Zirconia and Hafnia Monolithic Structures for Electrokinetic Micropumps

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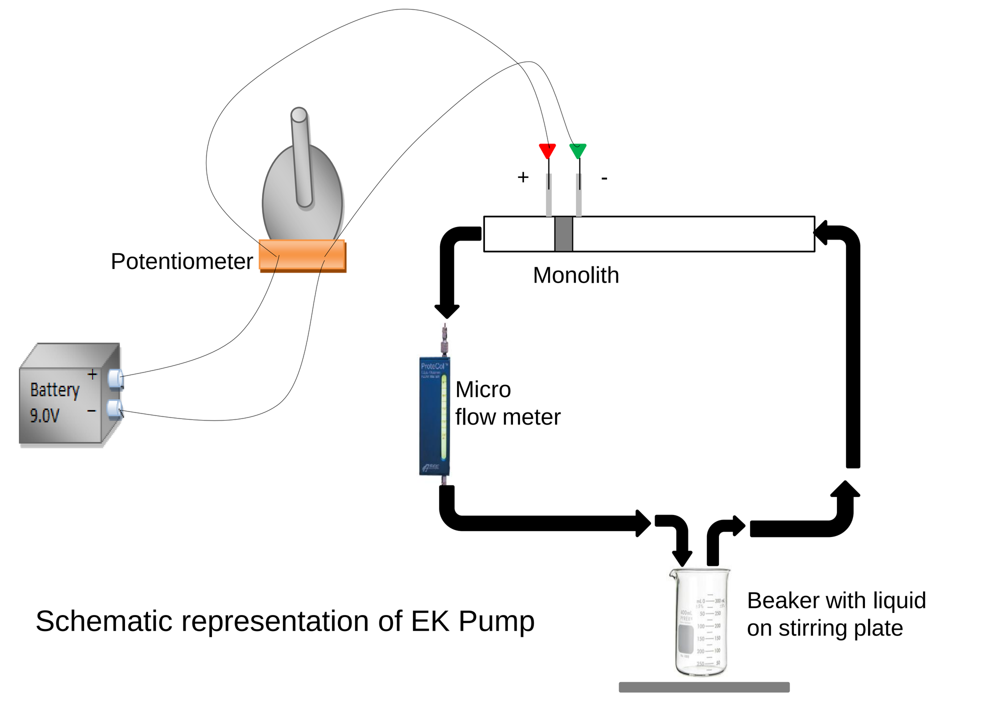
INTRODUCTION

There is a constant need for the development of new technology that can provide ways to reduce weight and space requirements, as well as energy consumption when pumping fluids. The use of electrokinetic (EK) pumps would be favor over conventional pumping systems because of their simplicity, lightweight, compact size, and low energy demands. Developed based on electroosmosis, the movement of liquid through a stationary porous material as a result of an externally applied electric field, EK pumps allow for the flow magnitude and direction to be controlled. The use of porous silica monoliths for EK pumps has shown limitations since they degrade/corrode with time, particularly under alkaline solutions. In search for an alternative to silica, we have synthesized zirconia and hafnia monoliths and studied their electrokinetic pumping abilities.

