

FINAL REPORT

**THERMOPHYSICAL PROPERTY DATA FOR
LITHIUM BROMIDE/WATER SOLUTIONS
AT ELEVATED TEMPERATURES**

PREPARED FOR

**THE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND
AIR-CONDITIONING ENGINEERS**

UNDER PROJECT 526-RP

SUPERVISED BY

**TECHNICAL COMMITTEE 8.3
(ABSORPTION AND HEAT OPERATED MACHINES)**

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INTRODUCTION

Aqueous lithium bromide (LiBr) solutions and similar mixtures have long been used in absorption refrigeration. Accurate thermophysical data including thermodynamic and transport data are needed for adequate design analysis and evaluations of such systems. In the past, much of available thermophysical property data had been based on proprietary data or on the results of measurements that had not been fully disclosed or described. To alleviate this shortcoming, Technical Committee 8.3 initiated a project for the measurement of the following properties:

1. Thermal Conductivity
2. Density
3. Kinematic Viscosity
4. Liquid Specific Heat
5. Vapor Pressure

The Georgia Institute of Technology was selected as the contractor on this project. With assistance and forbearance from the sponsoring Technical Committee, the required measurements and data reduction and analysis are now (nearly) complete. This report represents the completion of the project.

Important accomplishments of this project include the following:

1. The development and successful operation of a fused quartz thermal conductivity cell using a liquid metal thermometric fluid suitable for implementing the hot wire thermal conductivity measurement in an electrically conductive fluid.
2. The demonstration of a high pressure capillary viscometer system successfully used for measurements of the viscosity of a volatile fluid at elevated temperature.
3. Successful demonstration of an innovative static vapor pressure measurement system using water as the pressure transmitting fluid which is capable of highly accurate measurements of the pressure of water vapor above water solutions with non-volatile solutes.
4. Successful application of classical drop calorimetry with design improvements in temperature measurement and environmental control.

Details of the experimental procedures and designs are given in the following sections along with raw data and correlations.

The entire research team expresses its gratitude for the opportunity to be involved in this challenging and worthwhile project.

Thermal Conductivity of Lithium Bromide and Water Solutions

Abstract

The thermal conductivity of lithium bromide and water solutions was measured over the temperature range 20 ° - 190 °C using a modified hot wire technique. Solutions containing 30.2, 44.3, 49.1, 56.3, 60.0, 62.9, and 64.9 wt % lithium bromide were studied and comparisons were made with reported data on aqueous lithium bromide solutions at lower temperatures. The data were correlated as a function of temperature and weight percent lithium bromide with an average deviation of 0.6%. The accuracy of the measurements was estimated to be $\pm 2\%$.

1 Introduction

The design of refrigeration and heat pump systems which use aqueous lithium bromide solutions requires accurate thermal conductivity data. Most literature data, however, are limited to low temperature and low concentrations of lithium bromide. The objectives of this work were therefore to measure lithium bromide solutions at high temperatures and concentrations of lithium bromide.

The most accurate technique for the measurement of the thermal conductivity of liquids is the transient hot wire method [1] in which a thin wire immersed in the liquid is electrically heated. The temperature rise of the wire is used to determine the thermal conductivity of the liquid. Electrically conducting solutions can be measured with this technique if the wire is electrically insulated from the liquid under study. The insulation blocks current paths through the liquid which would interfere with the small voltages which must be measured. However, the addition of an insulating layer to the wire has proved difficult to achieve in practice, especially at higher temperatures. In 1981, Nagasaka and Nagashima [2] successfully insulated a platinum wire with a polyester coating and reported measurements up to 150 °C. In 1982, Alloush et al. [3] used a tantalum filament coated with a layer of tantalum oxide to obtain data on LiBr solutions at temperatures up to 80 °C. Recently Nagashima et al. [4] used the tantalum - tantalum oxide filament to make measurements on LiBr solutions up to 100 °C. However, they noted that the oxide coating failed to insulate the wire properly above 100 °C. This limitation was confirmed by our own efforts to use the tantalum - tantalum oxide filament at temperatures above 100 °C as shown in Figure 1 where the thermal conductivity of water as measured with a tantalum wire is plotted as a function of temperature. Above 100 °C, deviation from the ESDU [5] recommended values occurs. The probable reasons for failure are the cracks that develop in the insulation due

to the unequal expansion coefficients of the base metal and the oxide and the decrease in dielectric strength with temperature of the oxide. Both effects might permit current paths into the liquid and allow polarization of the fluid near the wire. A different technique was pioneered by Nagashima et al. [6,7] in 1981 and 1982. This technique uses a fine glass capillary filled with liquid mercury instead of the insulated wire. The apparatus was used to measure the thermal conductivity of molten salts up to 300 °C. The accuracy of these measurements was verified by Le Neindre et al. [8] using a coaxial cylinder method to measure the thermal conductivities of some of the same systems. Since the liquid metal technique has been validated at the temperatures of interest in this study, it was adopted in this work. Measurements were made in the range of concentration from 30 % to 65 wt % LiBr and of temperature between 20 °C to 190 °C.

2 Apparatus and Procedure

The transient hot wire apparatus employed in this work is shown in Figure 2. The major components of the apparatus are a Wheatstone bridge, a power supply, and a data acquisition system.

