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A CALIBRATION TECHNIQUE FOR A MERCURY GLASS THERMOMETER USING A PLATINUM RESISTANCE THERMOMETER

Anwar Ejaz Beg

Department of Pharmaceutics, Faculty of Pharmacy, University of Karachi

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A technique to calibrate a mercury glass thermometer and a thermostated bath (viscometry bath) using a Platinum Resistance Thermometer and a Stabaumatic Potentiometer, has been developed. The method is based on the measurement of potential difference across the thermometer at a particular temperature under a known current supplied from a standard resistor. The study was carried out over the nominal temperature range 25-35^{o}C. A plot between Hg/Glass temperature against bath temperature was a straight line showing a good linear co-relation over the temperature range studied.

INTRODUCTION

There are many factors in physico-chemical and biological studies which are markedly affected by temperature. A 10K rise in temperature, for instance, frequently increases the rate constant by between 50% and 300% [1]. The viscosity of a liquid usually decreases with rise in temperature. The amount of such a decrease is often of the order of 1 to 10% per ^{o}C [2]. Moreover, surfactant-drug interaction studies reveal that the effects of temperature changes on the critical micelle concentration (CMC) of a surfactant are so small that the best obtainable precision for CMC measurements is required to determine differences for quantitative purposes. The CMC-temperature curve for ionic surfactants generally shows a minimum. At lower temperatures (generally at 30^{o} or below) the CMC decreases with increasing temperature, which is probably due to desolvation of parts of the monomers which make it more hydrophobic. Minimum values range between 25-30^{o} for n-dodecyltrimethyl ammonium bromide and sodium dodecylsulphate are apparent in CMC temperature plots [3,4].

The spherical shape of ionic micelles is determined by the repulsion between the charges and their radius by the hydrocarbon chain length and the bulkiness of the polar end groups; their size is therefore not very dependent on the temperature in contrast to non-ionic surfactants where the repulsion between the non-ionic end groups is governed mainly by the binding of water, which is highly temperature-dependent [5, 6]. Where temperature effects are observed with concentrated surface active agents the micelle size decreases with increase in temperature [7] which may be attributed to thermal agitation.

Thus, such studies need very accurate temperature measurement. However, mercury glass thermometers and thermostated baths used in such studies may not be accurate to high precision. This paper therefore describes a method to calibrate the both using Platinum Resistance Thermometer and a Stabaumatic Potentiometer.

EXPERIMENTAL

A mercury glass thermometers range 10-35^{o} graduated at intervals of 0.1^{o} was calibrated against a NPL Certificated Platinum Resistance Thermometer which was reproducible to ± 0.001^{o}.

The equipment used is shown diagramatically in Fig. 1. The mercury glass thermometer was fixed to the Platinum thermometer and both immersed in the water bath (in this case viscometry bath) going to be used in actual experiment. The thermometer reading and resistance were monitored over a 7 hours period. The bath temperature is obtained from NPL certified 'tables' of resistance ratio, W, covering the temperature range −183 to 630^{o}. The resistance ratio W_t at any temperature t is the ratio of the thermometer resistance (R_t) at temperature t^{o} to that at 0^{o} (R_o)

$$W = \frac{R_t}{R_o}$$

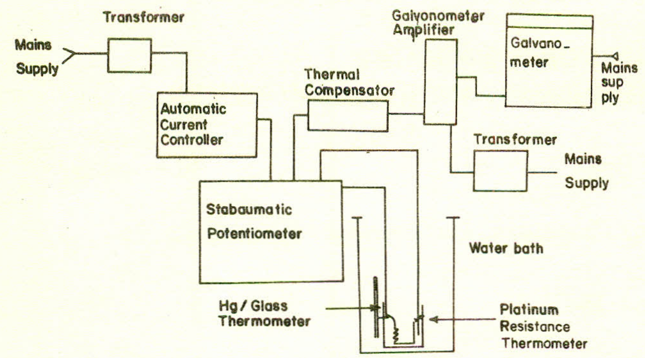

Fig. 1. Block diagram of platinum resistance thermometer and potentiometer circuit.

