Self-diffusion of Tin in a liquid Tin-Lead alloy at the Eutectic Composition

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By the shear cell technique, the self-diffusion coefficient (D_{Sn}) of tin in a liquid Sn−38.1 wt% Pb alloy has been measured in the temperature range 466 to 786 K. The slope of the D_{Sn} vs. T curve decreases up to about 573 K, where it gets constant. This behaviour may be explained by the cluster hypothesis.

A shear cell, as first used by Nachtrieb [1, 2] for liquid metals (Hg, Ga), has been employed. It was made of graphite to avoid bubble formation and chemical reactions and for ease of handling. The cell consisted of ten disks, mounted coaxially; each one was 0.5 cm thick, with three off center capillary holes of 1 mm diameter.

Before a diffusion experiment was begun, the capillaries of the two last disks – which contained the Sn radiotracer – were misaligned with respect to the others. The run was started by aligning the holes, and finished by rotating each disk so as to section the liquid thread. By measuring the specific activity in each capillary section the diffusion profile was obtained.

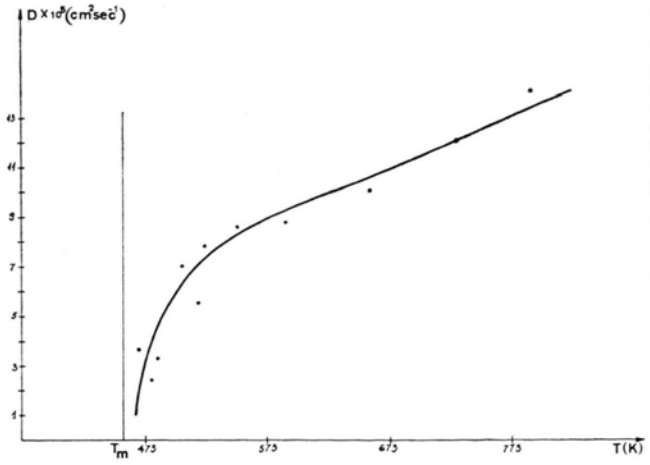

Fig. 1. Self-diffusion coefficient of tin in the liquid Sn−Pb eutectic alloy as a function of temperature.

The solution of Fick's equation with the boundary conditions $\partial c/\partial x = 0$ for $x = 0$, L and the starting condition $c = c_0$ for $0 < x < h$ and $c = 0$ for $h < x < L$ is given e. g. in [3]. In our case $h = 1$ cm, $L = 5$ cm. The solution of this problem has been tabulated by Stefan and Kawalki [4].

The radiotracer was Sn^{113} (half-life 112 days). Tin and lead were 4 N purity. All the operations were performed under Argon (1 atm) with previous degassing under 10^{-4} mm Hg. The temperature was controlled with a P.I.D. thermoregulator and measured with chromel-alumel thermocouples. A small positive temperature gradient ($\leqq 0.2$ K/cm) avoided convective effects (thermodiffusion was considered negligible).

The filling of the capillaries was made by plunging the disks into the respective liquids and forcing the liquids to enter the capillaries by means of pressurized Argon (2 – 3 atm). The results are shown in Figure 1.

Measurements of the viscosity as a function of temperature [5, 6] in liquid Sn – 38.1 wt% Pb (eutectic composition) show a soft change in slope near 623 K. Taking into account Ubbelhode's theory [7], Kumar [8] explains this behaviour as due to the presence of clusters (pseudo-molecules) in the liquid. This hypothesis may also explain our findings. Between T_{melting} and 573 K, relatively small changes in temperature produce dissociation of the clusters and the diffusion flow is largely increased. Above 573 K the liquid is "monomeric" and the variation of the self-diffusion coefficient with temperature is smaller.

Acknowledgments

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