# Density and Viscosity of Concentrated Aqueous Solutions of Potassium Hypochlorite

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This paper reports the densities and viscosities of concentrated aqueous solutions of potassium hypochlorite containing low concentrations of chloride and chlorate impurities. It also reports solubility results for the system KOCl + $H_2O$ in the essential absence of impurities.

## 1. Introduction

Hypochlorite salts are an industrially important class of oxidizers, sanitizers, and bleaches. Recent advances in the technology of manufature of hypochlorous acid have allowed the preparation of highly concentrated solutions of metal hypochlorites which have a much higher degree of purity than previously available solutions (*1*, *2*). Physical property data for aqueous solutions of potassium hypochlorite have not been previously reported. In this paper, the solubility of potassium hypochlorite is given as a function of temperature and concentration over the range 0–58 mass % KOCl in water, with an impurity level not exceeding 2.5 mass % KCl and 1.5 mass % $KClO_3$. Viscosities of aqueous solutions of KOCl are given over the temperature range 0–20 °C and the concentration range 20–40 mass %. Densities are given over the same temperature range for concentrations up to 58 mass % KOCl.

## 2. Apparatus and Procedures

***2.1. Solubility of KOCl as a Function of Temperature.*** Solutions of KOCl in water were analyzed iodometrically for hypochlorite and chlorate ion concentrations and argentometrically for chloride ion concentration. The solutions were placed in a constant-temperature bath which was controlled to a temperature at least 20 °C below the anticipated freezing point. The temperatures of the solutions were measured as a function of time and cooling curves plotted to obtain the temperature for the initial crystallization and the eutectic temperature. Separation and analysis of the solid phase were done for solutions containing a solid phase involving the hypochlorite moiety. Duplicate crystallizations were conducted on several solutions. Replicate crystallizations agreed to with 0.2 °C.

***2.2. Viscosities.*** Viscosities were measured using a calibrated Cannon-Ubbelohde Semi-Micro dilution viscometer immersed in a constant-temperature bath controlled to ±1 °C. The viscosity of deionized water was measured at two temperatures to serve as a check on the calibration. The error for the viscosity measurements for water was 0.009 mPa·s at both temperatures. All measurements were done in quadruplicate. The precision of the measurements for the potassium hypochlorite solutions is given in Table 2.

***2.3. Densities.*** Density measurements were made using a Class A 25 mL pipet calibrated with deionized water. Tempertures were controlled to ±1 °C. All measurements were done in triplicate. The precision of the measurements for the potassium hypochlorite solutions is given in Table 3.

**Table 1. Freezing Temperatures $t$ for KOCl + $H_2O$ for Mass Fraction $w$ of KOCl**

| $100w$ | $t$/°C | $100w$ | $t$/°C |
|---|---|---|---|
| 10.2 | −5 | 41.1 | −34 |
| 15.0 | −9 | 44.2 | −30 |
| 20.4 | −13.5 | 49.3 | −24 |
| 25.0 | −19 | 55.0 | −21 |
| 30.7 | −28 | 58.7 | −20 |
| 35.0 | −38.5 | | |

**Table 2. Viscosities of Aqueous Solutions of KOCl (1) + KCl (2) + KOH (3) + $KClO_3$ (4) + $H_2O$ (5)**

| $100w_1$ | $100w_2$ | $100w_3$ | $100w_4$ | $t$/°C | $\eta$/(mPa·s) | $\sigma$/(mPa·s) |
|---|---|---|---|---|---|---|
| *a* | | | | 0 | 1.789 | 0.089 |
| 40.8 | 1.51 | 1.24 | 0.85 | 0 | 4.390 | 0.124 |
| 30.2 | 1.11 | 0.92 | 0.63 | 0 | 3.000 | 0.022 |
| 19.9 | 0.73 | 0.61 | 0.42 | 0 | 2.337 | 0.009 |
| *a* | | | | 20 | 1.010 | 0.007 |
| 40.8 | 1.51 | 1.24 | 0.85 | 20 | 2.055 | 0.018 |
| 30.2 | 1.11 | 0.92 | 0.63 | 20 | 1.419 | 0.003 |
| 19.9 | 0.73 | 0.61 | 0.42 | 20 | 1.230 | 0.012 |

[a] Water standard.