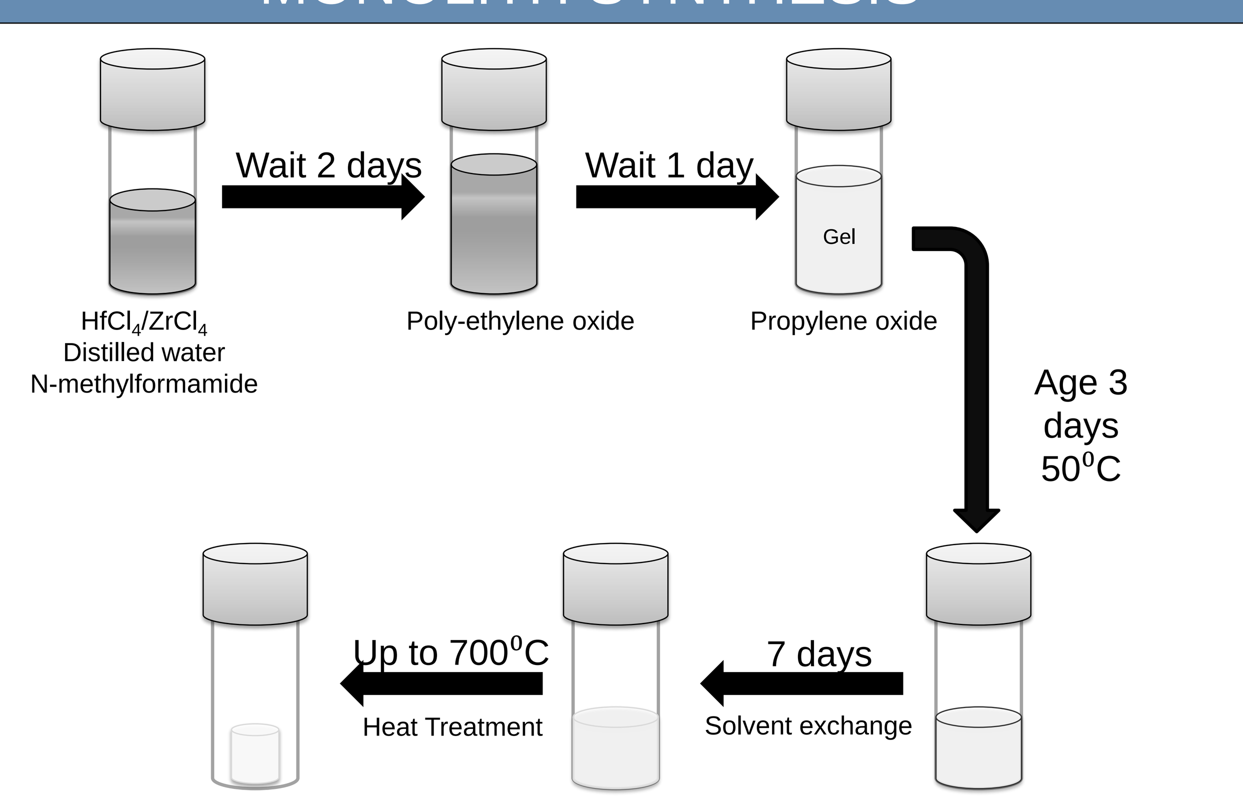
ELECTROKINETIC PUMPING SYSTEM



Schematic representation of EK Pump

The voltage applied to the EK pump is supplied by 9V batteries connected in series. The potentiometer allows control of the voltage being applied across the monolith using platinum electrodes. The monolith is encapsulated in a plastic tube. The generated flow is measured via a microflow meter.