The value of R_0 is a certified thermometer constant, in this case 24.6252 ohms and the value of R_t is obtained by measuring the potential difference across the thermometer (E_t) under a known current I, supplied from a standard cell. 'I' is obtained by measuring the potential difference across a standard resistor (E_{Rs}). (R_s = 999.997 ± 0.0005 ohms at 20.5^0) when in circuit with the standard cell:

$$I = \frac{E_{Rs}}{R_s} = \frac{E_t}{R_t}$$

The calculated value of the resistance ratio W_t is then compared to the tabulated values, interpolating between tabulated values to obtain the correct temperature as shown below:

$$W_t = 1.1190725$$

From calibration tables W (t^{o}) Difference

1.11 27.7092
1.12 30.2399 2.5307

1.12 – 1.1190725 = 0.0009275

$$\therefore\ t^o = 30.2399 - 2.5307 \times 0.09275$$
$$= 30.2399 - 0.2347224$$
$$= 30.005^o$$

DISCUSSION

Table 1 shows a typical set of results at a nominal temperature of 25^{o}. The bath shows a temperature fluctuation of 0.013^{o} over the 7 hour period. The mean reading is 24.851^{o} with a coefficient of variation (0.02%). The mean thermometer reading is 25.140^{o} with a coefficient of variation (0.08%), showing the thermometer has a +ve deviation of 0.289.

Table 1. Platinum thermometer resistance data – nominal bath temperature 25^{o}.

Time (in mins)	Std. cell Setting	Pot. std. res. (ER)	Pot. Pt. therm. Et	I = ER/R	Rt = Et/I	W = Rt/Ro	Bath temperature	NPL thermometer reading
0	638	1.000210	0.0270601	0.0010002	27.054689	1.0986675	24.840	25.10
15	637	1.000206	0.0270618	0.0010002	27.056388	1.0987365	24.860	25.10
30	637	1.000211	0.0270606	0.0010002	27.055188	1.0986878	24.850	25.15
45	637	1.000212	0.0270608	0.0010002	27.055388	1.0986959	24.850	25.15
60	637	1.000225	0.0270606	0.0010002	27.055188	1.0986878	24.850	25.10
75	647	1.000225	0.0270613	0.0010002	27.055888	1.0987073	24.853	25.15
90	648	1.000226	0.0270613	0.0010002	27.055888	1.0987073	24.853	25.15
105	645	1.000199	0.0270613	0.0010002	27.055888	1.0987073	24.853	25.15
120	648	1.000201	0.0270613	0.0010002	27.055888	1.0987073	24.853	25.15
180	642	1.000200	0.0270612	0.0010002	27.055788	1.0987032	24.852	25.15
240	642	1.000201	0.0270607	0.0010002	27.055288	1.0986829	24.847	25.15
300	644	1.000199	0.0270604	0.0010002	27.054989	1.0986708	24.844	25.15
360	642	1.000202	0.0270611	0.0010002	27.055688	1.0986992	24.851	25.15
420	644	1.000202	0.0270612	0.0010002	27.055788	1.987032	24.852	25.15

Table 2. Mean values of the thermostatic bath temperature and Hg/glass thermometer readings over a period of 7 hours

Mean resistance thermometer temp. (Bath temperature) T_R °C	Standard deviation	Mean Hg/glass temperature T_{Hg} °C	Standard deviation	Deviation of Hg/glass thermometer
24.851	0.0049	25.140	0.0220	+0.289
25.929	0.0044	26.240	0.0048	+0.311
30.000	0.0110	30.250	0.0100	+0.250
35.000	0.0120	35.250	0.0000	+0.250

Table 2 shows the mean readings obtained over the nominal temperature range 25-35°. This data is plotted in Fig. 2 which shows there is a good linear co-relation over this range.

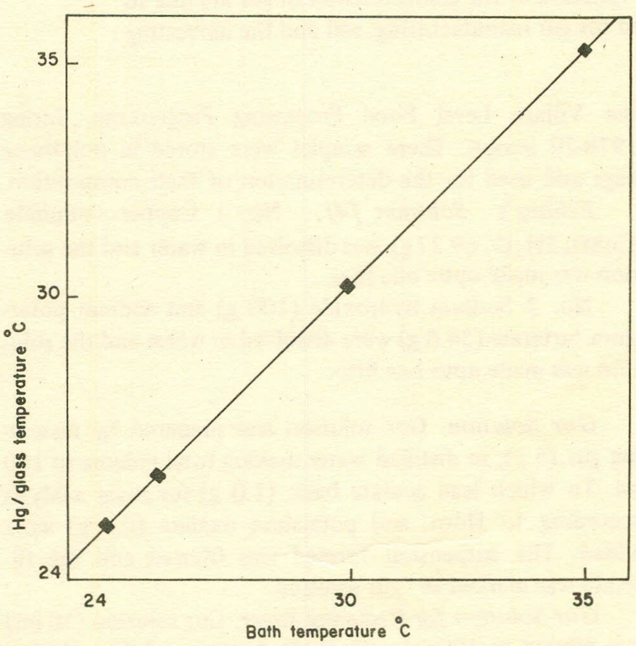

Fig. 2. Plot of Hg/Glass temperature versus bath temperature.

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