Viscosity and Density of Mercury-Thallium Amalgams

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Viscosity and density values of mercury-thallium amalgams have been determined as a function of thallium concentration and temperature. Values were obtained for thallium concentrations from 0 to 40 weight % at 25°, 50°, and 80° C.

THE AUTHORS HAVE REPORTED (*6*) the surface tension values of mercury-thallium amalgams at 25° C. They have also determined the viscosities and densities of these amalgams at 25°, 50°, and 80° C. There is excellent agreement between the results of this report and the previous work of Foley *et al.* (*3*).

EXPERIMENTAL PROCEDURE

The viscometer used was a modified Ostwald type with a specially designed fill apparatus. A calculation of Reynolds numbers showed that the flow rates in the capillary were well below the turbulent region. The entire viscometer apparatus could be evacuated and flushed with hydrogen prior to the introduction of an amalgam through the fill spout. This viscometer was filled using the fill apparatus shown in Figure 1, which also served as a pycnometer and delivered a constant volume of amalgam to the viscometer.

Mercury of the highest purity was used. The purification procedure (*5*) consists of oxidation and chemical treatment followed by distillation. The thallium metal was obtained from the Cerro de Pasco Sales Corp., New York, N. Y., and was specified to be 99.999% pure.

The mercury-thallium amalgams were prepared and stored under water to minimize surface oxidation. Since the oxide (Tl_2O) is soluble in water, no interfering oxide film could form on the amalgam surface. The thallium was weighed under water, and a calculated quantity of mercury was added to form an amalgam of the desired concentration.

The general procedure for filling the viscometer was as follows: The fill apparatus, *B*, was weighed, evacuated, and then flushed with hydrogen to eliminate all traces of oxygen. With the hydrogen flowing, the amalgam reservoir, *C*, was attached to the fill apparatus, which was placed in a water bath thermostated at 25°, 50°, or 80° C. After the amalgam reached the desired temperature, *B* was filled with amalgam by applying a partial vacuum on the upper end. Because the amalgams and mercury do not wet glass, the reservoir was filled about a quarter of an inch past the mark. When hydrogen was again introduced, the level fell to the mark. With the two stopcocks on the main stem closed, all amalgam below the lower stopcock was removed.

After a second weighing for the density determination, the fill apparatus was then placed on the fill spout, *D*, of the viscometer. The viscometer was flushed with hydrogen through the side arm, *E*, of the fill apparatus and evacuated. After turning the appropriate stopcocks, the amalgam from the fill apparatus was allowed to flow into the viscometer. By using the pressurized expansion bulb, *F*, the amalgam could be forced into the upper reservoir, *G*, of the viscometer, after which the pressure in the two arms of the viscometer was equalized as measured by manometer *H*. The viscometer was held at all times in a constant-temperature bath thermostated to within ±0.05° C. of the desired temperature.

Viscosity values were calculated from the Poisseuille equation corrected for kinetic energy loss (*1, 7*)

$$\eta = \frac{\pi a^4 h \rho g t}{8LV} - \frac{m \rho V}{8 \pi L t}$$

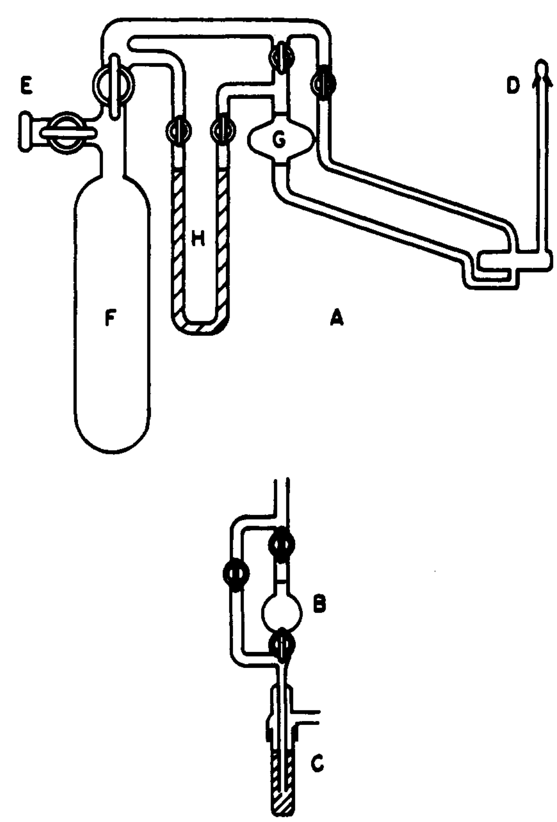

Figure 1. Viscometer and fill apparatus

A. Viscometer
B. Fill apparatus (enlarged). To be attached to viscometer with inner tube fitting inside fill spout at *D*. Ŧ10/18
C. Amalgam reservoir (enlarged)
D. Fill spout
E. Side arm
F. Expansion bulb
G. Upper reservoir
H. Manometer