MONOLITH SYNTHESIS

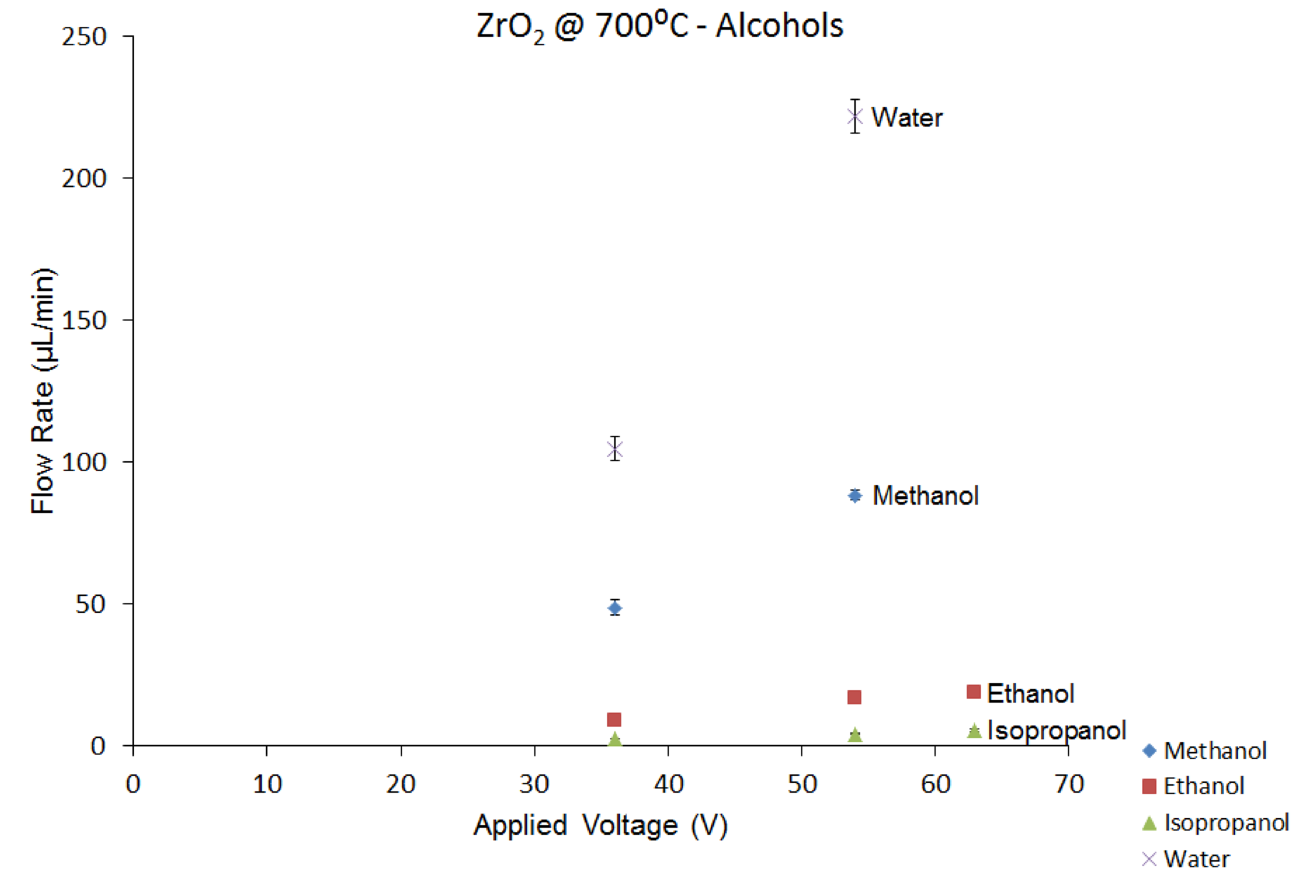


HfO_2 and ZrO_2 monolithic structures were synthesized by sol gel processing.

ELECTROKINETIC PUMPING SYSTEM

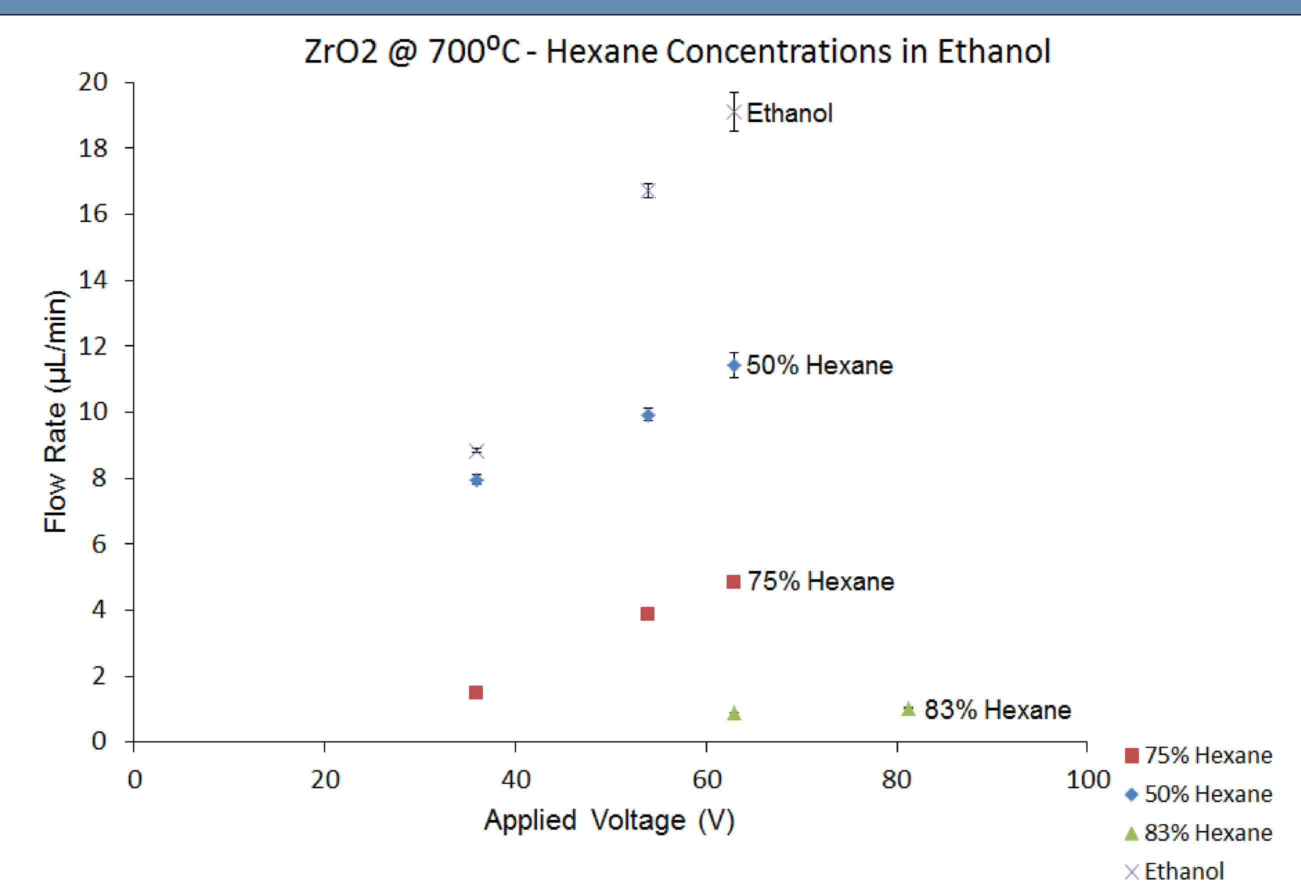
Full view of the EK micropump along with a close up of the wires secured to the mesh platinum electrode and a view of how the pump components are connected.

