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Research Letter

Effects of Electrolyte on Floating Water Bridge

Hideo Nishiumi and Fumitaka Honda

Chemical Engineering Laboratory, Hosei University, Koganei, Tokyo 184-8584, Japan

Correspondence should be addressed to Hideo Nishiumi, nishi@hosei.ac.jp

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Fuchs found phenomena that when high voltage is applied to deionized water filled in two contacted beakers, a floating water bridge forms spontaneously. In this paper, we examined flow direction of water bridge and what effects the addition of electrolytes such as NaCl, NaOH, and NH_4Cl to the floating water bridge would give. We found that ionization degree reduced the length of water bridge though insoluble electrolyte Al_2O_3 had no effect on the length of water bridge.

1. Introduction

A lot of experiments on water have been reported since the ancient time. Water is a familiar substance and has many interested features. Dipole moment is one of them. Floating water bridge seems to be caused with it. It can be easily reproduced if you have a high voltage electric generator and deionized water.

First the top of two beakers filled with deionized water was in contact with each other, and then they were setting apart gradually under high voltage. Then spanning a bridge of water could be observed between top of two beakers. This experiment was reported by Fuchs [1–3].

We believe that the phenomenon was caused by electrical dipole moment of H_2O molecular. So the addition of an electrolyte will disturb the aligned structure, and length of water bridge will be expected to be decreased with the concentration of electrolyte. In this paper, we would like to know the flow and the effects of adding electrolytes to deionized water on the length of water bridge.

2. Experimental

2.1. Apparatus. Figure 1 shows a main part of the apparatus which contains two 100 mL beakers and electrodes with D.C. 12 kV high voltage generator and about 100 mA (Clear Pulse Inc, Model 9045). They were filled with water and a small quantity of water soluble electrolyte (NaCl, NaOH and NH_4Cl) or insoluble electrolyte (Al_2O_3). Electrical conductivity was measured with an electrical conductance meter (EC Tester 11^+. OAKTON Instruments Inc).

2.2. Observation. First, both beakers were in contact with each other. Next, applying voltage to electrode, a beaker of anode side was moved away slowly. Finally, floating water bridge could be observed between both beakers like Figure 2. For deionized pure water at 12 kV, the length of water bridge reached 13 mm at the maximum at room temperature and atmospheric pressure.

We cannot obtain water bridge spontaneously. But we can observe it easily when high voltage is applied. High voltage arranges water molecules in a line of positive and negative polarity by turns like a rope. One cm long water bridge may bundle many water ropes which are composed of arranged more than hundreds of millions of water molecules. Because water molecules were attracted by the gradient of electricity, water flows from a beaker to the other. Once a rope decays with produced heat, it almost falls down. However it comes back again as polarity pulls back a rope. It is a surprising view. After several decays, finally produced heat as you can see in the figure breaks a rope and finished spanning the bridge. Streamer was also observed between two beakers after water bridge finished spanning.

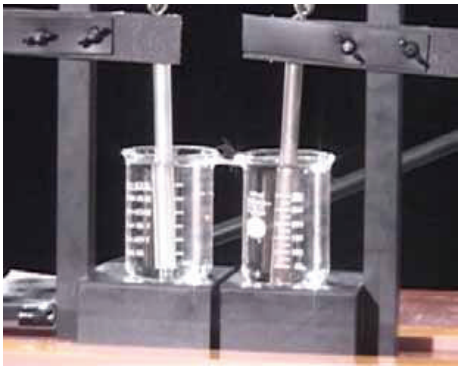

Figure 1: Main part of apparatus.

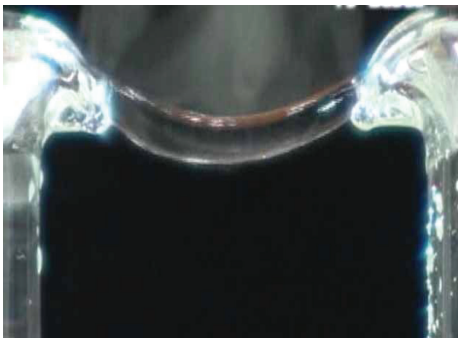

Figure 2: Floating water bridge.

