THERMOELECTRIC PROPERTIES OF AQUEOUS ELECTROLYTE INFILTRATED IN ANODIC ALUMINIUM OXIDE (AAO) NANOCHANNELS

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INTRODUCTION

In an electrolyte confined within a nanopore or nanochannel a voltage can be created when a temperature gradient is applied along the channel. The transport of ions inside a nanochannel is a complex superposition of electromigration, advection and diffusion and far different from the predominant Soret diffusion observed in bulk electrolytes. In a channel with electric-double layer (EDL) overlap, a temperature gradient along the channel creates an electric field leading to a flux of the dominant ion species, the counter ions.

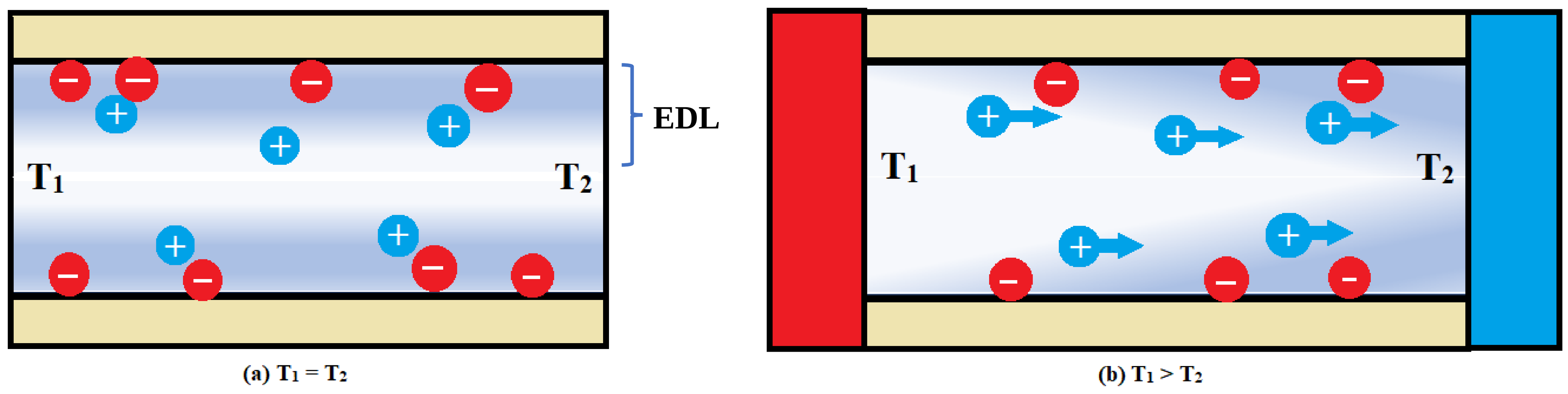


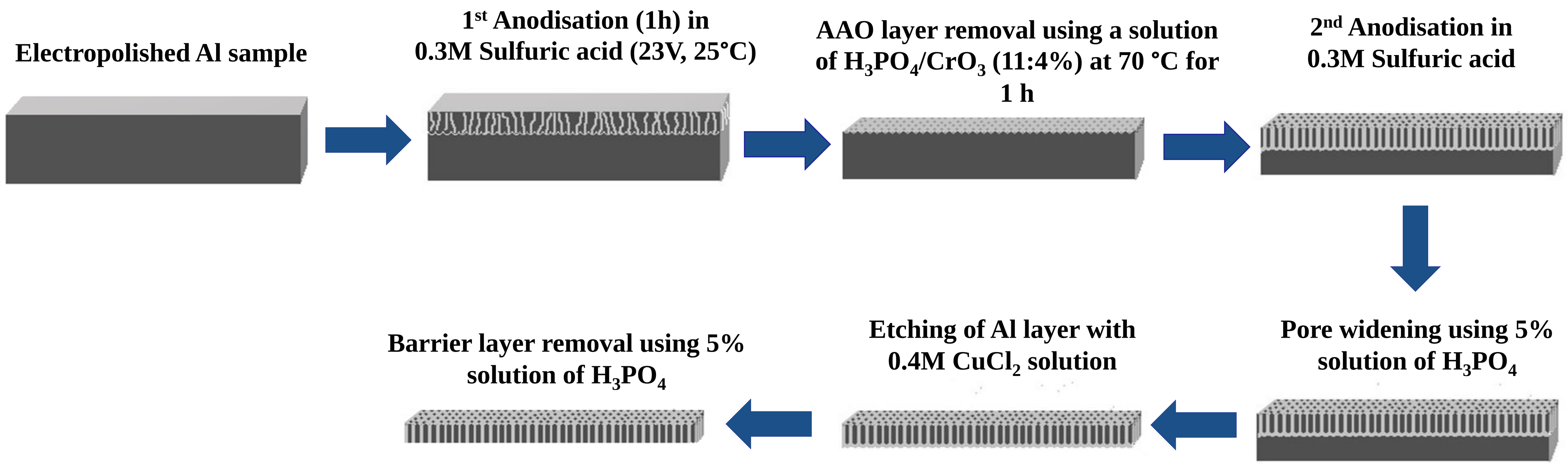
Figure 1. *Schematic representation of a nanochannel with overlapping EDLs, along which a temperature gradient is applied.*