The Wheatstone bridge consists of two $100 \pm 0.01 \Omega$ precision resistors, a resistance decade box (General Radio Model 1433 U) with a range of 0 - 111.11 Ω , and a hot wire cell. The hot wire cell was constructed of quartz and is shown in Figure 3. The cell is in the shape of a U tube with one leg consisting of a quartz capillary tube (13.6 cm long, 0.05 mm ID, 0.08 mm OD) and the other a larger bore quartz tube (2 mm ID by 4 mm OD). The open end of the U tube is supported with a piece of machinable ceramic. The connection between the larger tube and the capillary tube is achieved by drawing down the larger tubing and sealing the capillary tubing into place with silicone rubber (General

Electric RTV-106). Originally, it was intended to use liquid gallium to fill the U tube. Liquid gallium has the advantages of low toxicity and very low vapor pressures. However, the reactivity of gallium with water vapor at high temperatures forced the choice of mercury as the liquid metal. The entire U tube was filled with liquid mercury with the thread of mercury in the capillary tube serving as the hot wire. A small piece of tungsten wire was inserted into the liquid mercury at each end of the open U-tube to serve as electrodes. The tungsten wires were, in turn, connected to copper wires which attached to the bridge. The cell itself was placed in a glass sleeve with ceramic supports at the top and bottom of the U-tube to ensure that the U-tube remained centered in the sleeve. The sleeve was then placed inside a pressure vessel. A 0.0625 in Type E thermocouple was inserted through both ceramic supports along the axis of the larger bore tube. The bridge was powered by a precision power supply (Hewlett-Packard Model 6213A) which served as a constant voltage source. The supply was used both to balance the bridge and provide the voltage for heating. A lab quality multimeter (Fluke Model 8840A) was used to indicate a balanced condition in the bridge. A data acquisition system consisting of an IBM PC XT with a 16 bit analog to digital converter card (Strawberry Tree ACPC-16) was used to read both the offset voltage and the applied voltage.

The test fluid was loaded into the glass sleeve and the sleeve inserted into a stainless steel pressure vessel. The quartz cell was then lowered into the glass sleeve and the pressure vessel sealed. The apparatus was then placed in a fluidized sand bath (Techne Model SBL-2D) which maintained the temperature to ± 0.1 °K. The sample was pressurized to 15 bar with nitrogen to prevent boiling during measurement. A Type E thermocouple, calibrated against a PRT (Leeds and Northup SN 709892), was used to determine the stability of the bath and the sample equilibrium temperatures. After temperature equilibrium had been

achieved, the air flow to the sand bath was stopped to prevent any vibration of the cell during measurement.

The procedure for each measurement was as follows. The bridge was first balanced and the computer program started. The program initiated a step input to the bridge using an electromechanical relay (Magnecraft W172DIP-1). The relay settled in less than 0.3 ms. The program sampled the offset voltage on one channel, then switched channels to sample the applied voltage to insure its constancy. The time between any two samples was 0.0084 s and that between two successive readings of the same channel was 0.0168 s. The delay between the closing of the relay and the first sampling was found to be 0.0132 s using an oscilloscope. Two hundred points were measured during each run and the experiment lasted about 3.4 seconds. From a previous calibration of the temperature versus resistance, the temperature of the wire was found. A plot of ΔT versus \ln time was made and the slope in the time interval from 0.7 to 2.2 s was calculated using a least squares fit as described in the analysis section. The applied voltage was varied from about 2.5 to 3.5 V so that a more or less constant temperature rise in the quartz capillary surface of about 1.7 °K was achieved. This resulted in offset voltages on the order of 5 mV. The A/D card has 16 bit resolution and the ± 25 mV range was used. Thus the card is capable of 0.08 μ V resolution.

3 Source and Purity of Materials

Anhydrous lithium bromide was obtained from Morton Thiokol Inc. (Lots F06H, L02F, and H26G). The minimum stated purity of the sample was 99 wt% LiBr. Distilled water was used to prepare the solutions. Solutions were first prepared gravimetrically based on weight percent LiBr. To ensure that no change in the composition of a solution occurred during the measurement procedure, samples of each composition were taken before and

after measurement and checked by titration. Titration was done with silver nitrate using a computer aided titrimeter (Fisher, Controller Model 450, Buret Model 400, Stirrer Model 460). The compositions reported are the averages of two measurements. No variation in composition during the measurement procedure was observed.

4 Analysis

The model for the experiment is an infinite line source of heat submersed in an infinite fluid medium. By monitoring the temperature response of the wire to a step voltage input, the thermal conductivity of the fluid can be deduced. For an infinite line source of heat in an infinite fluid medium, the ideal temperature rise of the wire can be calculated using an expression derived by Carslaw and Jaeger [9] and Healy et al. [10] for $t \gg \frac{r_w^2}{4\alpha}$. The inequality is satisfied shortly after heating is started, that is, for $10 \text{ ms} < t < 100 \text{ ms}$. The expression is:

$$\Delta T_{id} = \frac{q}{4\pi\lambda} \ln \left(\frac{4\lambda t}{r_w^2 \rho C_p C} \right) \quad (1)$$

where q is the heat dissipation per unit length, λ is the thermal conductivity, ρ the density, C_p the heat capacity, r_w the radius of the filament and C is equal to $\exp(\gamma)$ where γ is Euler's constant. If it is assumed that all physical properties are independent of temperature over the small range of temperature considered (ca. 1.7 °K), then,

$$\lambda = \frac{q}{4\pi \left(\frac{d\Delta T_{id}}{d \ln t} \right)} \quad (2)$$

where $\frac{d\Delta T_{id}}{d \ln t}$ is found experimentally from a plot of ΔT_{id} vs $\ln t$.

Healy et al. [10] also derived several corrections for the deviation of the model from reality. These may be written as:

$$\Delta T_{id} = \Delta T_w(t) + \sum_i \delta T_i \quad (3)$$

δT_1 accounts for the finite physical properties of the wire (liquid mercury) and is given by [9]:

$$\delta T_1 = \frac{r_w^2 [(\rho C_p)_w - (\rho C_p)]}{2\lambda t} \Delta T_{id} - \frac{q}{4\pi\lambda} \frac{r_w^2}{4\alpha t} \left(2 - \frac{\alpha}{\alpha_w} \right) \quad (4)$$

where $(\rho C_p)_w$ is the volumetric heat capacity of the liquid mercury and α and α_w are the thermal diffusivity of the fluid and mercury respectively.

