Densities and Viscosities of Potassium Hydroxide Solutions at Low Temperatures

W. R. KELLY, P. F. BORZA, and R. D. HARRIGER
Solvay Process Division, Allied Chemical Corp., Syracuse, N. Y.

The densities and viscosities of aqueous solutions of potassium hydroxide were measured in the concentration range of 0 to 49%, at 0° C. and down to temperatures a little above the points of incipient crystallization.

THE viscosity of aqueous solutions of potassium hydroxide is important in fluid flow, heat transmission, and gas absorption. Knowledge of this property above zero (0° C.) has been supplied by Hitchcock and McIlhenny (*3*), Faust (*2*), and others (*4*). Viscosity data of potassium hydroxide solutions are also needed for alkaline storage batteries which could operate well below ordinary temperatures.

EXPERIMENTAL

KOH Solutions. The potassium hydroxide solutions were made with degassed, deionized water having a specific conductance of 0.52×10^{-6} ohms^{-1} cm.$^{-1}$. The KOH pellets used were of reagent grade quality meeting specifications of the American Chemical Society.

The aqueous solutions of various concentrations were analyzed for total alkalinity as K_2O and for CO_2 expressed as K_2CO_3. The K_2CO_3 contents of these solutions ranged from 0.02 to 0.15%. With reference to densities and viscosities given in Table I, total alkalinity is expressed as % KOH and corresponding molalities are given.

The solutions were kept in polyethylene bottles, rather than glass, to minimize contamination. Transfers to viscometers and pycnometers were made quickly to exclude carbon dioxide.

Viscometers. The Cannon-Fenske viscometers used were those made and furnished with a certificate of calibration by the Cannon Instrument Co. in accordance with Standard Test ASTM D445-61, Appendix A. They were cleaned with warm chromic acid solution, rinsed with tap water, rinsed three times with distilled water, twice with ethanol, twice with ethyl ether, then warm-dried.

The constants, *K*, of the four viscometers used in this work were determined by extrapolation to the various temperatures.

Two sources of error were considered negligible in this work. One is the effect of aqueous KOH on glass, which is slight at these low temperatures. The other is the possible difference of 0.1 cm. per sec.^{2} in the gravitational constant at the authors' site and that of the Cannon Instrument Co.

Temperature. Temperatures were measured with toluol-filled thermometers graduated in 0.2° C. divisions, readable to 0.1° C. and less. They were calibrated at operating depths

Table I. Viscosities and Densities of Potassium Hydroxide Solutions at Low Temperatures, in the Range of 0 to 49% KOH

Total Alkalinity As KOH		Temperature		Densities in Air, d_a, Grams per Ml.	Corrected Efflux Time, θ, Sec.	Viscosities, *Z*	
%	Molality, *m*	° C.	$1/T \times 10^4$, $T =$ ° K.			Cp.	Log *Z*
0.00		0.0	36.6	0.9998			
10.04	1.99	0.0	36.6	1.0969	457.0	2.097	0.3216
		−5.5	37.4	1.0979	547.1	2.509	0.3995
20.01	4.46	0.0	36.6	1.1955	541.8	2.710	0.4330
		−14.1	38.6	1.1959	364.6	4.499	0.6531
		−22.4	39.9	1.1966	492.9	6.134	0.7877
25.19	6.00	0.0	36.6	1.2480	259.0	3.307	0.5194
		−14.1	38.6	1.2508	422.0	5.449	0.7363
		−30.1	41.1	1.2542	222.1	10.39	1.0166
		−36.1	42.2	1.2554	311.2	14.58	1.1638
31.53	8.21	0.0	36.6	1.3147	327.8	4.409	0.6443
		−14.1	38.6	1.3180	554.5	7.542	0.8775
		−28.9	40.9	1.3213	287.0	14.14	1.1505
		−40.9	43.1	1.3240	198.5	27.71	1.4426
		−50.9	45.0	1.3262	424.7	59.41	1.7739
		−53.8	45.6	1.3270	575.0	80.53	1.9060
35.43	9.78	0.0	36.6	1.3560	397.6	5.515	0.7416
		−14.1	38.6	1.3577	190.4	9.626	0.9835
		−30.1	41.1	1.3598	144.2	20.66	1.3151
		−45.5	43.9	1.3619	455.3	65.38	1.8154
40.10	11.93	0.0	36.6	1.4088	520.5	7.502	0.8752
		−14.1	38.6	1.4093	266.8	14.00	1.1461
		−25.0	40.3	1.4104	161.8	24.02	1.3806
		−30.1	41.1	1.4109	225.1	33.46	1.5245
		−34.4	41.9	1.4113	309.5	46.02	1.6630
45.72	15.01	0.0	36.6	1.4737	228.2	12.51	1.0973
		−14.1	38.6	1.4858	169.9	26.55	1.4241
		−30.1	41.1	1.4939	489.9	77.07	1.8869
48.98	17.11	0.0	36.6	1.5131	316.6	17.82	1.2509

