ECONOBURETTE: A GREEN CHEMISTRY BURETTE FOR MICROSCALE TITRATIONS

Man SINGH
University of Delhi, India

Abstract: Econoburette [Calibration No.M/0408/10970 by Testing Centre, Ministry of MSME, Govt. of India, New Delhi] is a green chemistry instrument to perform valuable titration with microlitres of liquid samples. The microlevel amounts of titer and titrant consume less time in doing a volumetric tititration and also prevent escape of materials. In general, after titration a significant quantity of indicator, additive, titer and titrant are consumed and drained out in sink to cause air, water and soil pollutions. The econoburette prevents such wastages by nine times with high accuracies in results with no pipetting an aliquot.

Keywords: econoburette, titration, microlitre, titer, pollution.

Introduction

Currently the resources: electricity, water, solvents, space, chemicals, are of great concern, their wise and smart uses are in focus for current research [1-3]. Thus nanotechnology and microscale chemistry have become a key point of the environmental sciences to avoid wastage of the natural resources [3-7]. Thus this paper presents an econoburette that saves 90% amounts of materials and efforts; however there are several types of microburettes which are in use in biosciences [8]. But their capacity is too small to be sufficient for routine titrations. In general, for ordinary

titrations, the capacity of burette is 50 mL with zero mark at the top end. For titration purpose a 100 or 150 mL conical flask containing the titer is used. For titration the burette is filled upto zero mark to hold the 50 mL solution and 10 mL of titrant is used for titration. The indicator for detection of an end point of chemical reaction in the titration is taken in same proportion, and after titration whole material is drained out to sink. Routinely, a single user repeats a titration at least 3 times for reproducibility with too much wastage of chemicals. If there are "n" users, the wastage would be "3 x n" times but econoburette needs 1 mL each of titer and titrant, and a drop of indicator. Thus it works with 10% of the solution used with 50 mL burette with minimum operational steps to save time. For safety reasons a wooden box was used to store the flasks, funnel, and stainless steel stand as it is potable. In our previous paper, titration of acid and base were done with 1 molar solution of each and a ratio of comparative methods is found the same [9].

Instrument

Description

A line sketch of the econoburette with dimensions in millimeter is shown in the figures below (Figs. 1 and 2). It is made up of borosil glass material (Borosil Glass Pvt. Ltd, India). The econoburette is developed by the author and can be had for use. The L1, L2, L3 and L4 limbs of 0.00-5.00 mL, are attached to the L5 flask having Teflon stoppers S1, S2, S3, S4, respectively, the S5 is fitted with flask L5. Each limb opens to a common flask marked with number L5 whose top end remains open for pressure control. Each limb is graduated with 0.05 mL with etching technique using hydrofluoric acid and wax. An upper end of each limb is fitted with standard joint and movable stopper and the lower end with air and liquid proof rotating Teflon stoppers open to a common flask number L5. The L1, L2, L3 and L4 open to bulb L5 connected to high quality airtight stopper S5 which discharges the mixture out of the flask after titration. The titrant and titer solutions are taken in limbs L1 and L2 respectively and indicator in L3. The econoburette is vertically clipped on a specifically made stainless steel stand (SSS) rod fitted with the outer box (fig.2). The SSS rod is in part number 1 and 2 with nut and screw tie-up arrangements for assembling part 1 on 2 for mounting the econoburette with an ordinary burette clamp. Reproducibility in vertical position is assisted with spirited leveler.

