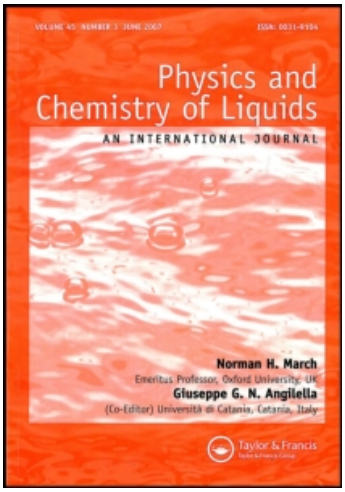

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HgTl AMALGAM AT 40% At. Tl: EUTECTIC AT 1°C

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By means of a toroidal oscillating viscometer logarithmic decrements of dampings have been measured in presence or absence of HgTl amalgam at 40 atomic percent tallium at different temperatures, ranging from −2°C to +15.625°C, with fluctuations every 0.25°C. Measurements were performed in two different periods (1: 31/07/1990–21/12/1990 and 2: 05/01/1991–09/05/1991). In both periods, the eutectic was found at 1.125°C.

KEY WORDS: Phase diagram, viscometer damping, eutectic.

INTRODUCTION

In previous papers (1, 2, 3) the HgTl amalgam was investigated at various atomic percentages. The HgTl amalgam at 40% at. Tl raised some interest about its melting process.

In the present paper we focused on the logarithmic decrements of a viscometer dampings, in the presence or absence of this amalgam at different temperatures, from −2°C to +15.625°C. Measurements were performed in two different periods: the first from 31/07/1990 to 21/12/1990, the latter from 05/01/1991 to 09/05/1991.

EXPERIMENTAL APPARATUS

The toroidal oscillating viscometer used in the present investigation was the same as employed in References 1, 2, 3.

EXPERIMENTAL RESULTS

The viscometer dampings in presence or absence (δ and δ_0, respectively) of HgTl amalgam at 40% at. Tl have been measured at different temperatures, ranging from −2°C to +15.625°C, with fluctuations every 0.25°C and in two different periods (1: 31/07/1990–21/12/1990 and 2: 05/01/1991–09/05/1991).

Experimental results are plotted in Figures 1, 2 and 3.

Figure 4 shows the phase diagram.

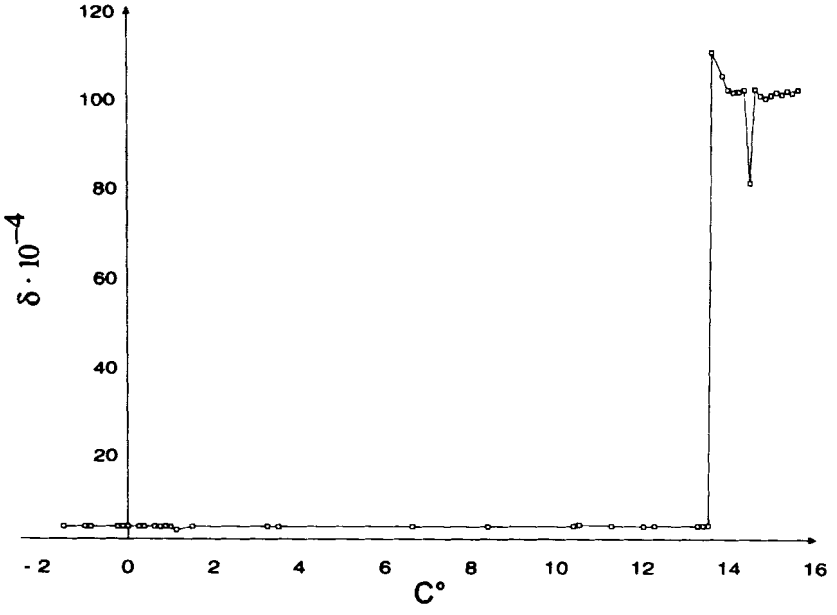

Figure 1 Logarithmic decrements of dampings of the viscometer containing the HgTl amalgam at 40% at. Tl versus temperature (−2°C to +15.625°C) in period 1 (31/07/1990–21/12/1990).