FLOW RATE: ALCOHOLS



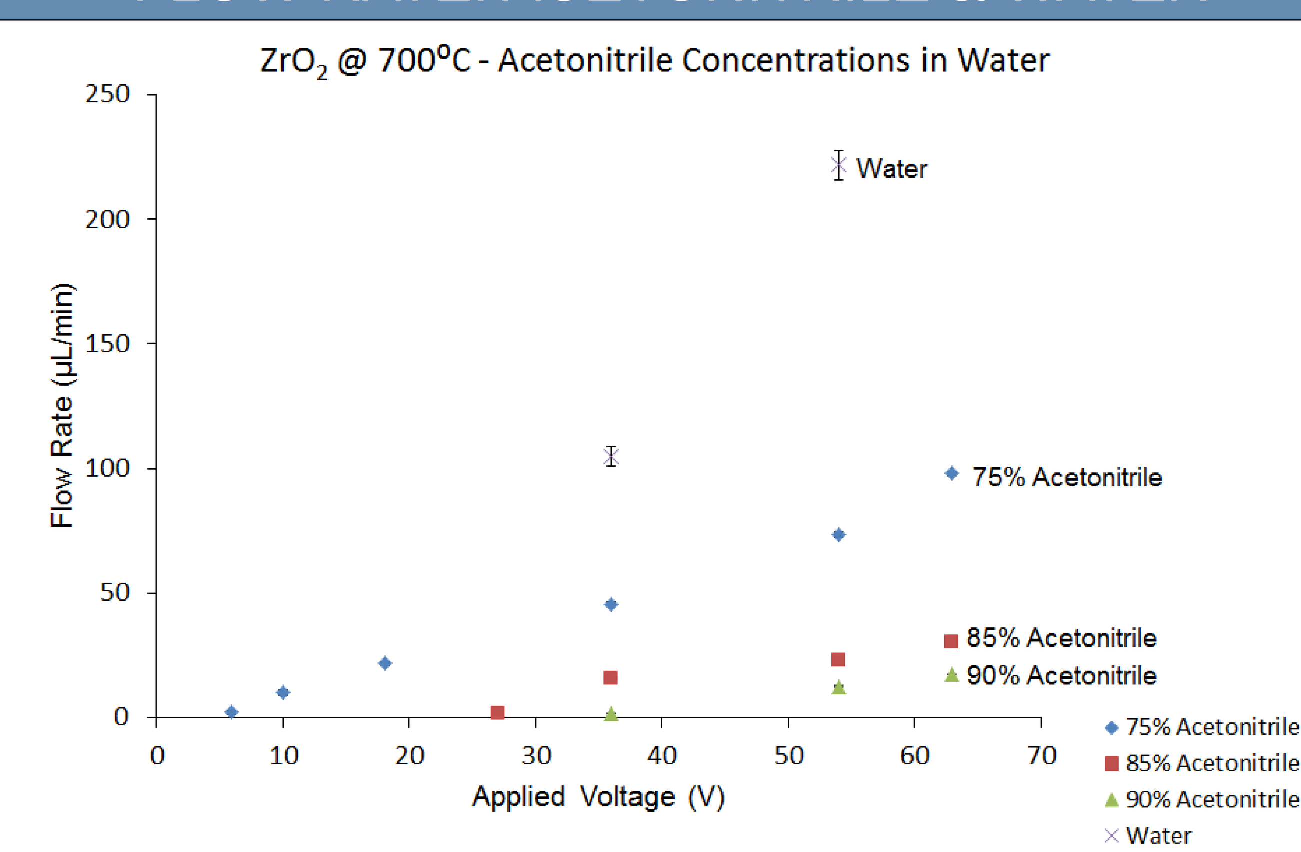
- The flow rate of various alcohols and water as a function of applied voltage: ZrO_2 monolithic EK pump.