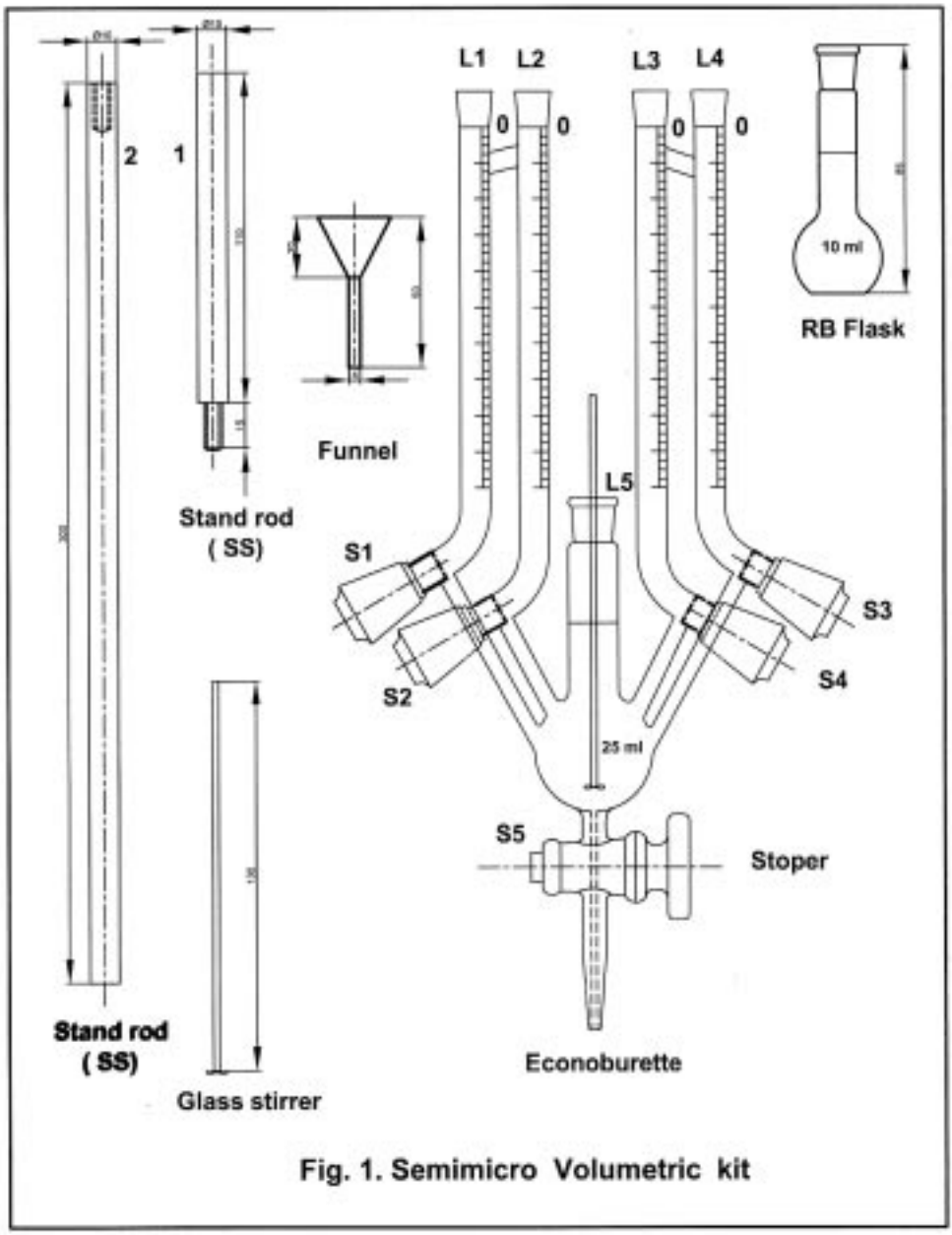

Fig. 1. Semimicro Volumetric kit

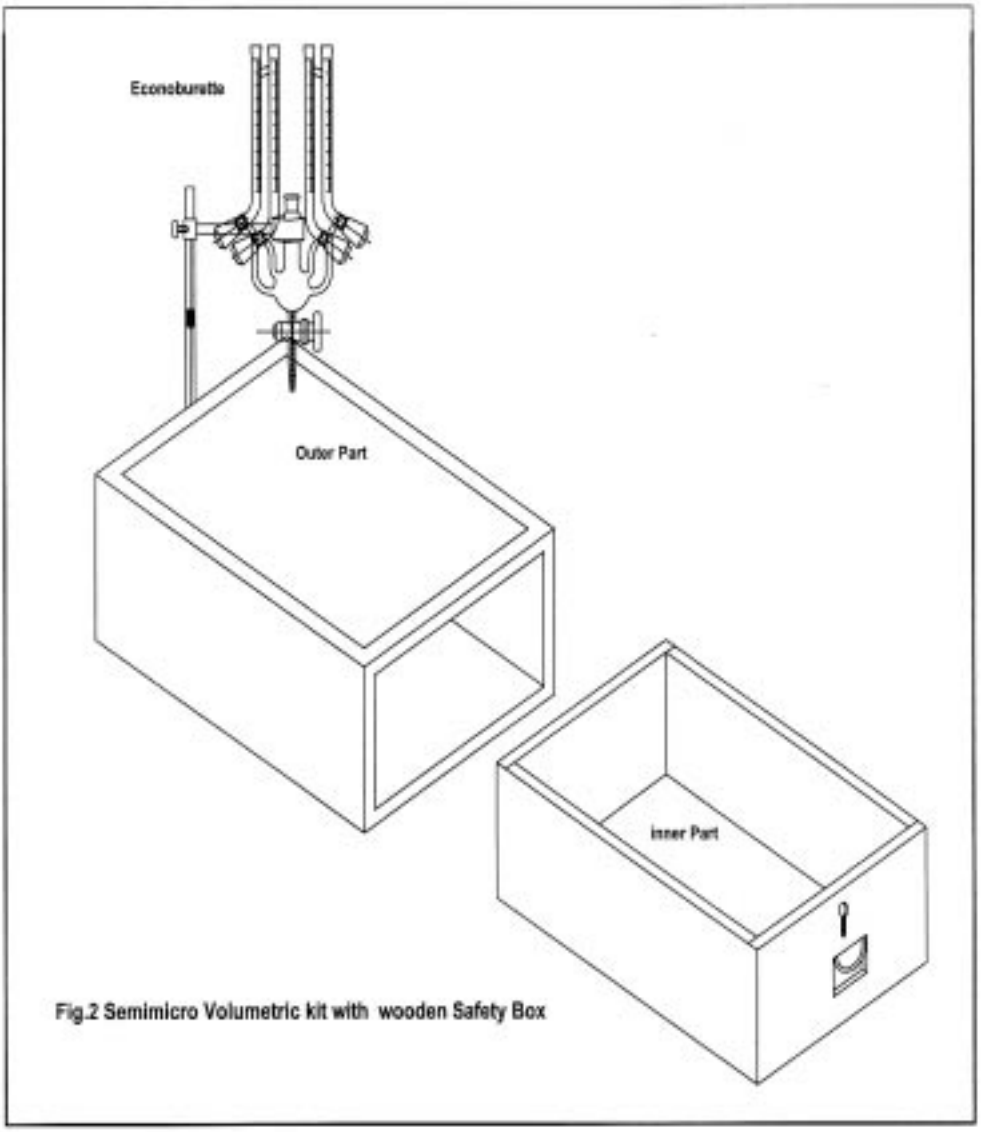

Fig.2 Semimicro Volumetric kit with wooden Safety Box

The L4 limb is used for desired solution to assist a completion of the reaction or pH control of the titration reaction in bulb L5. Comparatively there is a much less consumption of the glass materials and resources: glass blowing gases like oxygen, butane etc with the econoburette than an ordinary burette. This difference comes 90%.

Comparative Expenditure

A cost incurred with 50 mL burette with a class of 40 students for HCl vs NaOH titration was estimated using 2 molar (2 M) HCl and NaOH. A student fills up the 50 mL burette to a zero level with 2 M NaOH with consumption of 40x50 = 2000 mL (2 L) NaOH. Each student takes 10 mL 2 M HCl in conical flask for titration with 2 M NaOH for 3 reproducible readings with 10x3x40 = 1.2 L HCl. The 1.2 L of M HCl needs 200 mL of 12 M HCl. Similarly an amount for the 2 M NaOH for 40 students = 10x3x40, = 1.2 L, with 96 g NaOH. Thus the 40 students fill 50 mL burettes with 2 M NaOH where 2 L of 2 M NaOH with 160 g NaOH is prepared. For acid and base solutions the water is distilled with distillation plant of 2000 watt heating element, it takes an h for distilling a liter of water and consumes about 25 units. Each unit costs about rupees 5/- only, the 1.2 L+ 2 L = 3.2 L distilled water for acid + base titration was used with 3.2x25x5 = rupees 400/- only, Indian currency or about $ 10 USD. Thus for n classes with m students, the cost would be [(n)x(m)x (10)] USD excluding the water used for cleaning. In chemistry laboratories the titration is most common experiments in schools, colleges, universities and industries, so the wastage is huge and the econoburette is asset to minimize it by 90%.

Cost with econoburette

For similar titrations with econoburette, the 120 mL 2 M HCl and 120 mL 2 M NaOH were used consuming 20 mL of 12 M HCl and 9.6 g NaOH, respectively. This analysis has noted 95% saving as compared to conventional burette.

