Viscosity of Aqueous NaCl Solutions in the Temperature Range 25–200°C and in the Pressure Range 0.1–30 MPa

J. Kestin1 and I. R. Shankland1

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New precise viscosity data are presented for aqueous solutions of NaCl; these data cover the temperature range 25–200°C, the pressure range 0.1–30 MPa, and the concentration range 0–6 mol·kg⁻¹. The experimental precision is ±0.5%; a comparison of the present results with data available in the literature indicates that the accuracy of the present data is also of the order of ±0.5%. Two empirical correlations that reproduce the data within the precision are also given.

KEY WORDS: aqueous solutions; sodium chloride; viscosity.

1. INTRODUCTION

In a series of papers [1–6] we have reported the viscosity of various aqueous electrolyte solutions over the ranges 20–150°C and 0.1–30 MPa. These data were obtained with a modified oscillating-disk viscometer [2], previously employed for measurements of the viscosity of steam [7]. Because this instrument suffered from several disadvantages when subjected to high temperatures and corrosive environments [2, 8], a new viscometer was built to continue the study of these systems to higher temperatures and pressures. In a recent paper [8] we have described the construction of the new viscometer and reported data for the viscosity of water over the ranges 25–200°C and 0.1–30 MPa. This preliminary work proved that the new instrument was capable of providing viscosity data with a precision of ±0.3% for 20 < t < 150°C, degrading to ±0.5% for temperatures in excess

1 Division of Engineering, Brown University, Providence, Rhode Island 02912, U.S.A.
of 150°C. In this paper we present new precise data for the viscosity of aqueous NaCl solutions in the concentration range 0–6 mol·kg⁻¹, the temperature range 25–200°C, and the pressure range 0.1–30 MPa. The reasons for choosing this system for study were twofold; first, because of the existence of a wealth of experimental data for the NaCl system in the literature, it was possible to validate the accuracy of the new results, and, second, the corrosive nature of this system would permit us to judge the behavior of the new instrument under the conditions for which it was designed.

2. EXPERIMENTAL PROCEDURE

2.1. The Viscometer

The viscosity was measured in an oscillating-disk viscometer, which has been described in an earlier publication [8]. Details of the methods of temperature measurement and control and pressure measurement are also included in that paper. The characteristics of the oscillating system are given in Table I.

2.2. Calibration

Due to design limitations [2], absolute measurements of the viscosity of the liquids of interest here are almost impossible in an oscillating-disk viscometer. Hence a relative methods based upon the formulation of Kestin et al. [9, 10] was employed. The working equations pertinent to this method have been well documented [2, 8–10]. Calibration of the viscometer involves measurements upon a fluid of known viscosity in order to determine the dependence of the edge-correction factor C on the boundary-layer thickness \( \delta \), defined by

\[
\delta = \left( \nu T_0 / 2\pi \right)^{1/2}
\]

(1)

Here \( \nu \) is the kinematic viscosity of the reference fluid and \( T_0 \) is the period

<table>
<thead>
<tr>
<th>Table I. Characteristics of the Oscillating System</th>
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<tbody>
<tr>
<td>Radius of disk ( R ) (mm)</td>
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<td>Thickness of disk ( d ) (mm)</td>
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<tr>
<td>Separation between disk and fixed plates ( b ) (mm)</td>
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<td>Moment of inertia ( I ) (g·mm²)</td>
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<td>Period in air at 25°C, ( T_0 ) (s)</td>
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<tr>
<td>Decrement in vacuo at 25°C, ( \Delta_0 )</td>
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