The correction due to the finite extent of the fluid is given by [10]:

$$\delta T_2 = \frac{q}{4\pi\lambda} \left(\ln \frac{4\alpha t}{b^2 C} + \sum_{\nu=1}^{\infty} \exp^{-g_\nu^2 \alpha t / b^2} [\pi Y_0(g_\nu)]^2 \right) \quad (5)$$

where b is the inside diameter of the cell, Y_0 is the zero order Bessel function of the second kind and g_ν are the roots of J_0 , the zero order Bessel function of the first kind. Although the first several roots are readily available, the higher roots can be found to sufficient accuracy from [11]:

$$g_\nu = (\pi\nu - \pi/4) + \frac{1}{8(\pi\nu - \pi/4)} - \frac{31}{385(\pi\nu - \pi/4)^3} + \frac{3779}{15366(\pi\nu - \pi/4)^5} \quad (6)$$

Values of Y_0 were calculated using the polynomial approximation given by Abramowitz and Stegun [12].

The effect of the quartz capillary tube on the measurement has been evaluated analytically by Nagasaka and Nagashima [2]. The correction is given by:

$$\delta T_3 = \frac{-q}{4\pi\lambda} \left[\ln \left(\frac{r_w}{r_l} \right)^2 + \frac{2\lambda}{\lambda_l} \ln \frac{r_l}{r_w} + \frac{\lambda}{\lambda_l} + A \right] \quad (7)$$

with :

$$\begin{aligned} A &= \frac{1}{t} (C0 + B \ln t) \\ C0 &= C1 + C2 + B \ln \left(\frac{4\alpha}{r_l^2 C} \right) \\ C1 &= \frac{r_w^2}{8} \left[\left(\frac{\lambda - \lambda_l}{\lambda_w} \right) \left(\frac{1}{\alpha_w} - \frac{1}{\alpha_l} \right) + \frac{4}{\alpha_l} - \frac{2}{\alpha_w} \right] \end{aligned}$$

$$C2 = \frac{r_l^2}{2} \left(\frac{1}{\alpha} - \frac{1}{\alpha_l} \right) + \frac{r_w^2}{\lambda_l} \left(\frac{\lambda_l}{\alpha_l} - \frac{\lambda_w}{\alpha_w} \right) \ln \left(\frac{r_l}{r_w} \right)$$

$$B = \frac{r_w^2}{2\lambda} \left(\frac{\lambda_l}{\alpha_l} - \frac{\lambda_w}{\alpha_w} \right) + \frac{r_l^2}{2\lambda} \left(\frac{\lambda}{\alpha} - \frac{\lambda_w}{\alpha_w} \right)$$

where r_l, α_l, λ_l are the radius, thermal diffusivity, and thermal conductivity of the quartz capillary.

Radiation by the fluid can be accounted for using an analytical expression for the temperature rise of the mercury thread given by Wakeham et al. [13] :

$$\Delta T = \frac{q}{4\pi\lambda} \left(1 + \frac{Br_w^2}{4\alpha} \right) \ln \frac{4\alpha t}{r_w^2 C} + \frac{Bqr_w^2}{16\pi\alpha\lambda} - \frac{Bqt}{4\pi\lambda} \quad (8)$$

where B is the radiation parameter and is a measure of the contribution of radiant emission by the fluid to the heat transfer process. From equation (8) Wakeham et al. [13] derived the following expression for the correction to the observed temperature rise:

$$\delta T_4 = \frac{-qB}{4\pi\lambda} \left(\frac{r_w^2}{4\alpha} \ln \frac{4\alpha t}{r_w^2 C} + \frac{r_w^2}{4\alpha} - t \right) \quad (9)$$

They used equation (8) to show that emission from a fluid causes the ΔT vs $\ln t$ slope to exhibit a slight curvature, concave to the $\ln t$ axis.

ΔT , after correction for the other effects mentioned, can be fit to equation (8) to obtain B as suggested by Wakeham et al. [13]. Equation (9), then can be used to calculate δT_4 . If there is no radiation contribution, B is equal zero and thus there is no danger of biasing the data.

Since both sides of the U tube are made of quartz and the mercury is free to expand, there are no effects due to wire-slackening which must be accounted for in hot wire methods. End effects must, however, still be considered. End effects result mostly from conduction of heat axially away from the mercury thread to the thicker leads. No analytical correction exists for this source of error and it is generally compensated for experimentally using

either potential leads or a long and a short wire [1]. However, liquid mercury has a thermal conductivity only about 10% of that of platinum, which is commonly used in hot wire apparatus. Therefore, any end effects were expected to be small or negligible. This expectation was experimentally verified by the excellent agreement of our data with the IUPAC [14] data for water and with the data of Nagashima et al. [4] for LiBr solutions. Nagashima et al. used a two wire technique to account for end effects.

The actual temperature at which the thermal conductivity is reported is the average temperature of the fluid during the heating process. That is:

$$T_R = T_o + \frac{\Delta T(t_I) + \Delta T(t_F)}{2} \quad (10)$$

where T_o is the temperature of the fluid at the start of a measurement, and t_I and t_F refer to the initial and final times of the data used to find the slope of ΔT vs $\ln t$. ΔT in the case of an insulated wire is given by the temperature at the surface of the insulation adjacent to the liquid. This temperature has been determined by Nagasaka and Nagashima [2] and is given by:

$$\Delta T_i = \frac{q}{4\pi\lambda} \left[\frac{(P3 + P2 + P1)}{t_i} + \ln \left(\frac{4\alpha t_i}{r_l^2 C} \right) \right] \quad (11)$$

with :

$$\begin{aligned} P3 &= \frac{r_w^2}{4} \left(\frac{1}{\alpha_l} - \frac{1}{2\alpha_w} \right) + \frac{r_l^2}{4} \left(\frac{1}{\alpha} - \frac{1}{\alpha_l} \right) \\ P2 &= \frac{r_w^2}{2\lambda_l} \left(\frac{\lambda_l}{\alpha_l} - \frac{\lambda_w}{\alpha_w} \right) \ln \left(\frac{r_l}{r_w} \right) \\ P1 &= \ln \left(\frac{4\alpha t_i}{r_l^2 C} \right) \left[\frac{r_w^2}{2\lambda} \left(\frac{\lambda_l}{\alpha_l} - \frac{\lambda_w}{\alpha_w} \right) + \frac{r_l^2}{2\lambda} \left(\frac{\lambda}{\alpha} - \frac{\lambda_l}{\alpha_l} \right) \right] \end{aligned}$$

where the subscript i refers to t_I or t_F .