Method with econoburette

Each limb between L1 and S1, L2 and S2, L3 and S3, L4 and S4 holds 5 mL and the flask L5 with stopper S5 25 mL solutions, respectively. The M HCl was taken in L1, the M NaOH in L2 and phenolphthalein as indicator in L3, respectively. Initially the 1 mL of the HCl was released from the limb L1 to flask L5 by opening S1 and one drop of phenolphthalein was taken from limb L3 to the L5. Then the 0.01 M NaOH was added from a limb number L2 to the flask to titrate the M HCl, till a pink color was obtained at a completion of neutralization of the acid. The titration was repeated for 3 reproducible readings and each time the neutralized solution was discharged from the flask via valve S5. Each NaOH addition was stirred smoothly with glass stirrer (Fig 1).

Washing flask L5

With each neutralization reaction in flask L5, the solution sticks to an inner wall of a flask. This was washed out with a jet of distilled water through a tube of washing bottle. During washing the valves S1, S2, S3 and S4 were tightened and water was poured from a top of the L5 and after washing, the water was drained out through the stopper S5.

Accuracy in titration

An ordinary burette measures the volume with 0.1 mL accuracy but econoburette measures with 0.05 mL and ensures an accuracy in results because the volume values were directly used with $N_{NaOH}V_{NaOH} = N_{HCl}V_{HCl}$ relation. An inner radius of an ordinary burette tube is about 7 mm which escape liquid molecules due to evaporation with larger surface remains in contact of the air. But the radius of the econoburette is 2 mm with minimum surface exposure.

Results and discussions

Econoburette is found superior and advantageous for volumetric analysis over conventional burette. If it is used at a mass level, it would save environment from being polluted. Its fabrication, handling and operation are easy and it is useful for industries and educational institutions. It avoids pipetting of a liquid with mouth because sometimes the liquid to be sucked goes inside the body via mouth. Even if a user takes much precaution to avoid an entry of a liquid to user's mouth the dangerous fumes are certain to enter the body due to direction of a force to suck a sample. Such fumes are poisonous for growing children. The econoburette also facilities the titration of volatile liquids, thus it is very useful for chemistry laboratories.

Acknowledgement. The author is thankful to Dr. A.P. Raste, Principal, Deshbandhu College, DU, New Delhi, for infrastructural support.

REFERENCES

1. Singh, M., S. Yadav, S. Ahmad. Technique for Adsorption of Toxic Gases on Metal and Salt Impregnated Cellulose Strips. *J. Sci. & Ind. Res.* **64**, 205-225 (2005).

2. Singh, M. Studies of Intermolecular Force Coefficient (σ^{0}_{imf}) for Methyl Derivatives of Urea in Aqueous Solutions with Friccohesity, A New Physicochemical Function, from 293,15 to 303,15 K. *J. Indian Chem. Soc.* **82**, 1183-1189 (2005).

3. Singh, M. Measurements of Surface Tension and Viscosity of Liquids with Survismeter – A Green Chemistry Instrumental Approach. *Chemistry* **14**, 426-430 (2006).

4. Singh, M. Survismeter 1 and 2 for Surface Tension and Viscosity Measurements of Liquids for Academic, and Research and Development Studies. *J. Biochem. & Biophys. Methods* **67**, 151-161 (2006).

5. Singh, M. Depsurvismeter, Multipurpose and Fast Tech Instrument for Density, Potential/Ph, Surface Tension and Viscosity for Molecular Interactions of Ureas and Biomolecules. *Chemistry* **17**, 192-208 (2008).

6. Singh, M. Oscosurvismeter, A New Instrument for Osmotic Pressure, Conductance, Viscosity and Surface Tension Measurements of Liquid Solutions of Chemical Substances. *Instrumentation Science & Technology* **34**, 669-676 (2006).

7. Singh, M., S. Gupta. Spontaneity for Reactions of Triazine Dendric Molecules in Aqueous Medium Illustrated with Excess Viscosities, Volumes and Free Energies. *Phys. & Chem. Liquids* **45**, 281-288 (2007).

8. Singh, M. Upper Critical Solution Temperatures for Immiscible Solvent Systems with Halide Salts, Carboxylic Acids, Surfactants and Polynuclear Aromatic Compounds and Benzene Derivatives. *J. Chem. Thermodynamics* **39**, 240-246 (2006).

9. Singh, M. Semimicro Volumetric Econoburette, A Novel Technique for Microscale and Risk Free Titrations for Academic and Industrial Uses. *Anal. Lett.* **40**, 2617-2623 (2007).

✉ **Dr. Man Singh**,
Chemistry Research Laboratory,
Deshabndhu College,
University of Delhi,
New Delhi, INDIA
E-Mail: mansingh50@hotmail.com