EXPERIMENTAL PART

Nanoporous anodic aluminum oxide (AAO) is one of the most popular and cost-effective platforms for various applications: from templates and molecular separation to drug delivery and energy generation.

Sample synthesis was done using high-purity (99.999%) aluminum sheet (GoodFellow) with a thickness of 0.5 mm, cut in 10×10 mm² pieces. Porous anodic aluminium oxide membranes have been obtained according to the standard scheme of two-stage anodization of aluminium with subsequent removal of the barrier layer.

The surface analysis of the porous anode was done using a scanning electron microscope (SEM, Hitachi 4800).



RESULTS AND DISCUSSION

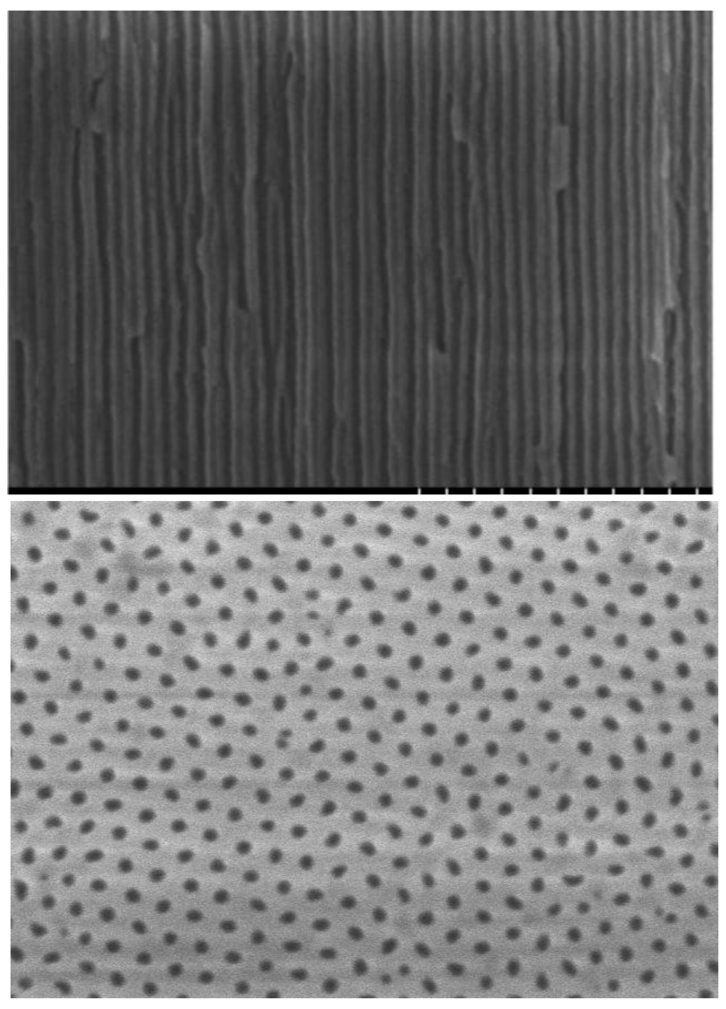


Figure 2. *SEM images of the cross-section (top) and 25 nm porous surface (bottom) of the AAO membrane synthesised in 0.3 M Na_2SO_4 electrolyte.*

To test the thermoelectrical properties of aqueous electrolyte-infiltrated AAO membranes, a sandwich-type cell was designed (Figure 3.).