3. Discussion

3.1. Direction of Water Bridge Flow. Flow direction of water bridge could not be visually confirmed. To know the flow direction, water soluble electrolyte of NaCl was added in a beaker and the other deionized water. Distance between two beakers was kept 1 mm long, and high voltage to the beakers was applied less than 25 seconds. After a run, electric conductivity of deionized-water side solution was measured with an electrical conductance meter.

Figure 3 shows no change of electrical conductivity of cathode side solution when NaCl was added to the anode side solution. It shows that it did not flow from the anode side to the cathode side. On the other hand, Figure 4 shows that electrical conductivity of anode side solution increased with time when NaCl was added to the cathode side solution.

Figures 3 and 4 reveal that water flows from the cathode side to the anode side under high voltage. It was probably related to the streamer generation.

3.2. Effect of Water Soluble Electrolytes on Floating Water Bridge. Assuming that floating water bridge is caused with dipole moment adding electrolytes will prevent forming floating water bridge. We chose soluble electrolytes in water as NaCl and NaOH, NH_4Cl whose electrical conductivities were changed from 0 to 40 μS/cm. Changing the amount of an electrolyte solution volume adjusted to 200 μS/cm to deionized pure water, maximum length of water bridge was measured. Figure 5 shows the effect of concentrations of

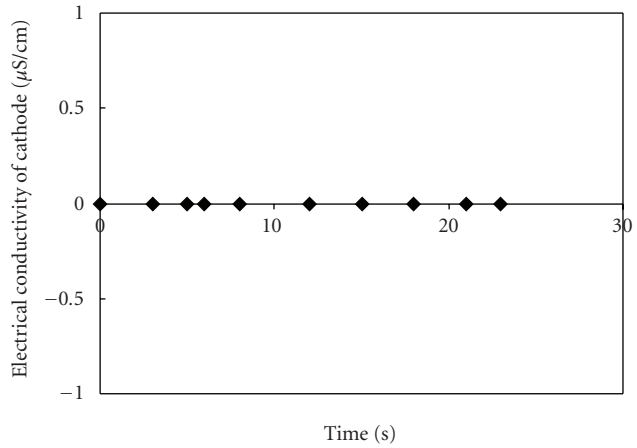

Figure 3: Change of electrical conductivity of cathode side solution when NaCl was added to the anode side solution.

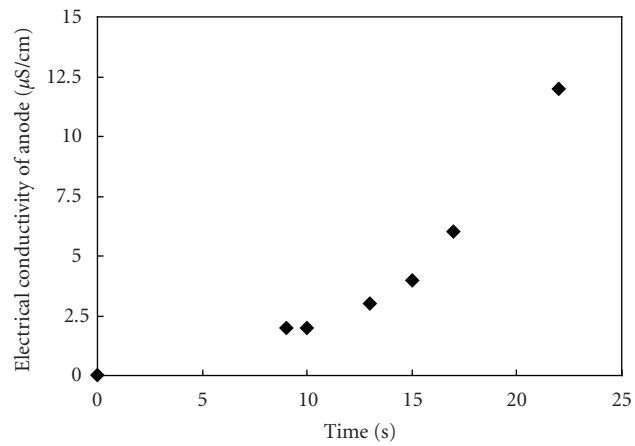

Figure 4: Change of electrical conductivity of anode side solution when NaCl was added to the cathode side solution.

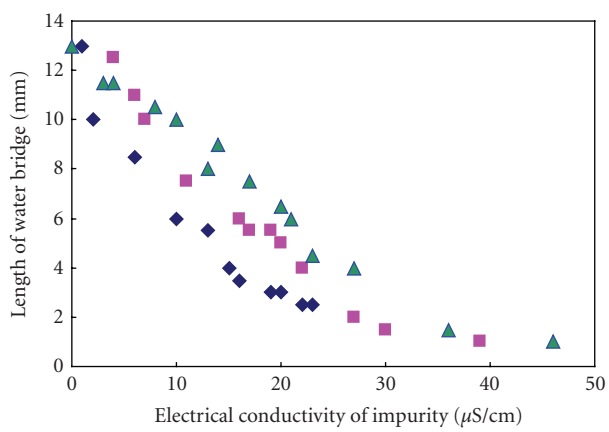

Figure 5: Effect of electrical conductivity of soluble electrolytes on length of water bridge: ▲ NH_4Cl; ■ NaCl; ◆ NaOH.

