

# Discriminating Among Alkali Ions in Aqueous Solutions by Seebeck Voltage Measurement in Microfluidic Channels

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## Abstract:

Microfluidic systems allow fast and parallel analyses of fluid samples consuming microscopic quantities of the analytes. While varieties of information acquisition techniques from microchannels are practiced, novel methods for extracting information regarding the nature of the fluid analyte are sought after. Here, for the first time, we record the liquid Seebeck voltages established along the liquid-filled channels with predetermined temperature gradients, and correlate the results to the chemical composition of the analyte. Liquid Seebeck voltages are measured along microfluidic channels filled with aqueous solutions of LiCl, NaCl, and KCl. At constant molality, these solutions demonstrate Seebeck coefficients of +250, +350, and +500  $\mu\text{V/K}$ , respectively. It is shown that the information acquired can be used for differentiation between electrolytes of different compositions.

**Keywords:** Seebeck effect, bodily fluids, microfluidics, electrolytes, alkali ions

## Introduction

Extracting analytical information from fluid analytes injected in microfluidic channels allows their detections and classifications important in numerous medical and industrial applications [1, 2]. Regardless of their different ionic mobilities, it is difficult to discriminate between alkali ions by conductometry in a channel as it varies with both concentration and nature of the unknown ion. Here, for the first time, we are presenting extraction of Seebeck coefficient

data and show that they provide information uncorrelated with those related to conductometry regarding the nature of the electrolyte.

## Methods

Structure of the designed microfluidic system is schematically presented in Fig. 1a-b. The system comprises a 1.2 mm x 0.5 mm x 2.5 mm channel terminated to two 70  $\mu\text{L}$  micro-reservoirs located at both ends. The system is

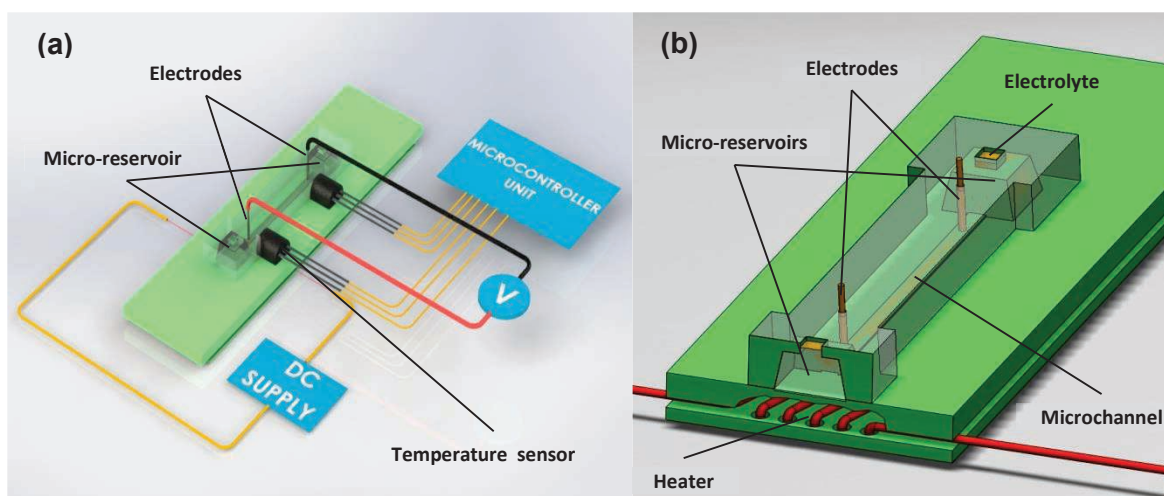


Fig. 1. Schematic diagram of the microfluidic system connected to the external measurement circuitry (a), and the magnified view of the hot reservoir and the heating microheater underneath (b).

constructed on a PMMA chip by CO<sub>2</sub> laser engraving; the fabrication method is described elsewhere [3]. The temperature gradient along the channel is established by applying a controlled heating voltage to the microheater constructed underneath one of the micro-reservoirs.

Two independent temperature sensors are used to monitor the temperatures of the hot and cold ends of the channel. Two pure platinum wire segments, 0.35 mm in diameter, are laterally inserted into the channel via two holes devised close to the channel ends as depicted in Fig. 1.

Tested analytes are LiCl, NaCl, and KCl 0.1 molar solutions in distilled water. The conductivity of each analyte is monitored using a standard conductometer prior to use; results are similar to the data available in the background literature. An analyte is introduced into the clod reservoir utilizing a sampler of 0.2 mL volume, which fills the channel and both reservoirs. Heating voltage is applied based on the prior experiences to establish the required temperature difference between the channel ends. Seebeck voltage established along the channel is measured between the electrodes after resuming temperature stability. The method used for Seebeck voltage measurement is as described in [4].

## Results

The temperature of the hot end is repeatedly varied by applying voltage pulses of different amplitudes to the microheater. The temporal variations of the temperature difference between the channel ends and the established Seebeck voltage are presented in Fig. 2. Based on similar experiments, plots of Seebeck voltage vs. temperature difference are produced for different analytes; results are

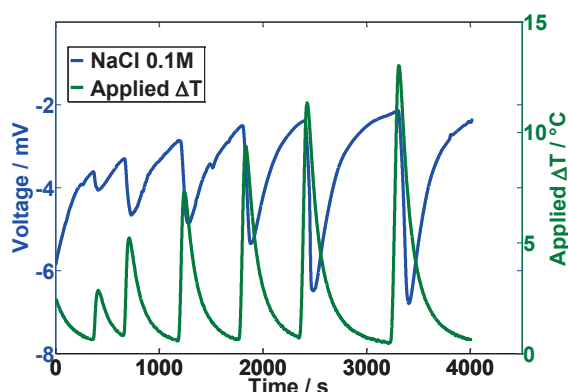


Fig.2. Raw data recorded for an analyte, showing the applied thermal gradient sequences and the resulting Seebeck voltage variations.

given in Fig. 3. The discrimination between the electrolytes depicted in Fig. 3 is much more significant than differences observed by conductometry.

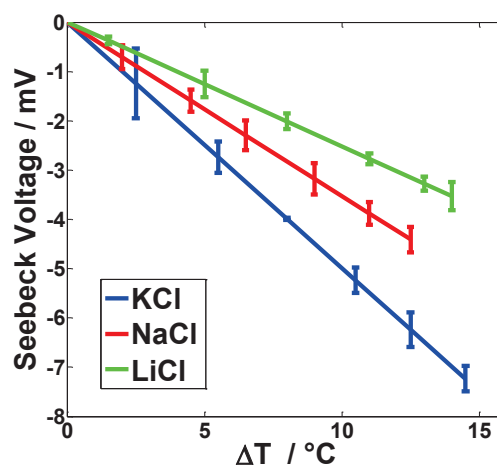


Fig. 3 Seebeck voltages of 0.1 mol.L<sup>-1</sup> LiCl, NaCl and KCl solutions vs. the temperature difference between the hot and the cold channel ends.

## Conclusion

Based on the presented, and many other acquired experimental data, it is concluded that Seebeck voltage measurements along microfluidic channels provide useful information on the nature of the charged species present in the analyte inside the channel. The results provide information uncorrelated to the conductometry data; useful for analyte discrimination, e.g. K<sup>+</sup> and Na<sup>+</sup> ions in bodily fluids.

## References

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