In order to apply the temperature corrections, various physical properties are required. The density and heat capacity of mercury were obtained from the CRC handbook [15], and

the thermal conductivity from the compilation of Ho et al. [16], and the electrical resistivity from the work of Williams [17]. The thermal conductivity and the thermal diffusivity of quartz were obtained from a manufacturer's catalog [18]. Finally, the heat capacity and density of lithium bromide solutions were measured in our laboratory.

The radiation parameter B for all fluids measured here was found to be negligible (less than 0.0007). Nevertheless, the correction was uniformly applied for consistency.

5 Results

Water was measured at room temperature to validate the liquid metal capillary technique. The agreement with the IUPAC data was excellent, with deviations between our measurements and IUPAC data being within 0.6%. However, the thermal conductivity of water at higher temperatures could not be measured because the low viscosity of water allowed convection to occur during the heating process. Fortunately, the viscosities of lithium bromide solutions were high enough to prevent the rapid onset of convection. In order to verify the linearity of the ΔT vs $\ln t$ curves, the deviation from the linear fit was checked. Figure 4 shows a plot of the deviation from the fitted line for a typical ΔT vs $\ln t$ curve. The points are evenly scattered so that no bias is evident.

Seven compositions of lithium bromide - water solutions were measured (30.2, 44.3, 49.1, 56.3, 60.0, 62.9, and 64.9 wt% LiBr) in the temperature range from 20 ° to 190 °C. The data are compiled in Table I and are shown graphically in Figure 5. Each data point represents the average of five experimental runs. The maximum deviation from the average value never exceeded 1.0%. Thus the precision of the data is 1.0% and the accuracy is estimated to be $\pm 2.0\%$. Direct comparison of our data with literature data is difficult due to differences in concentrations. Table II is a comparison of the correlation found using only our data

with the data of Nagashima et al. [4], Wakeham et al. [3], Uemura and Hasaba[19], and Riedel [20]. The agreement between our data and Nagashima et al. who claim an accuracy of $\pm 0.5\%$ is excellent. The average deviation on 15 data points is 0.65% and the maximum is 1.8%. Agreement with Uemura and Hasaba is also excellent. The average deviation on 25 data points is 0.63% and the maximum is 1.9%. The single point in our concentration range of Reidel agrees within 1.1%. The data of Wakeham et al. show much larger deviation. The average deviation for 19 points is 2.1% with a maximum deviation of 4.4%. However, Wakeham et al. claimed an accuracy of only $\pm 3.0\%$. Therefore, the overall agreement is within the accuracy of their experiments.

Nagashima et al. [4] measured the thermal conductivity of LiBr solutions at three concentrations (30.3, 46.5, and 56.6 wt % LiBr) at pressures up to 40 MPa. The effect of pressure was found to be small. For example, at 56.6 wt% LiBr and 100 °C, the change in thermal conductivity from .1 MPa to 40 MPa was 1.7%.

6 Correlation

The thermal conductivity of the lithium bromide solutions was correlated with temperature T in ° K and composition X in wt % as follows:

$$\lambda(T, X) = A(T) + B(T)X + C(T)X^2 \quad (12)$$

$$\text{with : } A(T) = a_1 + a_2T + a_3T^2$$

$$B(T) = b_1 + b_2T + b_3T^2$$

$$C(T) = c_1 + c_2T + c_3T^2$$

Values of the constants $a_1, a_2, a_3, b_1, b_2, c_1, c_2, c_3$ were obtained by regression of the data obtained in this work and are given in Table III. The average absolute deviation between correlation and experiment was found to be .6% for 47 data points and the maximum deviation was found to be 1.6%. The fitted curves are shown on Figure 5.

7 Conclusions

The thermal conductivity of aqueous solutions of lithium bromide ranging in composition from 30 to 65 wt % and in temperature from 20 ° to 190 °C were measured. A correlation was developed which was able to fit the data with an average absolute deviation of 0.6% and a maximum deviation of 1.6%. The estimated accuracy ($\pm 2\%$) of the thermal conductivity measurements is supported by comparison with the literature.

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Table I: Thermal Conductivity of LiBr - Water Solutions

Wt% LiBr	T [K]	λ [mW/M K]	Wt% LiBr	T [K]	λ [mW/M K]	
0.0	293.8	602.3	49.1	401.2	513.5	
	296.7	607.6		430.0	522.0	
	323.4	646.0		460.0	523.0	
30.2	292.9	508.1	56.3	294.1	419.0	
	296.9	512.1		329.4	453.5	
	326.1	544.6		362.3	468.4	
	329.1	545.9		397.6	484.2	
	359.5	570.7		430.1	493.5	
	365.0	579.5		461.1	501.6	
	385.2	592.0		60.0	299.6	408.8
	388.9	592.8			329.2	432.9
	404.7	597.5			369.7	457.5
	434.0	591.1			402.5	473.4
44.3	435.7	590.2	62.9	430.8	476.5	
	461.3	573.8		460.6	485.8	
	295.1	467.5		339.8	429.5	
	321.4	495.4		371.0	447.2	
	353.5	521.4		400.4	457.3	
	378.6	535.5		430.7	465.4	
	407.2	550.9		460.9	476.1	
	439.2	557.3		64.9	343.4	421.0
	463.3	553.4			370.5	432.1
	298.0	446.7			400.7	442.0
49.1	328.9	478.1	49.1	428.8	453.0	
	371.6	503.9		461.0	458.2	

Table II: Comparison of this Work with the Literature [P = 1 atm]