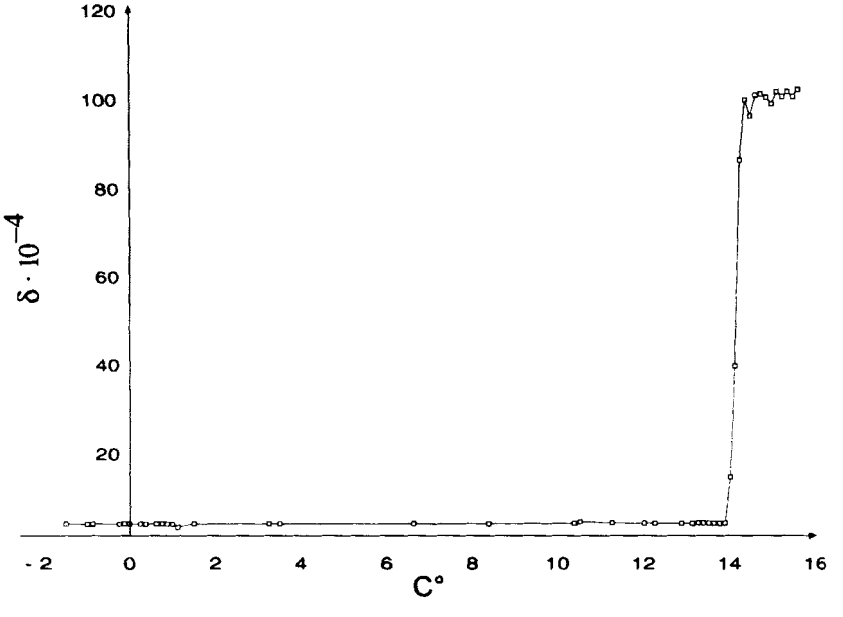

Figure 2 Logarithmic decrements of dampings of the viscometer containing the HgTl amalgam at 40% at. Tl versus temperature (−2°C to +15.625°C) in period 2 (05/01/1991–09/05/1991).

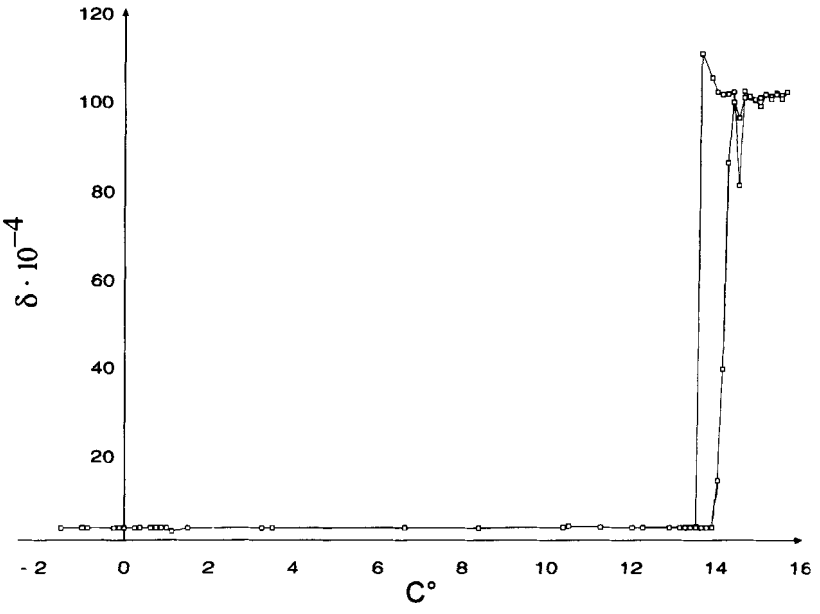

Figure 3 Logarithmic decrements of dampings of the viscometer containing the HgTl amalgam at 40% at. Tl versus temperature (−2°C to +15.625°C) in period 1 (31/07/1990–21/12/1990) and 2 (05/01/1991–09/05/1991).

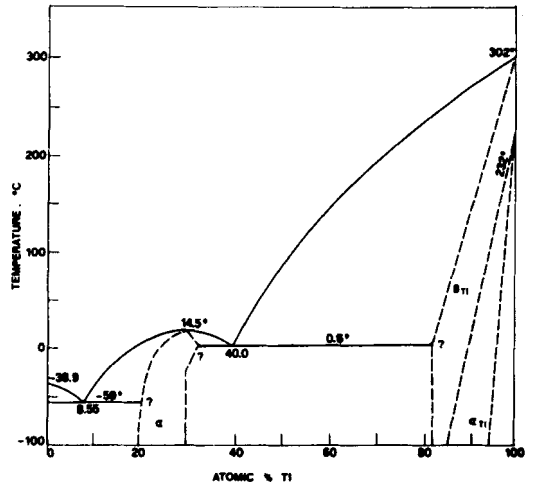

Figure 4 Phase diagram.