FLOW RATE: HEXANES & ETHANOL



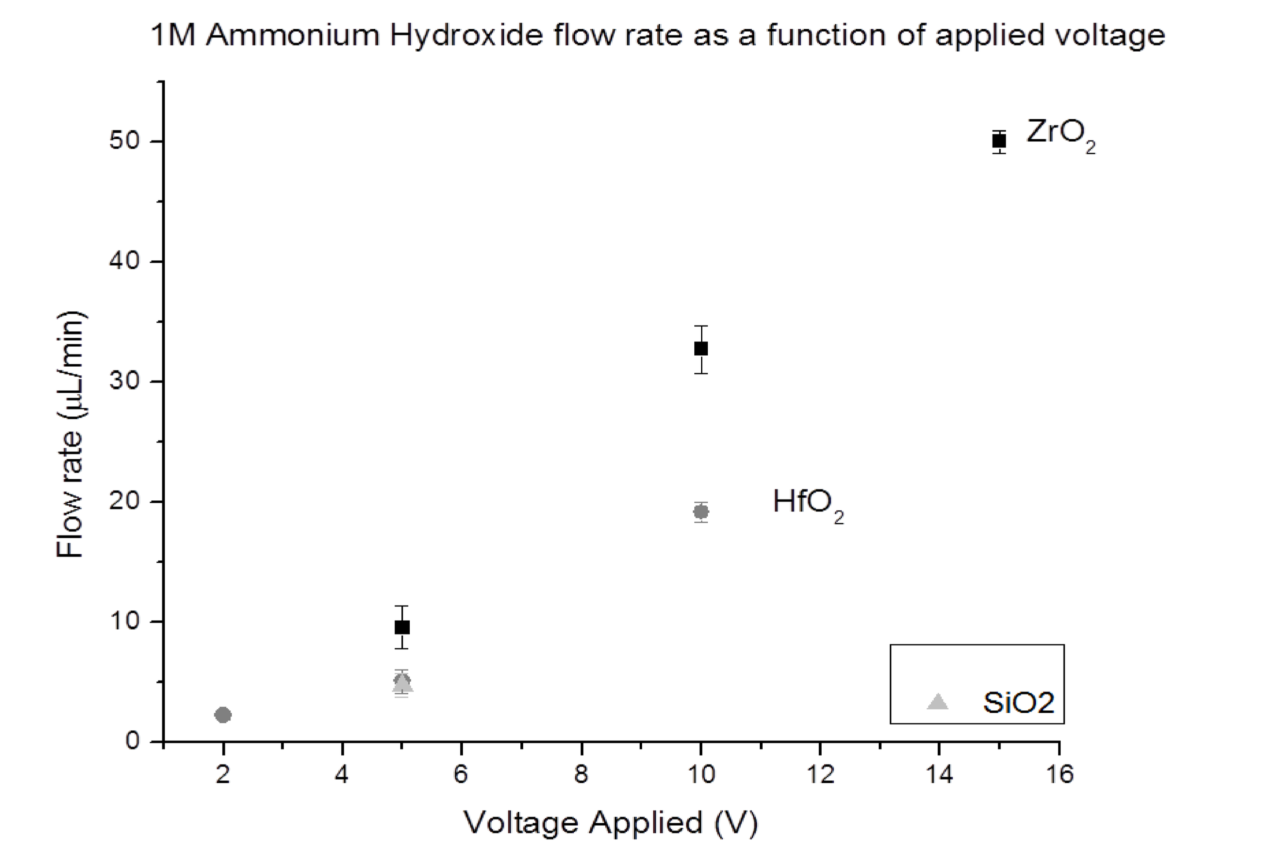
- Hexanes concentrations flow rate as a function of applied voltage: ZrO_2 monolithic EK pump.