T [K]	Wt% LiBr	λ [mW/M K] Literature	Ref.	λ [mW/M K] This Work ¹	Claimed Accuracy [\pm %]	% Dev.
293.8	0.0	599.1	[14]	602.3 ²		0.55
296.7		604.1	[14]	607.6 ²		0.58
323.4		642.6	[14]	646.0 ²		0.52
323	26.04	557	[19]	558.0		0.18
313	26.05	551	[19]	545.5		-1.01
353	26.08	581	[19]	586.7		0.97
303	26.28	426	[19]	530.9		0.82
333	26.52	564	[19]	567.4		0.60
304.2	30.3	527.7	[4]	520.7	0.5	-1.35
313.9		536.0	[4]	533.2	0.5	-0.53
333.9		558.6	[4]	555.3	0.5	-0.60
353.5		575.1	[4]	572.1	0.5	-0.53
373.5		588.5	[4]	584.2	0.5	-0.73
313	34.93	521	[19]	516.8		-0.81
303	35.61	503	[19]	502.6		-0.09
323	35.90	521	[19]	524.4		0.65
293	36.21	492	[19]	487.8		-0.87
333	36.29	533	[19]	532.8		-0.04
343	36.50	547	[19]	540.8		-1.15
353	36.53	538	[19]	548.4		1.89
293	40	471	[20]	476.2		1.08
297.0	41.4	473	[3]	476.5	3.0	0.74
305.0		478	[3]	485.7	3.0	1.58
315.0		484	[3]	496.3	3.0	2.49
335.0		500	[3]	515.1	3.0	2.94
357.0		511	[3]	531.9	3.0	3.93
303	44.84	465	[19]	471.5		1.37
333	44.94	501	[19]	499.5		-0.30
323	44.98	489	[19]	490.6		0.33
313	44.99	486	[19]	481.1		-1.01
353	45.42	509	[19]	512.6		0.71
297.0	45.6	465	[3]	462.4	3.0	-0.56
305.0		467	[3]	470.9	3.0	0.82
315.0		469	[3]	480.8	3.0	2.45
335.0		483	[3]	498.5	3.0	3.10
357.0		499	[3]	514.6	3.0	3.02
293	46.05	459	[19]	456.5		-0.55
302.4	46.5	468.2	[4]	464.9	0.5	-0.70
313.8		477.3	[4]	476.2	0.5	-0.22
333.3		490.8	[4]	493.4	0.5	0.54
353.6		501.4	[4]	508.5	0.5	1.40
373.2		510.9	[4]	520.3	0.5	1.81

¹Values calculated from correlation of our data²Experimental Value (pure water not included in correlation).

Table II: Comparison of this Work with the Literature (Continued)

T [K]	Wt% LiBr	λ [mW/M K] Literature	Ref.	λ [mW/M K] This Work ¹	Claimed Accuracy [\pm %]	% Dev.
297.0	49.7	457	[3]	448.0	3.0	-2.01
305.0		463	[3]	455.8	3.0	-1.57
315.0		464	[3]	465.0	3.0	0.22
335.0		478	[3]	481.6	3.0	0.75
357.0		493	[3]	497.0	3.0	0.80
297.0	53.8	452	[3]	432.9	3.0	-4.40
305.0		457	[3]	440.2	3.0	-3.82
315.0		461	[3]	448.7	3.0	-2.74
335.0		474	[3]	464.2	3.0	-2.11
313	54.25	444	[19]	445.2		0.28
302.8	56.6	428.6	[4]	427.3	0.5	-0.31
313.6		438.0	[4]	436.1	0.5	-0.43
333.5		452.4	[4]	451.0	0.5	-0.32
353.7		464.0	[4]	464.1	0.5	0.01
373.5		473.7	[4]	475.0	0.5	0.27
353	56.61	463	[19]	463.6		0.13
323	56.62	442	[19]	443.3		0.30
293	56.70	416	[19]	418.4		0.57
303	56.71	429	[19]	427.0		-0.46
333	56.75	451	[19]	450.0		-0.23
313	60.35	418	[19]	420.0		0.47

Table III: Constants for Correlation

Constant	Value
a_1	-1407.5255
a_2	11.051253
a_3	$-1.4674147 \times 10^{-2}$
b_1	38.985550
b_2	-0.24047484
b_3	3.4807273×10^{-4}
c_1	-0.26502516
c_2	1.5191536×10^{-3}
c_3	$-2.3226242 \times 10^{-6}$

