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# Temperature-Insensitive Solution for Accurate Conductance Measurement

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## Extended Abstract

In order to design boilers, evaporators and condensers, a phase distribution is one of the most important factor to be determined. Although electrodes which are immersed into a coolant media give useful information such as void fraction and phasic velocity, one may suffer temperature variation which affect electric conductance of the coolant.

Potential gradient and electromagnetic wave which are generated in a test liquid due to energization, give critical measuring accuracy in the form of electric noise. If the test liquid has temperature dependency of electric conductivity, time-displacement of liquid temperature during the transient boiling phenomenon gives additional uncertainty to the measured value.

Figure 1 illustrates experimental apparatus, which consists of a pre-heater, test section, separator, condenser and circulation pump. A heater pipe is inserted in the test section and heated by direct current. Wire-Mesh Sensors (WMSs) were inserted near by the heated section. The experiment was conducted in non-boiling (no bubbles in a solution) condition to quantify temperature dependence of each solute. The test fluids are dilute aqueous solutions, whose solutes are vitriolic solutes ($K_2SO_4$ and $Na_2SO_4$), nitric solutes ($KNO_3$ and $NaNO_3$) and fluorescence (Rhodamine-B and Uranine) which is used in PIV, LDV. The experimental procedures are tabulated as follows.

1. Calibration using ion-exchanged water - rest potential of water was measured at intervals of 10℃ from 30℃ to 90℃. The value became larger in high temperature condition. -
2. Setup of solution concentration (Table 1) - Gain value of detector was set 1, and the concentration of each solute was calibrated that the electric potential of its solution is equal to one of water in the case of 90℃. -
3. Measurement of temperature dependency of electric potential (*dV/dT*, V: Voltage, T: Temperature) and SN ratio
4. Measurement of electric conductivity, pH and dissolved oxygen level (not mention in this extended abstract)

Results and discussion were given as follows. Time-series data of electric potentials of water and Rhodamine-B solution were indicated in Figure2. As shown in these trends, these all data were normalized with time-averaged one of 90℃. It was confirmed that amplification method of electric potential with solute concentration predominates that one method with detector gain in order to improve SN ration of the signal. Temperature sensitivity index (*dV/dT*) and SN ratio were illustrated in Figure 3. It shows the normalized *dV/dT* data when one of water is 100. It was clarified that the solutes except Uranine have the temperature dependency-reduction effect to 70 % of one water. Furthermore, SN ratio of all solutions were increased about 3 times than one of water. Finally, thermos-physical properties of test liquid solutions were illustrated in Figure 4 and 5, respectively. These graphs were normalized with the values at 30℃ each other. Fig. 4 indicates that addition of solute gives reduction effect of temperature change of electric conductivity. Especially in the case of Rhodamine-B, as shown in Fig. 5, its temperature dependence was indicated equal tendency with one of water because this fluorescence is not ionized. As the measurement of void fraction, reducing temperature dependency (dV/dT) without changing thermos-physical properties of water is important in order to avoid unnecessarily mixing the sensitive properties of electric conductivity.

In conclusion, it was identified that Rhodamine-B has the following effects, reduction of temperature dependency of electric potential, improvement of SN ratio without changing water properties (pH, DO).

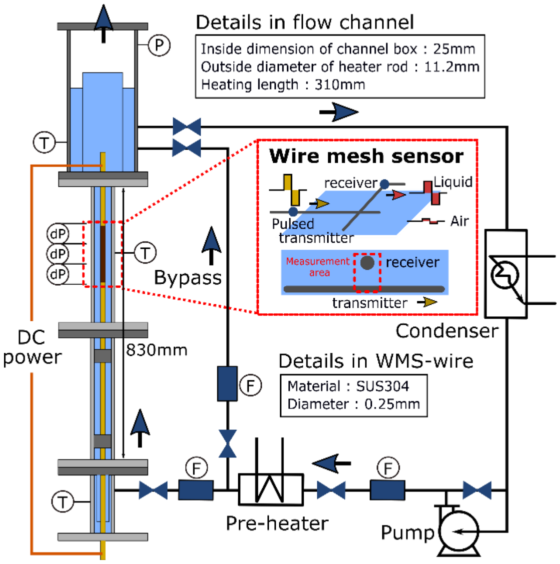

Fig. 1: Experimental apparatus.

