BULLETIN OF THE CHEMICAL SOCIETY OF JAPAN, VOL. 44, 3207 (1971)

An Empirical Formula for the Optimum Concentration for Hydrothermal Precipitation

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(Received July 6, 1971)

By means of visual autoclaving, *viz.*, visual studies on autoclaving processes with sealed glass tubes, we can easily observe the relation between the concentration of electrolyte solution and the temperature at which onset of turbidity takes place in the solution. It was found that if we plot temperature *vs.* concentration, we obtain a curve concave upward. This means that the incipient stage of hydrothermal precipitation takes place most easily at a certain concentration,[1,2] or that there is an optimum concentration for hydrothermal precipitation.

A simple formula fitting the curve can be obtained if we utilize the distance between solute particles as a unit of concentration. For this purpose let us take the case in which 6.02×10^{23} (Avogadro's number) particles are distributed in equal distance of 12 Å in a 1 *l* volume. The distance corresponds to 1 M solution.

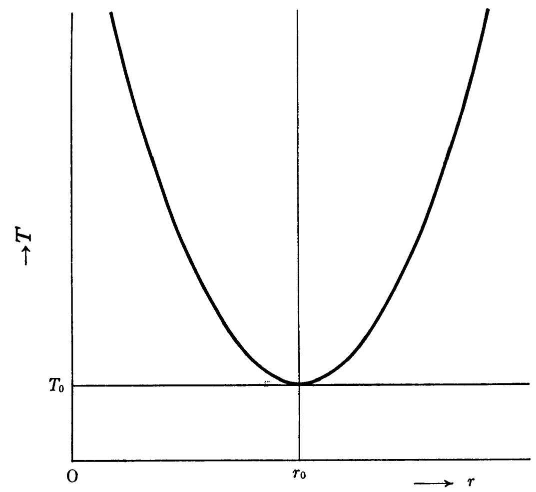

Fig. 1. Relation between inter-solute distance (concentration) and the temperature at which onset of turbidity takes place.

In the usual hydrothermal experiments, concentration is given in terms of mol per liter. The relation between the molar concentration c and the corresponding distance r is given by

$$r = \frac{12}{\sqrt[3]{c}}. \tag{1}$$

By means of this relation, we find that the data of visual autoclaving can be represented by

$$T = T_0 + \alpha(r - r_0)^2, \tag{2}$$

where T = temperature at which onset of turbidity takes place,
T_0 = the lowest temperature at which onset of turbidity takes place,
r = distance between solute particles,
r_0 = the value of r corresponding to T_0,
α = constant.

This is the equation of a parabola with its apex at (r_0, T_0) as shown in Fig. 1. For the sake of illustration, examples are given for aqueous solutions of some compounds.

Compound	T_0 in °C	r_0 in Å	α in Å^{-2}
$AlCl_3$	166	72	0.028
$Ce(NH_4)_2 \cdot (NO_3)_6$	107	35	0.069
$ThCl_4$	158	48	0.028
$Th(NO_3)_4$	151	54	0.028

So far there seems to be no theory on hydrothermal precipitation to afford an explicit formula for the relation between r and T. In the meantime, Eq. (2) might be utilized for its simplicity for grasping the process of hydrothermal precipitation.

1) T. Katsurai, *Kolloid-Z.*, **170**, 57 (1960).
2) R. G. Robins, *J. Inorg. Nucl. Chem.*, **29**, 431 (1967).