ELECTRICAL CONDUCTIVITY AND DENSITY OF MOLTEN SALTS AT ELEVATED TEMPERATURES AND VAPOR PRESSURES

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By now, a great deal of experimental data has been accumulated on the electrical conductivity and density of molten salts [1]. However, most of this data was obtained for relatively narrow (100–200 K) temperature ranges near the melting points of the salts due to the great experimental difficulties of conducting measurements at high temperatures and/or high vapor pressures. We measured the specific electrical conductivity of a number of salts: $BeCl_2$, $ZnCl_2$, $SnCl_2$, $PbCl_2$, $CdCl_2$, $InCl_3$, $TeCl_4$, $ZrCl_4$, $HfCl_4$, etc. at elevated temperatures and vapor pressures of up to several tens of atmospheres using an original quartz cell (see, for example, [2, 3]). To calculate the molar electrical conductivity of these molten salts, data on their density is required, which is not available for the high-temperature region. Density data are also of independent interest for the development and proper organization of many high-temperature processes.

We have developed a technique for extrapolating the available data on melt density, obtained experimentally at low temperatures, to a wide temperature range in which the density changes nonlinearly. For long-range extrapolation of melt density, we have proposed using the Racket equation [4, 5]:

$$d = A \cdot B^{-(1-T/T_{cr.})^{2/7}}, \qquad (1)$$

here d is the density of the molten salt; A, B are constants; T is the temperature, K; $T_{cr.}$ is the critical temperature, K.

The reliability of the extrapolation using this equation was tested for melts of several individual salts for which density data are available at both low and high temperatures, in particular for estimating the density of molten $BiCl_3$ (Fig. 1). The maximum difference from experimental data in this case reaches ±3% (near the critical temperature, 1178 K). At $T < 1070$ K the discrepancy becomes less than 1%, which does not exceed the experimental accuracy of density determination.

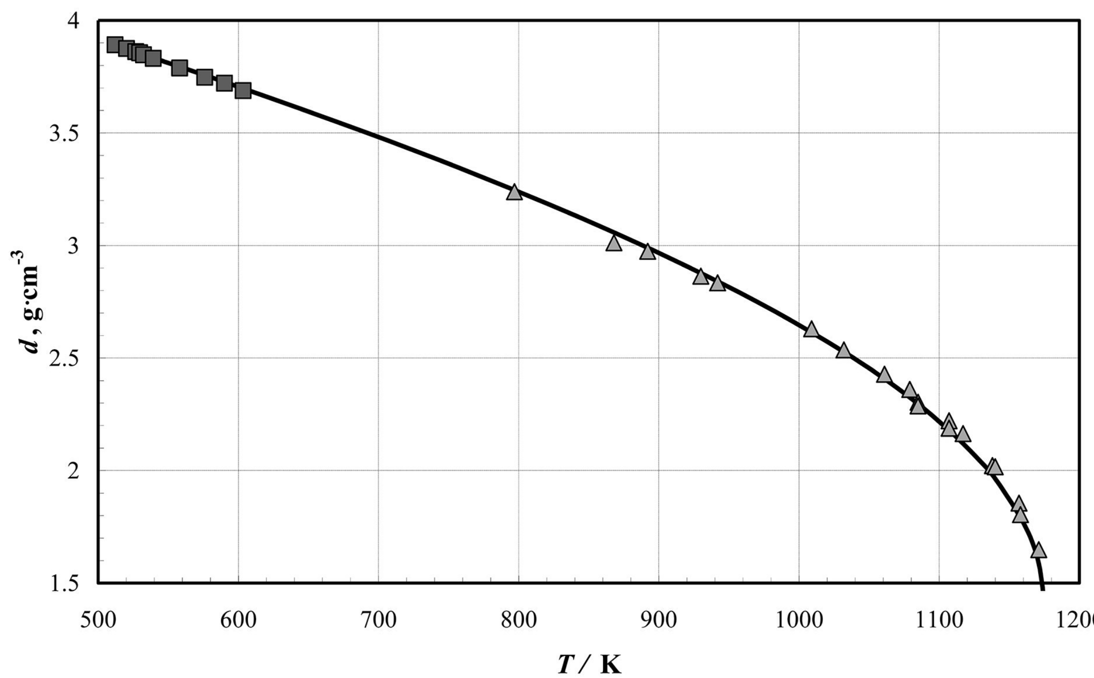

Fig. 1. Density of molten $BiCl_3$.

Line – extrapolation of $BiCl_3$ density data measured at low temperatures to the high temperature region, up to the critical point. ■ – experimental points of Keneshea et al., ▲ – Johnson et al.; ─── extrapolation.

To calculate A and B coefficients in the Racket equation (1) using our method, only two known values of the salt melt density in the low-temperature region are sufficient. Extrapolation using equation (1) allows us to estimate the melt density at temperatures up to the critical temperature. The $T_{cr.}$ values can be taken, for example, from reference books [5, 6]. For salts with unknown values of critical temperatures, various methods for their estimation are considered.

We have obtained equations for estimating the density of salt melts with a fairly high accuracy (error less than 1–3%) in wide temperature ranges exceeding the boiling point of the salt, and even higher – up to the critical point. For example:

$$d\left(InCl_3\right)=0.69936\cdot 0.200^{-(1-T/1195)^{2/7}},\ \text{g}\cdot\text{cm}^{-3},$$

$$d\left(PbCl_2\right)=1.3234\cdot 0.22102^{-(1-T/2058)^{2/7}},\ \text{g}\cdot\text{cm}^{-3},$$

$$d\left(ZnCl_2\right)=1.180874\cdot 0.423464^{-(1-T/1690)^{2/7}},\ \text{g}\cdot\text{cm}^{-3},$$

Conclusions. The molar conductivity of a number of molten salts was calculated in a wide temperature range $(T_m - T_{cr.})$. The Rackett equation was used to estimate their density.

References

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