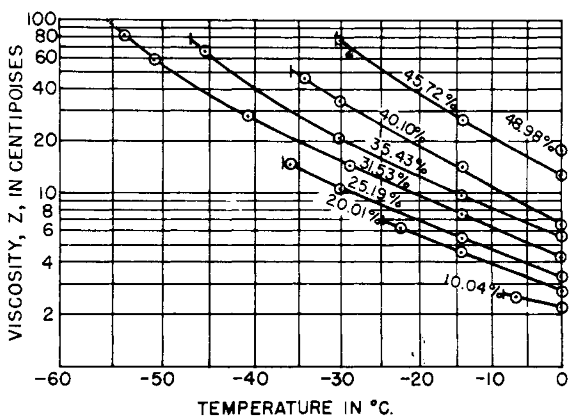

Figure 1. Viscosities of various concentrations of aqueous potassium hydroxide solutions plotted vs. low temperatures, ° C.

using the melting point of pure water and the freezing points of high purity spectrograde carbon tetrachloride (–22.9° C.), monochlorobenzene (–45.2° C.), and chloroform (–63.5° C.).

Densities, or viscosities, were measured while the pycnometer, or viscometer, was all but submerged in the cold methanol test bath. The bath methanol was kept cold by circulating chilled methanol through a submerged helical section of copper tubing in a controlled manner. The recirculated methanol was cooled by a mixture of dry-ice and acetone. The temperature of the test bath could be maintained constant within 0.1° C. or better.

Time. Time of efflux was measured with a stopwatch having a full sweep of pointer in seconds, and marked in 0.1-sec. divisions, readable to 0.05 sec.

The stopwatch, checked at room temperature against a chronometer, was consistently slow by 0.1%, including the human response.

At least four measurements were taken in determining time of efflux.

Density. These measurements were carried out at the various low temperatures using a boiled-water-calibrated glass pycnometer shaped like a volumetric flask of about 37 ml. capacity. The neck of the flask was of 1-mm. bore, 13 cm. long, and ending in a ground tapered male joint. To its tapered female joint, serving as a liquid expansion reservoir, was attached a short 1-mm. bore tube having a miniature stopcock.

Weighings were made on an analytical balance, using weights newly calibrated against those of the Bureau of Standards.

RESULTS

The viscosities and densities of the KOH solutions are given in Table I along with concentrations expressed in terms of molality as well as % KOH by weight. Viscosities were calculated from the data after the manner of Hitchcock and McIlhenny (*3*).

Figure 1 shows the viscosities (*Z*) in centipoises plotted against temperature in degrees centigrade.

Except for the 31.53% KOH curve, the "limits" of these curves correspond to temperatures of incipient crystallization as supplied by Pickering (*5*) and Cohen-Adad and Michaud (*1*).

The precision of the foregoing measurements is estimated as 0.1% for analysis, 0.01% for density, 0.05% for time of efflux, and 0.1% for the constant, *K*.

Relation of Viscosity Data to Data of Others. To get a measure of the over-all accuracy of this present work, a set of graphs was made from viscosity (and density) data at the low temperatures and the best data of others at higher temperatures.

That results at the low temperatures are consistent with those at higher temperatures has been established by the smooth curvilinear transitions in viscosities from the lower to the higher temperatures. For these graphs which plot viscosity against concentration of KOH, the particular values of concentration selected were smoothed values (up to 60° C.) at 10, 20, 25, and 40% KOH, obtained from Solvay's Technical and Engineering Bulletin (*6*), crediting reference (*3*). These smoothed concentrations most closely approximated the values 10.04, 20.01, 25.19, and 40.11% KOH taken from Table I for the check on accuracy.

LITERATURE CITED

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Vapor Pressure of Liquid Metal Solutions: Mercury-Lead

LEON E. WALLWEY[1] and LUH C. TAO
Department of Chemical Engineering, University of Nebraska, Lincoln, Neb.

THE PRESENT study is a continuation of experimental work on a binary system containing mercury and tin (*7*). The apparatus and operation have been discussed previously (*7, 8*). Vapor pressure data of mercury-lead are available at 324° C. (*3*), and this work extends these data to other temperature regions.

EXPERIMENTAL

The vapor pressure still was constructed of a 1½-inch diameter, 304 stainless steel pipe. The liquid metal in the still had a depth of 0.5 to 1.0 cm. Helium was used to transmit the vapor-phase pressure to a mercury manometer the interface of which was about 8 inches above the liquid level in the still. This difference of levels decreases with an increase of the pressure in the still so that its effect on

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[1] Present address: Dow Chemical Company, Midland, Mich.