The Thermal Conductivity of Molten NaNO₃ and KNO₃

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The thermal conductivity data for molten NaNO₃ and KNO₃ have been examined in order to propose recommended data sets for these two popular heat carriers and to establish the reference values above the temperature range covered by toluene and water. It is known that the measurement of the thermal conductivity of molten salts is very difficult, owing mainly to their corrosiveness and high melting temperatures, which introduce complications in apparatus design and significant systematic errors due to radiation and convection. However, some recent measurements seem to manifest more trustworthy values than obtained before. All available data have been collected and critically evaluated. The temperature range covered is 584 to 662 K for molten NaNO₃ and 662 to 712 K for molten KNO₃, with the confidence limits better than ±5%.

KEY WORDS: molten salts; potassium nitrate (KNO₃); sodium nitrate (NaNO₃); thermal conductivity.

1. INTRODUCTION

For the thermal conductivity of liquids the standard reference values are available in the temperature range from 190 to 370 K [1]. The standard reference materials recommended are toluene and water as the primary and n-heptane as the secondary. However, above this temperature range (>370 K), there are neither such internationally accepted values nor standard materials for liquid thermal conductivity. As far as the molten salts standard program [2] is concerned, reference values for the density, surface tension, electrical conductance, and viscosity of molten KNO₃ and NaCl have been recommended in the temperature range from 615 to

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While reliable data for the thermal conductivity of molten salts are required in order to establish standard reference values, in practice there are only a few experimental studies whose discrepancies are often far beyond their claimed accuracy. This is due to the fact that measurement of the thermal conductivity of molten salts is difficult, owing mainly to their corrosiveness and high melting temperatures, which introduce complications in apparatus design and notable systematic errors due to radiation and convection. It is worthy to note that several measurements reported in the past have shown a large increase in the thermal conductivity of molten salts with increasing temperatures, which is not common for other normal liquids, with the exception of water. However, some recent measurements seem to manifest more trustworthy values of the thermal conductivity of molten salts. Consequently, it may now be possible to establish reference values as for the thermal conductivity of molten salts through critical evaluations of existing experimental studies, even though they are not so accurate as for toluene and water.

2. PROPOSED REFERENCE MATERIALS FOR LIQUID THERMAL CONDUCTIVITY AT HIGH TEMPERATURES

Janz [2] selected molten KNO₃ (melting point, 610.15 K) and NaCl (melting point, 1073.15 K) as reference materials for other properties for the following reasons. (1) These two salts are readily dried and are not strongly hydrated. (2) The melting points of these two salts span the temperature range for measurements with moderately high and high melting systems. (3) These two materials are available commercially in highest purities (99.999%) and at only moderate cost. McLaughlin [3] suggested that molten lead and molten NaNO₃ are appropriate as standard materials for liquid thermal conductivity above 300°C. Here, we propose NaNO₃ and KNO₃ as reference materials for the moderately high temperature range (about 580 to 740 K), since these two molten salts fulfill the criteria for standard materials [1] and those above-mentioned by Janz [2]. Moreover, for these two materials, several experimental studies with different techniques have been reported in comparison with other molten salts.

3. EVALUATION OF EXPERIMENTAL DATA

3.1. Assessment of Accuracy of Data

All existing experimental data are listed in Tables I and II. The general criteria are basically the same as described in Ref. 1. In addition to those,