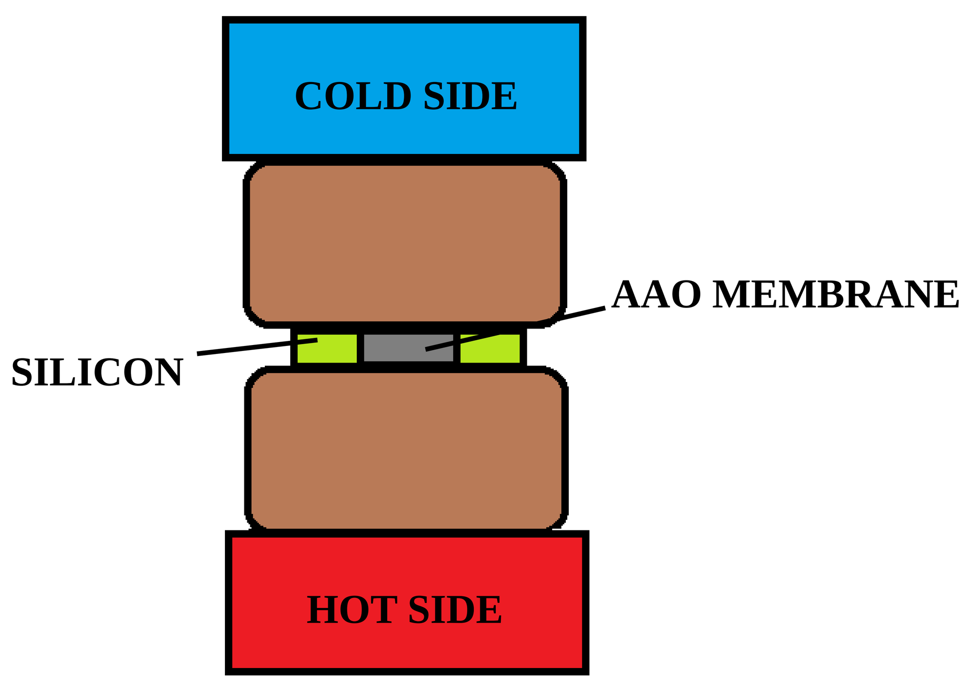
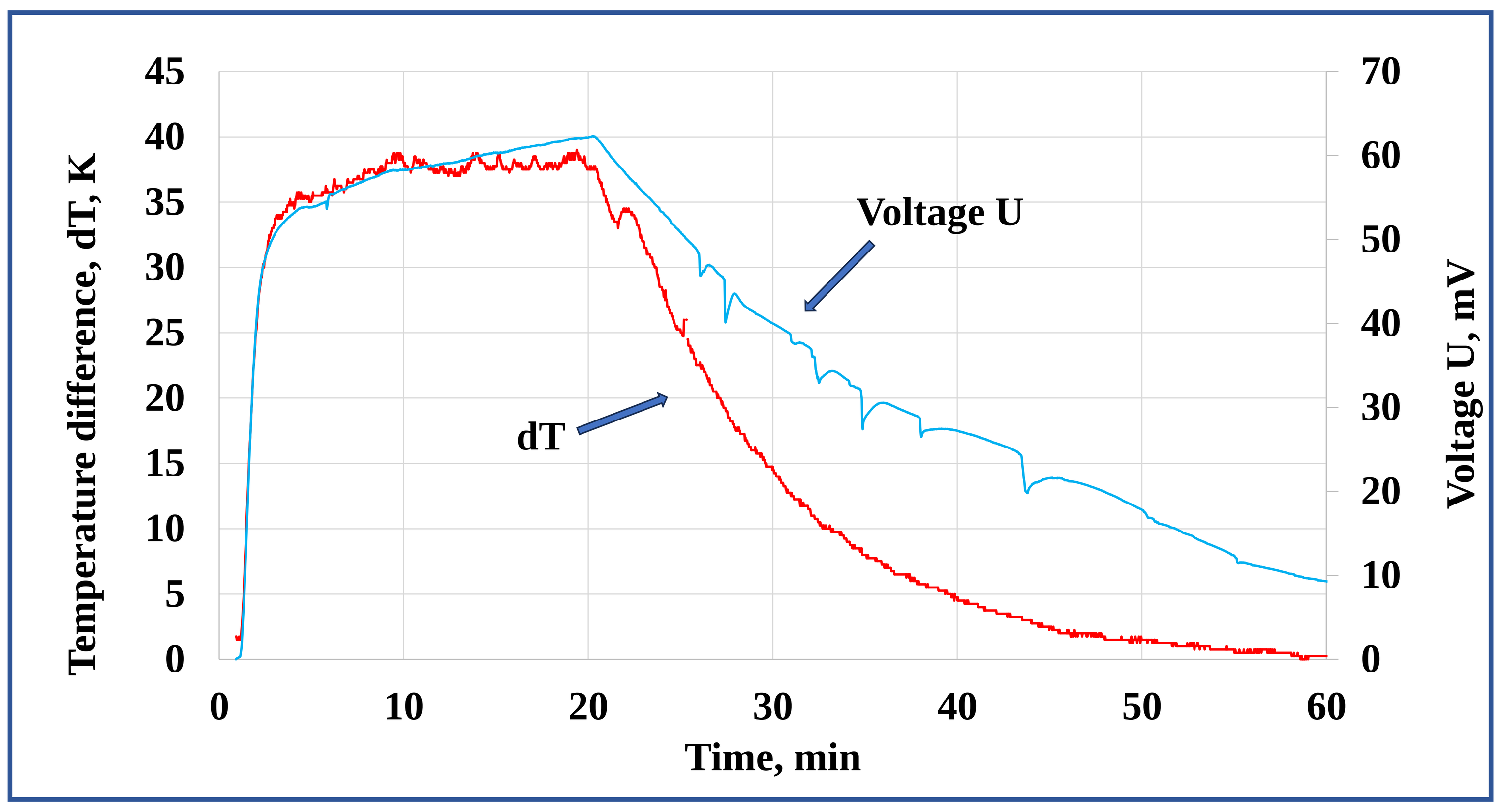


