-1}$ represent the values for the solutions and the $(\eta_0/\gamma_0) = \sigma_0$ of the solvent, respectively. The equation 1 now becomes equation 2 for friccohesity values. $\sigma = \sigma_0[(t/t_0 \pm B/t)((n/n_0) + 0.0012(1-w/w_0))]$ (2).

The B/t is kinetic energy correction to viscous flow, the $0.0012 \times 10^3 \text{ kg m}^{-3}$ air density and the $(1-w/w_0)$ is buoyancy correction to w and w_0 the weights of solution and solvent, respectively. The w/w_0 ratio may be replaced by density (ρ) values of the solutions hence factor $(1-w/w_0)$ becomes $(1-\rho)$.

The values of the γ are related as $w = mg = 2\pi r\gamma$, thus the buoyancy correction in weights is made, the B/t and kinetic correction (k) were obtained from the $\eta = \rho(k - B/t)$ with the known values of the η and ρ functions. The B/t and k values are found to be -0.182×10^{-4} and 1.897×10^{-4} , and -0.205×10^{-5} and 2.326×10^{-5} at 298.15 and 303.15 K, respectively. The value of the survismeter constant B with distilled water is calculated from the $\eta/\rho = Bt - V/8\pi rLt$, the V total volume of water that flows, r radius and L is length of capillary.

Discussion: The values of the σ parameter from equation 2 determine dipole moment (μ) of liquid solutions, the μ values vary due to the electrostatic forces involved in the heteromolecular interactions. The σ data in table 2, illustrate binding forces during drop formation applied on circumference, the lowermost tip of the capillary, as well as on the liquid layer being formed during viscous flow. Such divisions of the forces being associated with transport properties have never been taken into account for

measurements. Thus the σ values can plotted against the known μ values of the DMF, DMSO and AN for a standard calibration curve and calculated regression equation of the curve with an appropriate values of the coefficients given below at 293.15 K.

$$\mu = 4.20141 - 25.02689\sigma + 385.37892\sigma^2 \quad (3).$$

The 4.20141 is intercept, -25.02689 and 385.37892 are slope values of the equation and are correlation coefficients of σ vs μ plot. The σ values of the solutions can be put in equation 3 for the μ values in table 2. Briefly the orders of the σ values are noted as DMSO > DMF > THF > AN for pure solvents and DMSO > DMF > AN, AN > DMF > DMSO and AN > DMF > DMSO for 0.05, 0.15 and 0.20 mol kg⁻¹, respectively. Thus the friccohesity depicts the state of electrostatic charge in solutions.

Merits: The coefficients of on going processes like hydrolysis, polymerization and reactions can be measured.

The advantages of the disclosed invention are thus attained in an economical, practical, and facile manner. While preferred embodiments and example configurations have been shown and described, it is to be understood that various further modifications and additional configurations will be apparent to those skilled in the art. It is intended that the specific embodiments and configurations herein disclosed are illustrative of the preferred and best modes for practicing the invention, and should not be interpreted as limitations on the scope of the invention. The applicants are also provided herewith some experimental details for various solvents and comparison with details available in literature for illustration purpose of the said invention, however this should not be construed to limit the scope of the invention.

Table1: Experimental and literature data of surface tension (dyne cm⁻¹) and viscosity (milipoise) of solvents measured with the Survismeter at two temperatures. Δ is the difference between the two values.

Lit^{6,7} (the literature) and exp (the experimental) values. Δ = Exp-lit.

Systems	T. K	Surface tension		exp-lit Δ	Viscosity		Exp-lit Δ
		Lit.	exp.		Lit.	exp.	
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
	293.13	22.55	22.98	0.43			
Ethyl ether	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
Glycerol	298.15	64.00	64.01	0.01	1.49	1.489	-0.001

ADVANTAGES OF THE INVENTION

The instruments are highly useful in solution chemistry for viscosities, surface tension and the friccohesity measurements. It can measure the viscosities, surface tension and friccohesity data of wide range of concentrations of polymers and biopolymers solutions. The survismeters reduce operational efforts in the laboratories and industries to measure rheological and CMC values of the industrial solutions and detergents, respectively. It can accurately measure the interfacial surface tension with high accuracy. Till date the two separate instruments are in practice to measure viscosity and surface tension separately engaging the labs infrastructure for longer time and larger materials with several operational steps in the measurements. Thus the solutions of biological importance get spoiled (due to inter conversion, oxidation/reductions) and evaporated with times. The manufacturing, storing and maintenance of two separate instruments involve double efforts and much of the glass material along with fuel gases for glass blowing for manufacturing the instruments.

The survismeters-type I and II have almost similar structures except few changes, their schematic drawings are shown in Figures 1 and 2. The type I is a very handy and simple in operation and most suitable for academic work for school and graduate students with minimum delicacy in designing and handling. Its exposure to the students can develop the concept of simultaneous measurements of surface tension and viscosity, which are never been done with single instrumental unit.

The type II is an advance version of the 2 in 1 technique and is most appropriate for research and developmental work having high level of delicacy and needs utmost attention for handling and operation with high resolution. Basically it allows the slow flow as fast viscous flow causes higher disruptions in the hydrodynamics of the liquids. The survismeter are most suitable to measure surface tension and viscosity of surfactants, sols and gels, paints, pigments, textile, paper pulps and petroleum products. Both of the instruments consist bulbs, capillary limbs and capillaries for solution, pressure and liquid flow control with almost similar in structural designing and operational methods.