WATER MEASURED WITH TANTALUM CELL

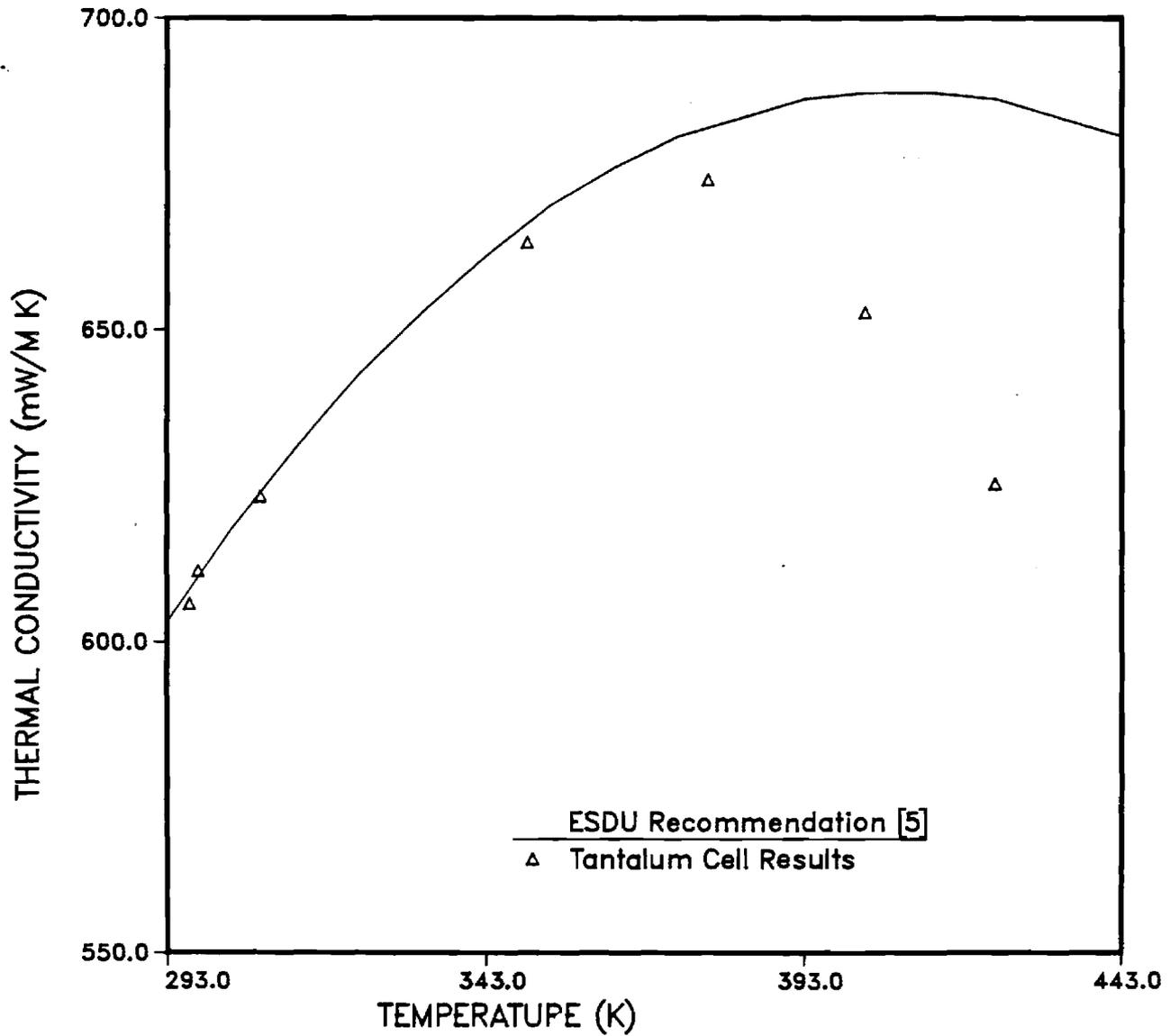


Figure 1: Thermal conductivity of water measured with a tantalum filament insulated with tantalum oxide. The oxide coating fails to insulate above 100 °C.

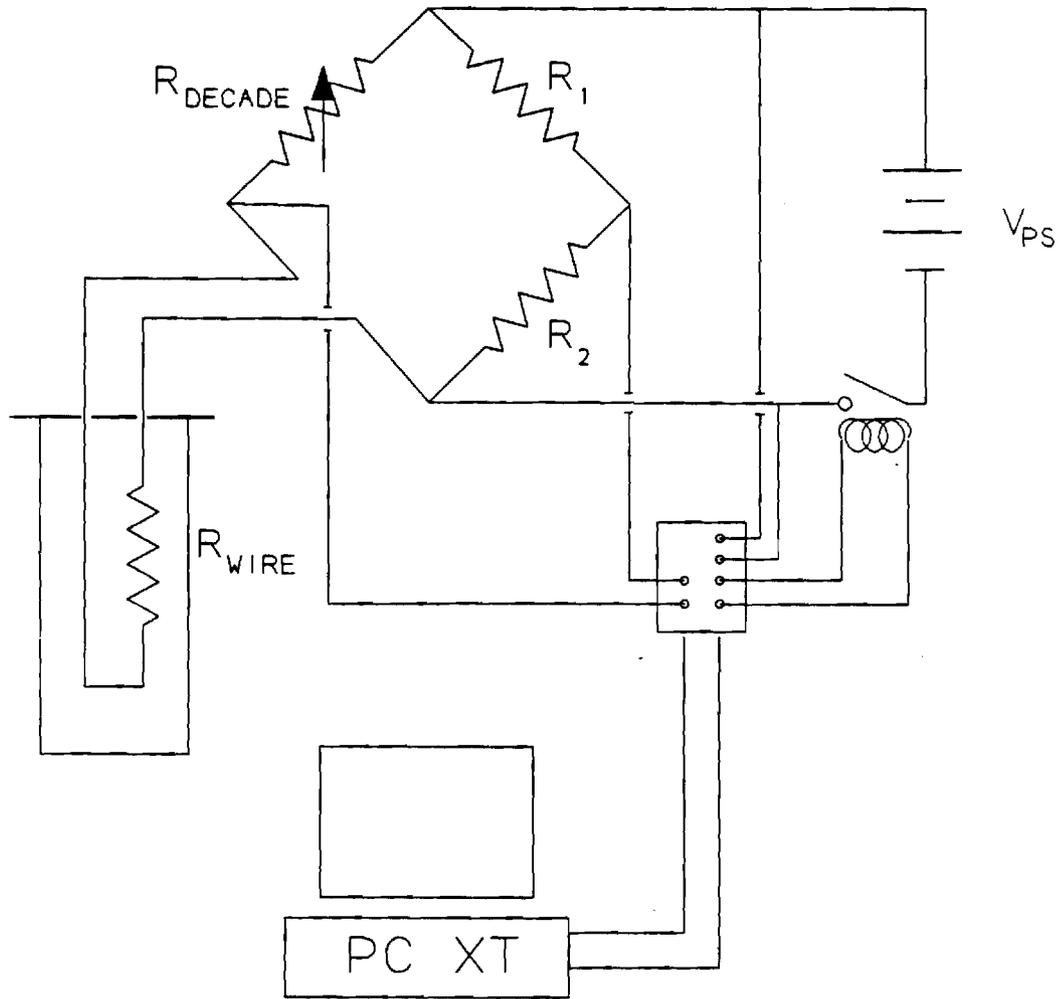


Figure 2: Schematic diagram of apparatus.