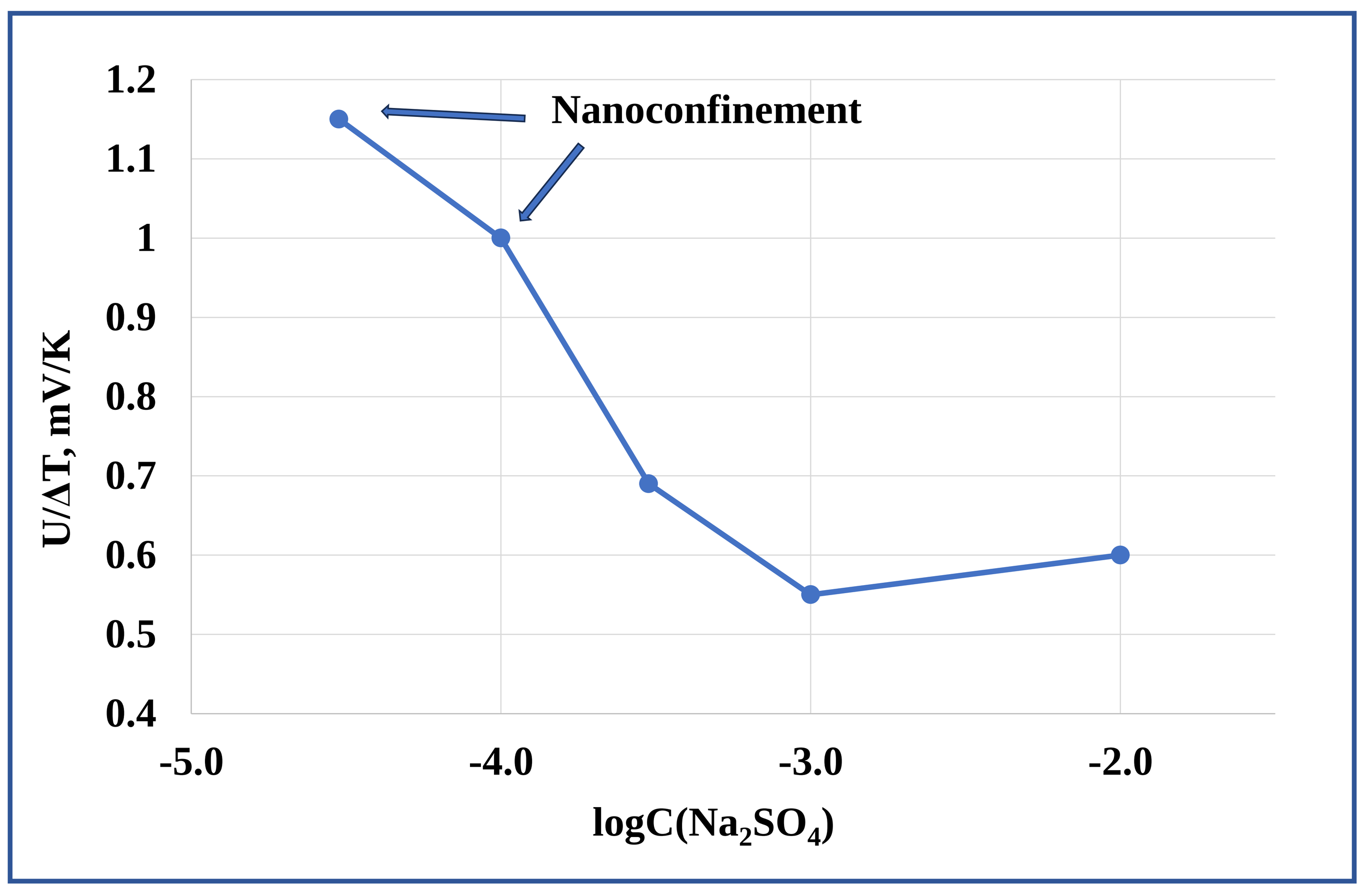
Figure 3. *Schematic representation of a sandwich-type cell*