FLOW RATE: ACETONITRILE & WATER

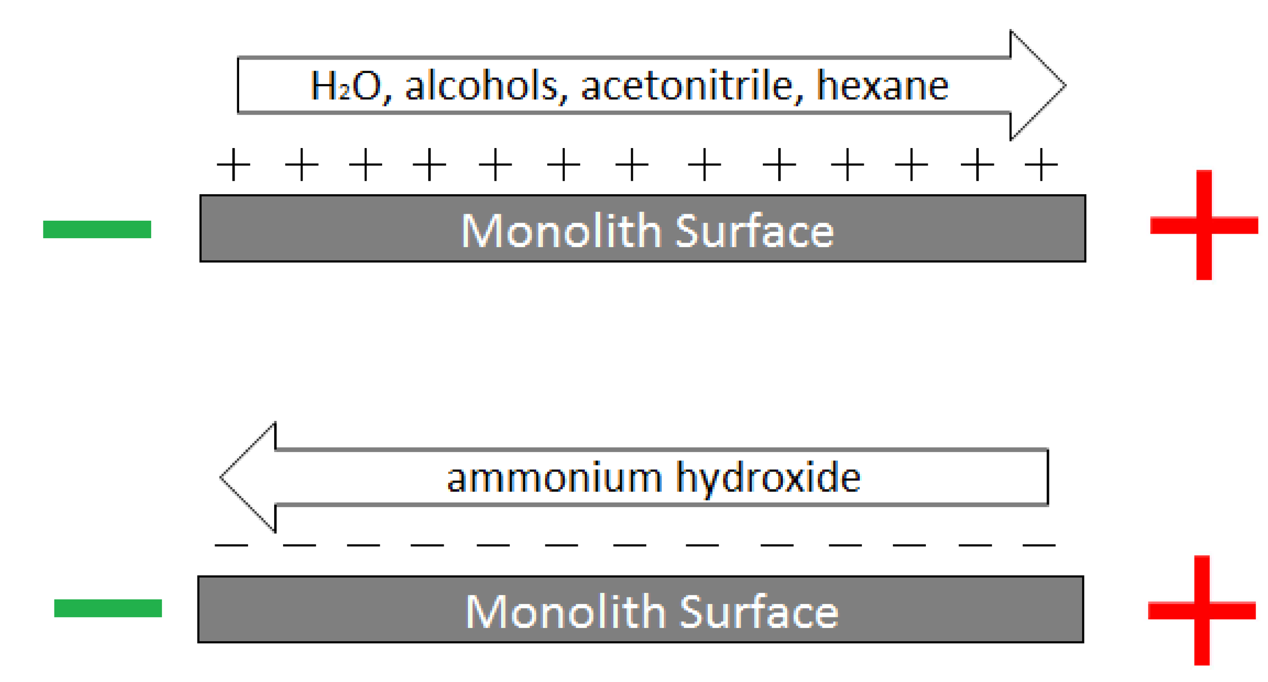


- Acetonitrile concentrations flow rate as a function of applied voltage: ZrO_2 monolithic EK pump.

FLOW RATE: AMMONIUM HYDROXIDE



ELECTRO-OSMOTIC FLOW



CONCLUSIONS & FUTURE WORK

- There is a direct linear relationship between the voltage applied and the flow rate achieved
- The amount of solvent in the solution has a direct effect on the flow rate of the solution
- Study the effect of the electrode position and composition (e.g., carbon instead of platinum) in the assembly on the flow rate
- Study the electrokinetic behavior of various solutions at low voltages (.5 V – 2 V)

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