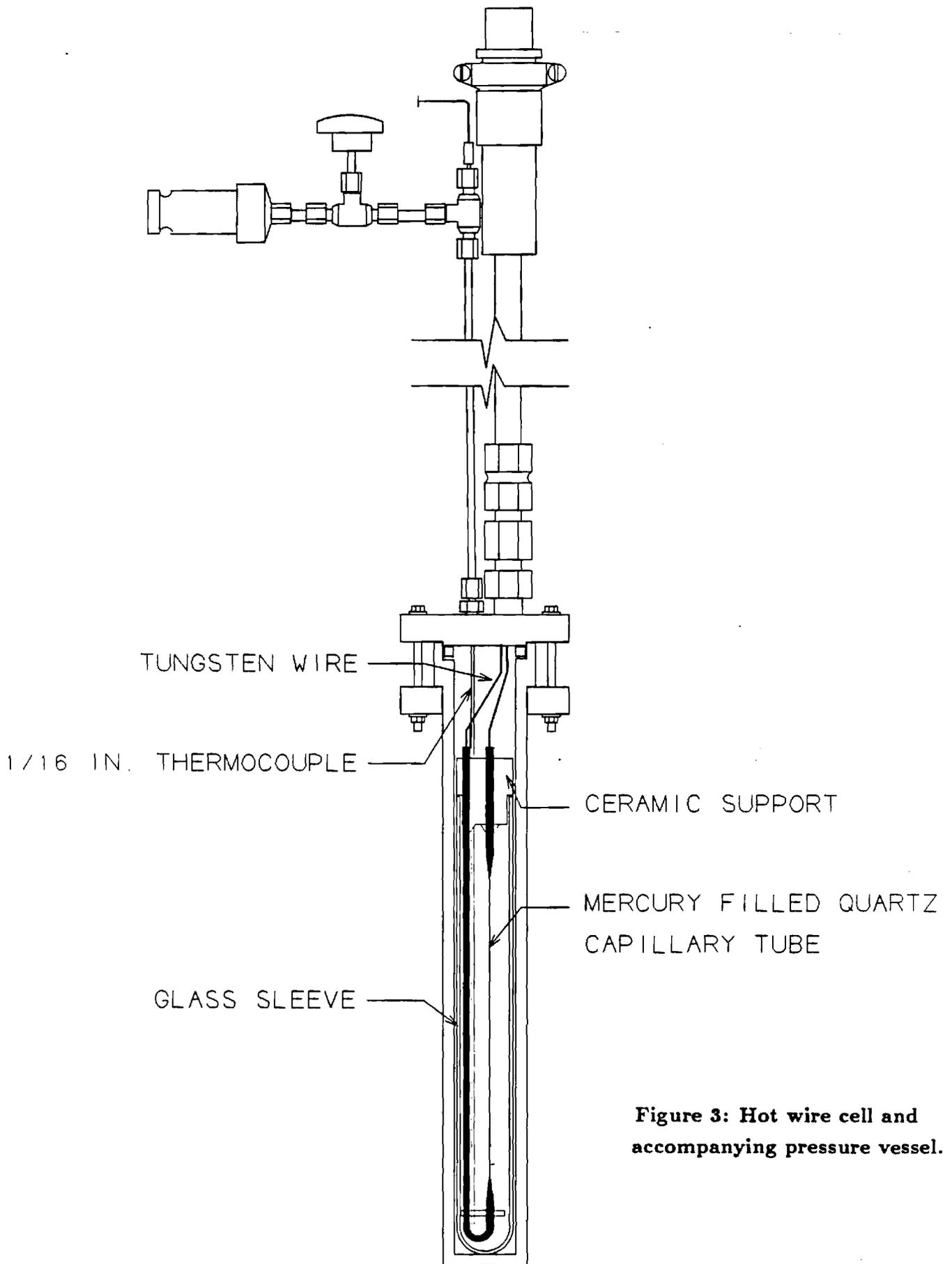


Figure 3: Hot wire cell and accompanying pressure vessel.