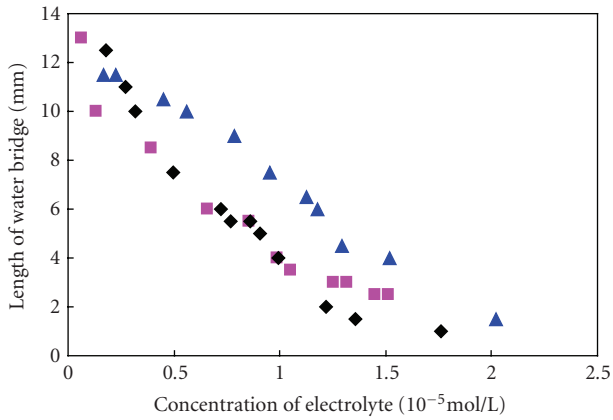

Figure 6: Effect of concentrations of soluble electrolytes on length of water bridge: ▲ NH_4Cl; ■ NaCl; ◆ NaOH.

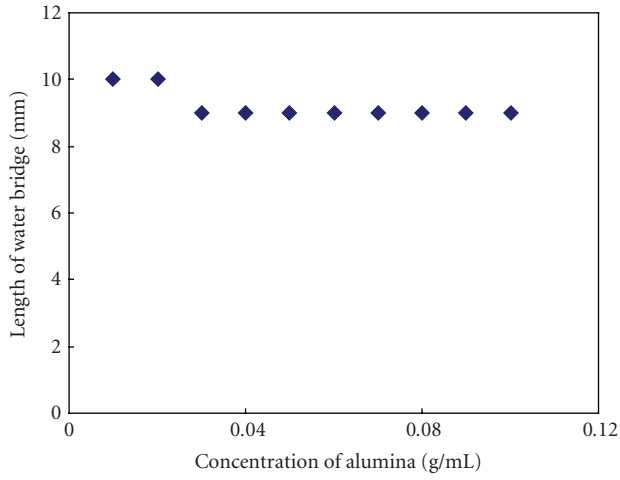

Figure 7: Effect of Al_2Ol_3 on length of water bridge.

electrical conductivities on length of water bridge. Lengths of water bridge decreased as electrical conductivities increased as we expected, although we cannot find regularity among electrolytes.

Figure 6 shows the effect of concentrations of soluble electrolytes on length of water bridge. It is interesting that at the same concentration, the length of water bridge containing NaCl was the same as that of NaOH though that of NH_4Cl was larger. It suggests that ionization degree of electrolyte is one of factors of decreasing water bridge length. When a strong electrolyte such as NaCl or NaOH is added, more ions than weak electrolytes such as NH_4Cl passes through a bridge, and more produced heat disturbs the order of water arrangement kept with dipole moment and makes the length of water bridge shorter.

3.3. Effect of Insoluble Electrolyte on the Bridge. We tried to add insoluble electrolyte Al_2O_3. Figure 7 shows that Al_2O_3 gave little effect on the length of water bridge. It has been thought that does not disturb the aligned structure. A slight decline seems to be caused by greater density.

4. Conclusion

An experimental study on reduction of length of water bridge caused by added electrolytes was carried out.

(1) Flow of the water bridge was observed in the experiment. The direction of flow was from the cathode side to anode side when the electrodes were applied 12 kV.

(2) Adding soluble electrolytes, NaCl, NaOH and NH_4Cl decreased the length of water bridge. Experimental results suggest that ionization degree of electrolyte affects decreasing water bridge length.

(3) Addition of insoluble electrolyte Al_2O_3 to water gave little effects on the length of water bridge.

Acknowledgment

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