Table. 1: Concentrations of test liquid solute.

| | $K_2SO_4$ | $KNO_3$ | $Na_2SO_4$ | $NaNO_3$ | Rhodamine-B | Uranine |
|---|---|---|---|---|---|---|
| Conc. [wt%] | 0.0140 | 0.0161 | 0.0140 | 0.0170 | 0.0800 | 0.0604 |

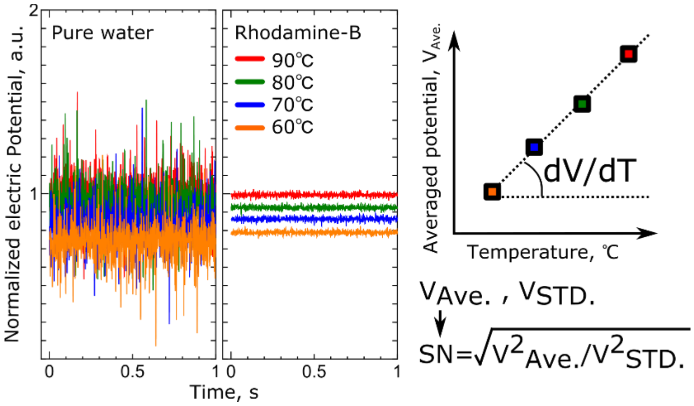

Fig. 2: Detected signals and evaluation setup.

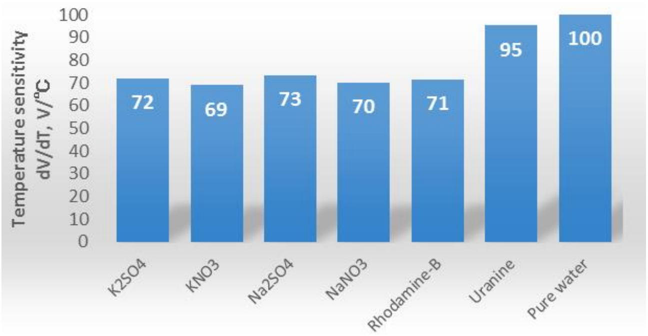

Fig. 3: Temperature sensitivities dV/dT.

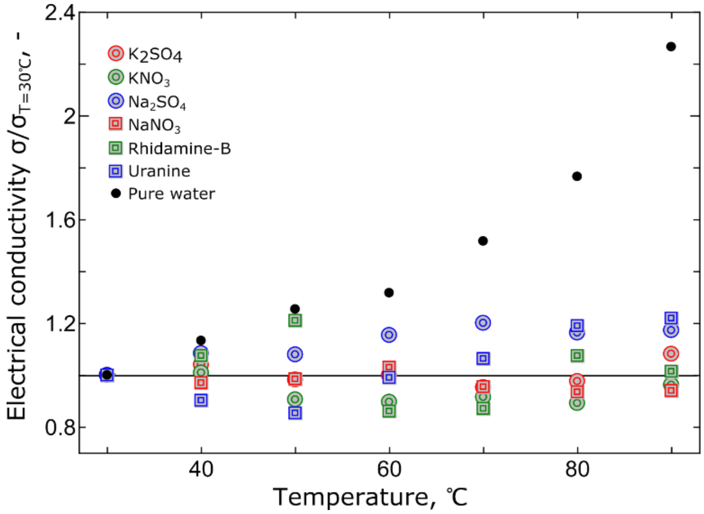

Fig. 4: Temperature dependence of electric conductivity.

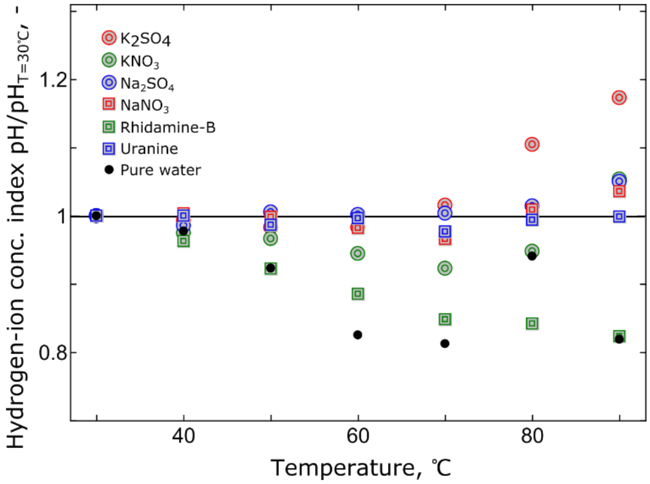

Fig. 5: Temperature dependence of pH.

Table 2: Assessment results of temperature sensitivity and SN ratio for test liquid solutions.

| | dV/dT | SN ratio | pH | |
|---|---|---|---|---|
| $K_2SO_4$ | -30% | 3 times than water | 20% | ✕ |
| $KNO_3$ | | | ±9% | ✕ |
| $Na_2SO_4$ | | | ±2% | ✕ |
| $NaNO_3$ | | | ±4% | ✕ |
| Rhodamine-B | | | -19% | ○ |
| Uranine | -5% | | -4% | ✕ |