**Table 3. Densities of Aqueous Solutions of KOCl (1) + KCl (2) + KOH (3) + $KClO_3$ (4) + $H_2O$ (5)**

| $100w_1$ | $100w_2$ | $100w_3$ | $100w_4$ | $t$/°C | $\varrho$/(g·cm$^{-3}$) | $\sigma$/(g·cm$^{-3}$) |
|---|---|---|---|---|---|---|
| 58.5 | 2.48 | 2.76 | 0.90 | 0 | 1.582 | 0.002 |
| | | | | 10 | 1.578 | <0.001 |
| | | | | 20 | 1.556 | 0.001 |
| 49.3 | 1.94 | 1.60 | 0.61 | 0 | 1.486 | 0.001 |
| | | | | 10 | 1.483 | 0.001 |
| | | | | 20 | 1.476 | 0.001 |
| 41.1 | 1.59 | 3.22 | 0.48 | 0 | 1.400 | 0.001 |
| | | | | 10 | 1.396 | 0.001 |
| | | | | 20 | 1.392 | 0.001 |
| 40.8 | 1.51 | 1.24 | 0.85 | 0 | 1.376 | 0.001 |
| 30.7 | 0.95 | 2.17 | 0.95 | 0 | 1.283 | <0.001 |
| | | | | 10 | 1.279 | 0.001 |
| | | | | 20 | 1.275 | <0.001 |
| 30.2 | 1.11 | 0.92 | 0.63 | 0 | 1.277 | 0.002 |
| | | | | 20 | 1.273 | 0.001 |
| 20.4 | 0.89 | 1.30 | 0.28 | 0 | 1.179 | <0.001 |
| | | | | 10 | 1.174 | <0.001 |
| | | | | 20 | 1.176 | <0.001 |
| 19.9 | 0.73 | 0.61 | 0.42 | 0 | 1.173 | 0.001 |
| | | | | 20 | 1.169 | 0.001 |
| 10.2 | 0.56 | 0.27 | 0.21 | 0 | 1.087 | <0.001 |
| | | | | 10 | 1.085 | <0.001 |
| | | | | 20 | 1.083 | <0.001 |

## 3. Source of Materials

KOCl solutions were prepared by the reaction of KOH solutions with concentrated solutions of HOCl. All solutions were analyzed as described above. Replicate analyses

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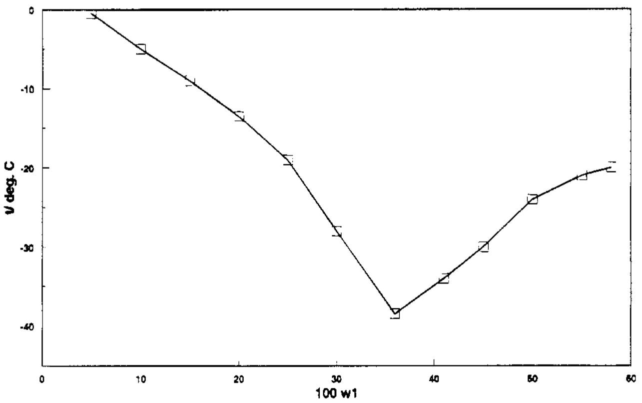


**Figure 1.** Freezing temperatures $t$ for KOCl (1) + water (2) as a function of mass fraction $w$.

of solutions resulted in standard deviations of 0.03 mass % potassium hypochlorite and 0.1 mass % in all other components.

## 4. Results and Discussion

Table 1 lists the results of the cooling curve analyses for the various solutions. The temperature given is the first inflection point. In all cases where solid analyses were conducted, the concentrations of non-hypochlorite salts were below 2 mass %. The solubility as a function of temperature is given in Figure 1.

Table 2 lists the measured viscosities, and Table 3 gives the measured densities. The experimental densities were regressed against temperature and mass fraction $w$ of KOCl where $w$ = (mass % KOCl)/100. Equation 1 fits all results to within 1.5%.

$$\varrho/(\mathrm{g{\cdot}cm^{-3}}) = 0.9686 - 3.69 \times 10^{-4}(t/°\mathrm{C}) + 1.04w \quad (1)$$

## Literature Cited

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Received for review April 6, 1994. Accepted June 17, 1994.[⊗]

[⊗] Abstract published in *Advance ACS Abstracts*, September 1, 1994.