LINEARITY OF TEMPERATURE VS LN(t) CURVE

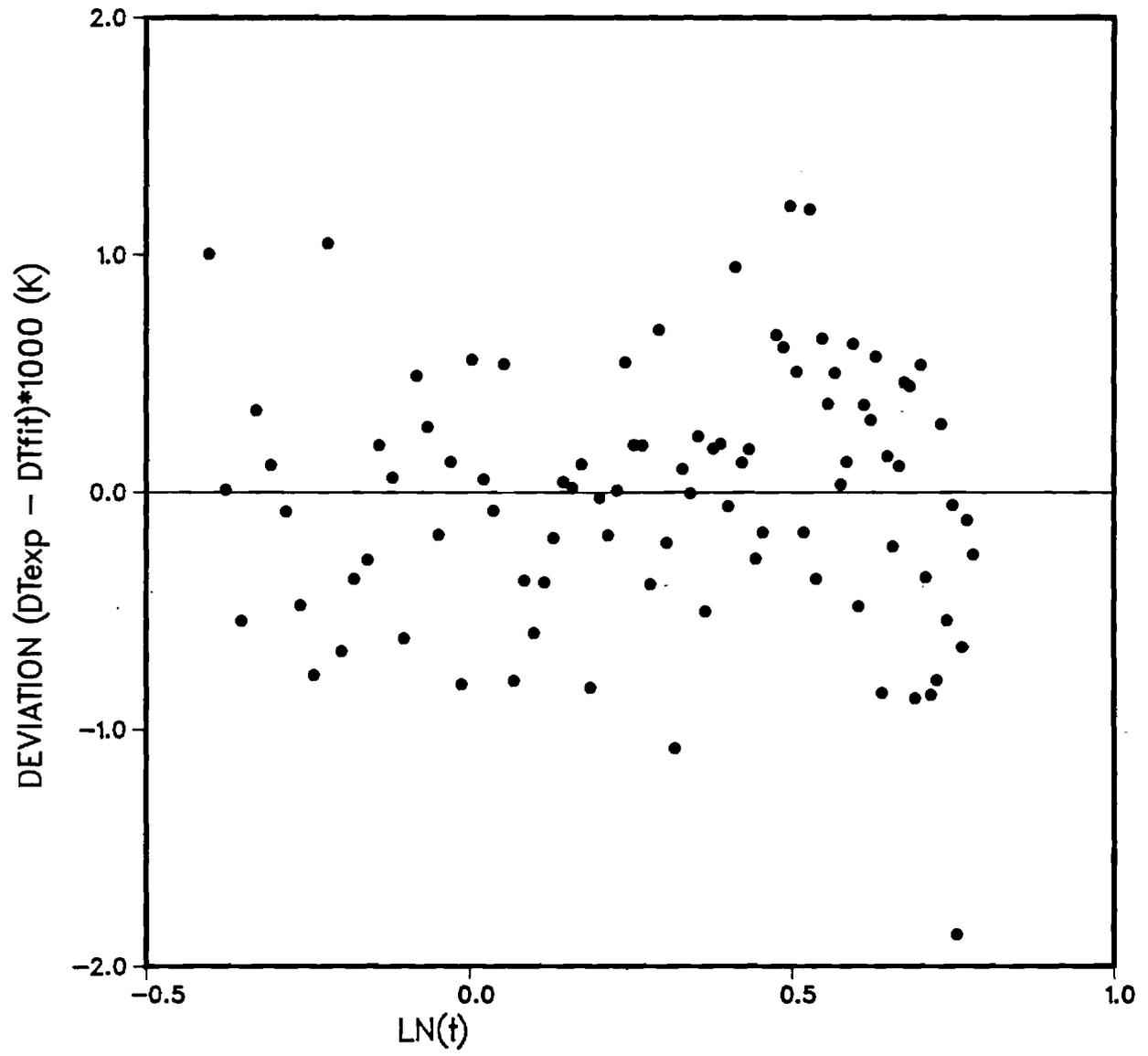


Figure 4: Plot of ΔT vs $\ln t$ to verify function linearity.

THERMAL CONDUCTIVITY OF AQUEOUS LiBr

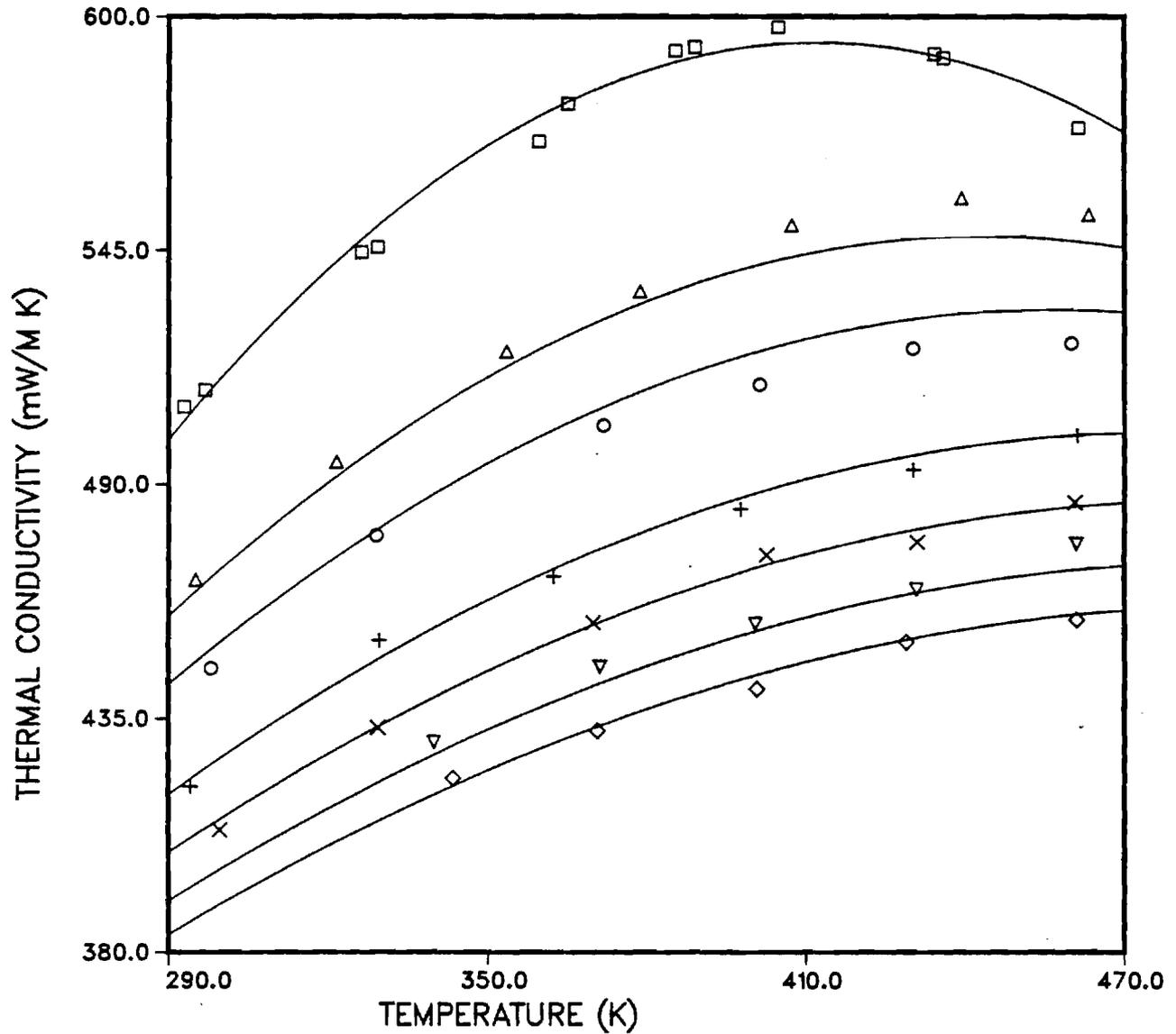


Figure 5: Thermal Conductivity of aqueous lithium bromide solutions. Solid curves are from the correlation. □ = 30.2 wt% LiBr, △ = 44.3 wt% LiBr, ○ = 49.1 wt% LiBr, + = 56.3 wt% LiBr, x = 60.0 wt% LiBr, ▽ = 62.9 wt% LiBr, ◇ = 64.9 wt% LiBr.