DISCUSSION OF EXPERIMENTAL RESULTS

The melting process of the HgTl amalgam at 40% at. Tl occurs gradually, as the temperature-dependent variations show in Figures 1 and 2. At the temperature of 1.125°C we obtained $\delta_1 = 2.747093 \cdot 10^{-4}$, $\delta_{01} = 2.460750 \cdot 10^{-4}$ (Figure 1) and

$\delta_2 = 2.747143 \cdot 10^{-4}$, $\delta_{02} \equiv \delta_{01} = 2.460750 \cdot 10^{-4}$ (Figure 2). We may conclude that at this temperature the amalgam is completely solid and this is the eutectic temperature. The value of the eutectic is perfectly coincident in the two periods. These results are in accord to theoretical values (T^*;δ^*) obtained from Ref. 4. In fact, from Ref. 4:

$$T^* = \frac{\pi T_0 I}{\sqrt{I_0[I(\pi^2 + \delta_0^2 T_0)] - \delta_0 I_0)}} \tag{1}$$

$$\delta^* = \frac{\delta_0 I_0 T}{I T_0} \tag{2}$$

where I_0 = the total moment of inertia of the system without the amalgam; $I = I_0 + 2\pi^2 R^3 a^2 [1 + 3/4(a^2/R^2)]$; a, R and ρ have the same values as in Ref. 2; T and T_0 are the period of the system with and without the amalgam, respectively. Introducing experimental values obtained at the temperature of 1.125°C in formula (1), it derives:

$$\delta_1^* = 2.458624 \cdot 10^{-4}$$

$$\delta_2^* = 2.459 \cdot 10^{-4}$$

The differences between experimental and theoretical values of δ relevant to the two periods at the above temperature are:

$$\Delta\delta_1 = (2.747093 - 2.458624) \cdot 10^{-4} = 0.288469 \cdot 10^{-4} = 0.3 \cdot 10^{-4}$$

$$\Delta\delta_2 = (2.747143 - 2.459) \cdot 10^{-4} = 0.288143 \cdot 10^{-4} = 0.3 \cdot 10^{-4}$$

It follows that at the temperature of 1.125°C the amalgam is completely solid. The eutectic reaction consists of the simultaneous solidification of two solid phases from a single liquid solution. The type of free energy diagram usually constructed to represent the simplest binary eutectic phase diagram is obtained by assuming random mixing in the liquid of the two types of atoms present, and the free energy of the liquid at the eutectic temperature is then drawn as a smooth curve. For an ideal liquid, the free energy curve is symmetrical to the center point; for a non-ideal liquid the curve need not be symmetrical. The free energy curves of the solids are usually drawn with a fairly sharp curvature. The eutectic composition is then given as the composition at which the common tangent to the three curves touches the free energy curve of the liquid. With regard to the HgTl amalgam at 40% at. Tl, we found the eutectic at 1.125°C $\approx$ 1°C. As shown in the phase diagram, the eutectic temperature for this amalgam is reportedly 0.6°C $\approx$ 1°C, thus being coincident with our findings. When increasing the temperature from 13.5°C to 14.5°C, the logarithmic decrement relevant to the two periods is substantially identical, but is reached in a different way. In the first period (31/07/1990–21/12/1990) the transition to the liquid state is more rapid, with maximum and minimum being at closer values of temperature (maximum: temperature = 13.25°C;

$\delta \cdot 10^{-4} = 109.4898$; minimum: temperature = 14.5°C; $\delta \cdot 10^{-4} = 80.0688$). In the latter (05/01/1991–09/05/1991) such transition occurs more gradually (maximum: temperature = 14.375°C; $\delta \cdot 10^{-4} = 98.6735$; minimum: temperature = 14.5°C; $\delta \cdot 10^{-4} = 95.0499$).

On the other hand, the liquid state is coincident for the two periods. Our data indicate that measurements of the logarithmic decrement as a function of temperature are highly repeatable (Figure 3).

SUMMARY

The logarithmic decrement of the dampings of an oscillating viscometer in presence or absence (δ and δ_0, respectively) of the HgTl amalgam at 40% at. Tl have been investigated at different temperatures, ranging from −2°C to +15.625°C and in two different periods (31/07/1990–21/12/1990 and 05/01/1991–09/05/1991). We found that the HgTl amalgam at 40% at. Tl is completely solid at the temperature of 1.125°C, with $\delta = 2.7447093 \cdot 10^{-4}$ and $\delta_0 = 2.460750 \cdot 10^{-4}$ in the two different periods. The liquid state was coincident as well.

Acknowledgement

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