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A floating water bridge produces water with excess charge

Elmar C Fuchs[1], Martina Sammer[1], Adam D Wexler[1], Philipp Kunkte[1] and Jakob Woisetschläger[2]

[1] Wetsus, European Centre of Excellence for Sustainable Water Technology, Oostergoweg 9, 8911 MA Leeuwarden, The Netherlands
[2] Institute for Thermal Turbomachinery and Machine Dynamics, Working Group Metrology - Laser Optical Metrology, Graz University of Technology, Inffeldgasse 25A, 8010 Graz, Austria

E-mail: elmar.fuchs@wetsus.nl

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Abstract

Excess positive and negative Bjerrum-defect like charge (protonic and 'aterprotonic', from ancient Greek ἄτερος, 'without') in anolyte and catholyte of high voltage electrolysis of highly pure water was found during the so-called 'floating water bridge' experiment. The floating water bridge is a special case of an electrohydrodynamic liquid bridge and constitutes an intriguing phenomenon that occurs when a high potential difference (~kV cm^{-1}) is applied between two beakers of water. To obtain such results impedance spectroscopy was used. This measurement technique allows the depiction and simulation of complex aqueous systems as simple electric circuits. In the present work we show that there is an additional small contribution from the difference in conductivity between anolyte and catholyte which cannot be measured with a conductivity meter, but is clearly visible in an impedance spectrum.

Keywords: floating water bridge, electrohydrodynamic liquid bridge, EHD, excess charge, impedance spectroscopy

(Some figures may appear in colour only in the online journal)

1. Introduction

We found excess positive and negative Bjerrum-defect like charge [1, 2] in anolyte and catholyte of high voltage electrolysis of highly pure water during the so-called 'floating water bridge' experiment. In order to make a clear distinction between charge defects in the solid state (Bjerrum defects in ice) and the liquid state (this experiment), we suggest a different nomenclature for the charge defects in the liquid, namely protonic and aterprotonic (from ancient Greek ἄτερος, 'without').

The floating water bridge is a special case of an electrohydrodynamic (EHD) liquid bridge and constitutes an intriguing phenomenon that occurs when a high potential difference (~kV cm^{-1}) is applied between two beakers of water. Induced by the field, the water is pulled up to the edges of the beakers and creates a free hanging water string through air connecting the two beakers. The investigation of this phenomenon goes back to the 19th century, when in 1893 Sir William Armstrong reported its discovery [3]. This stable rope of water has gained attention since new measurement techniques have enabled scientists to analyse this phenomenon in detail and it recently received scientific attention from different research fields [4, 5]. Whereas many properties are understood, especially in the macroscopic realm [6, 7], its microscopic properties still call for more research. Recently we described that electrolysis is the reason for proton production, transfer through the bridge and recombination in the catholyte [8]. Protons, which are produced during electrolysis, are mainly responsible for the charge transport through an EHD bridge in water [9]. In this work we show that positively and negatively charged liquid can be extracted from this anolyte and catholyte and characterised by the means of impedance spectroscopy. The existence of water with an excess electric charge under EHD conditions has been reported before [10], including a rationale why the existence of such a substance does not violate the electroneutrality principle. There is a lot of experimental evidence on excess concentration gradients due to local electric