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Table I. Densities and Viscosities of Mercury-Thallium Amalgams

% Thallium	25° C. Density,[a] g./cc.	25° C. Viscosity, cp.	50° C. Density, g./cc.	50° C. Viscosity, cp.	80° C. Density, g./cc.	80° C. Viscosity, cp.
0	13.534	1.526	13.473	1.450	13.400	1.306
2	13.490	1.640	13.428	1.501	13.359	1.400
4	13.443	1.743	13.389	1.591	13.316	1.467
6	13.405	1.859	13.344	1.700	13.272	1.545
8.5	13.353	2.053	13.296	1.825	13.222	1.648
11	13.305	2.163	13.249	1.925	13.175	1.735
13	13.258	2.316	13.202	2.045	13.135	1.830
15	13.222	2.430	13.164	2.151	13.088	1.911
25	13.021	3.170	12.962	2.715	12.898	2.351
40	12.727	4.683	12.674	3.780	12.612	3.098

[a] (6).

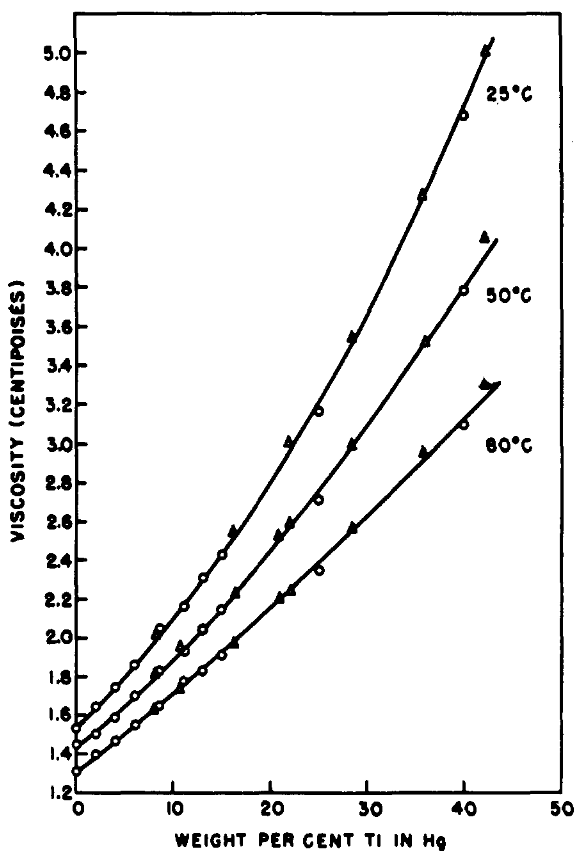

Figure 2. Relation of viscosity to weight per cent of thallium in mercury

○ Data from this study
△ Data from (3)

All the quantities in this equation could be obtained from the geometry of the equipment or from the density determinations, with the exception of factor m. Various investigators have proposed values ranging from over 1.0 to 0. Cannon *et al.* (*2*) state that m is a function of the Reynolds number. Wellman *et al.* (*7*) more recently considered the results of previous investigations, and concluded from their own work that m is constant for Reynolds numbers between 50 and 1500 but must be determined for each viscometer. Calibration with mercury using interpolated literature values (*4*) (1.525 centipoises at 25° C.) gave a value of 0.62 for m. This value should also be applicable at higher temperatures (*7*).

RESULTS

Table I summarizes the viscosity and density values obtained for mercury-thallium amalgams at 25°, 50°, and 80° C. Figure 2 summarizes in graphical form the results of this work and that of Foley *et al.* (*3*). Deviations from the smooth curves are for the most part no more than ±0.02 centipoise. In this work the authors estimated the maximum experimental error to be ±0.1%, due chiefly to errors in temperature, time, and fill measurements. Foley *et al.* (*3*) suggest that the literature values for the viscosity of mercury are accurate to ±0.3%. The over-all accuracy would be ±0.4%, which is comparable to the ±0.5% estimated by Foley *et al.* Thus, the deviations of ±0.02 centipoise for the curves of Figure 2 are reasonable.

NOMENCLATURE

a = capillary radius, cm.
g = gravitational constant, cm./sec.
h = average mean fluid head, cm.
L = length of capillary, cm.
m = dimensionless factor
t = time to transfer liquid volume V, sec.
V = volume of liquid transferred, cc.
η = viscosity, g./cm. sec.; poises
ρ = density, g./cc.

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