The present invention is capable to develop a survismeter having full control of the temperature and pressure and easy and simple in handling and operation with no possibility of the evaporation of the solution.

Yet another advantage of the present invention is to provide a purely qualitatively operating method for determining viscosities and surface tension, with which a large number of samples which can be evaluated within a short time.

Yet another advantage of the present invention is to provide a method to avoid onerous cleaning of the equipment components.

Still another advantage of the present invention is to provide a reliable quality control instrument for evaluating viscosity and surface tension for liquids such as Newtonian, Non-Newtonian, Biophysical, physiological, physicochemical and Polymeric fluids.

CLAIMS

1. An capillary instrument for determining the viscosity, surface tension, dipole moment of liquids, said instrument comprising:
 one or more capillary tube being connected with chambers / bulbs such as herein described wherein
 a first capillary is vertically connected to first bulb for stabilizing the flow by smoothening the pressure changes inside the bulb and controlling the upward flow of solution in second and fourth capillary,
 a second capillary is in vertically or horizontal shape and open into first bulb, wherein the drops of the said solution is counted at the end of capillary,
 a third capillary provided in the 'U' form and connected to first bulb at bottom through third bulb to take in the solution in first bulb,
 a fourth capillary is connected to first bulb through fourth and fifth bulbs, wherein the fourth capillary is vertically or horizontally placed between fifth bulb and first bulb, wherein the said fifth bulb having upper and lower indications to record the flow time.
2. The system as claimed in claim 1, wherein the capillary tube which adjoins fifth bulb and first bulb having inner concentric tubes.
3. The system as claimed in claim 1, wherein the second capillary tube which adjoins the first bulb having inner concentric tubes.

4. The system as claimed in claims 2 and 3, wherein the ratio of inner tube to outer tube diameter is in the range of 0.5 mm to 1.5 mm.
5. The system as claimed in claim 1, wherein the first capillary tube is directly connected to atmosphere in order to maintain pressure inside the first bulb.
6. The system as claimed in claim 1, wherein the bulbs are in the spherical, circular, cylindrical, square and rectangular shape.
7. The system as claimed in claim 1, wherein the fourth bulb is connected to fifth bulb for stabilizing the flow by smoothening the pressure change.
8. A method for determining the viscosity, surface tension and dipole moment of liquids with an instrument as claimed in claim 1, said method comprising the steps of:
 - a) allowing solution (L) of known viscosity value in bulb (8) through capillary third limb, while keeping other ends of capillaries are open;
 - b) sucking the said solution from third bulb through U form capillary adjoining fifth bulb and first bulb in order to collect the solution in fourth bulb, while said sucking is carried out upper end of fourth capillary is kept open while upper end of capillary (2) and (1) are blocked with stopper;
 - c) allowing down flow of said solution by removing stopper of first capillary and measuring time while solution flow between upper and lower marks of fifth bulb;
 - d) repeat the steps (a) to (c) several times;
 - e) measuring time data for test solution (V) and calculating the viscosity data with formula (1)

$$1. \quad \eta_{\text{soln}} = (\rho_{\text{soln}} \cdot t_{\text{soln}} / \rho_{\text{solv}} \cdot t_{\text{solv}}) \cdot \eta_{\text{solv}}$$

wherein η_{soln} =viscosity of solution, η_{solv} =viscosity of solvent

t_{soln} = flow time for solution, t_{solv} =flow time for solvent

ρ_{soln} = densities of solution, ρ_{solv} = densities of solvent

- f) sucking the solution (a) of known surface tension in third bulb through capillary (2) to second bulb (9), while blocking the socket of capillary limb (4) and (1) by stopper,
- g) allowing drop wise flow of solution from second bulb (9) and counting numbers of drops in first bulb,
- h) repeating step (f) to (g) several times for solution as well as solvent (b) and calculating surface tension with formula (2)

$$\gamma_{\text{soln}}/\gamma_{\text{solv}} = \eta_{\text{solv}} \cdot \rho_{\text{soln}}/\eta_{\text{soln}} \cdot \rho_{\text{solv}}$$

wherein

γ_{soln} , γ_{solv} = surface tension, η_{solv} , η_{soln} = number of drops for solution and solvent

ρ_{solv} , ρ_{soln} = density of solution and solvent at desired TK

- (i) obtaining flow time in step (e) and number of drops in step (g) for solution (L) & (V) and calculating the dipole moment with formula

$$\mu = 4.20141 - 25.02689\sigma + 385.37892\sigma^2$$

wherein σ is friccohesity

$$\sigma = \sigma_0[(t/t_0 \pm B/t)((n/n_0) + 0.0012(1 - w/w_0))]$$

wherein B/t is kinetic energy correction to viscous flow, $0.0012 \times 10^3 \text{ kg m}^{-3}$ air density and the $(1 - w/w_0)$ is buoyancy correction to w and w_0 the weights of solution and solvent, respectively.

9. An instrument for determining the viscosity, surface tension and dipole moment of liquids and a method therefore are substantially described herein with reference to the accompanying drawings and examples.