OUTPUT VOLTAGE AND TEMPERATURE DIFFERENCE DEPENDENCE ON THE MEASUREMENT TIME



DEPENDENCE OF OUTPUT VOLTAGE PER KELVIN ON THE CONCENTRATION OF ELECTROLYTE

C(Na_2SO_4), M	logC	U/ΔT, mV/K
$3\cdot10^{-5}$	-4.5	1.15
$1\cdot10^{-4}$	-4	1.00
$3\cdot10^{-4}$	-3.5	0.69
$1\cdot10^{-3}$	-3	0.55
$1\cdot10^{-2}$	-2	0.60



CONCLUSIONS

- Applying a temperature difference to the system revealed an increase in output voltage attributed to thermally driven ion transport in the nanochannels.
- The value of the generated voltage obtained is in the range of 0.55-1.15 mV/K when using copper electrodes. After switching off the heating/cooling elements the temperature gradient decreases and the output voltage slowly returns to initial value.
- Thermoelectric effects tended to increase with decreasing concentration due to nanoconfinement effect in very diluted solutions (C (Na_2SO_4) = $3\cdot10^{-5}$ M and $1\cdot10^{-4}$ M).
- Highest output voltage (U/ΔT = 1.15 mV/K) was achieved using the most diluted solution (C (Na_2SO_4) = $3\cdot10^{-5}$ M), the result obtained exceeds the value described in the literature with pure aqueous electrolytes.

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