Atomic force spectroscopy on ionic liquid fuel cell electrolytes

C. Rodenbücher,[1] *D. Mayer,*[2] *Y. Suo,*[1] *K. Wippermann*[1] *and C. Korte*[1]

[1]Institute of Energy and Climate Research (IEK-3)
[2]Institute of Complex Systems (ICS-8)
Forschungszentrum Jülich GmbH, 52425 Jülich, Germany
Email: c.rodenbuecher@fz-juelich.de

Fuel cells will be cornerstones of a future economy that is based on hydrogen as an energy carrier and storage medium. Particularly in automotive applications, polymer electrolyte membrane fuel cells (PEMFCs) are promising devices for providing electrical energy on demand from stored hydrogen, thus allowing for emission-free mobility. Currently, an increase in operating temperature of PEMFCs is being discussed (> 80 °C) which offer a variety of benefits, including simpler control of heat and water distribution, the possibility of reusing excess heat and the avoidance of poisoning of the Pt catalyst [1]. As promising non-aqueous electrolytes for high temperature applications, proton-conducting ionic liquids are considered. These offer a wide electrochemical window, low vapor pressure and high stability [2]. In order to model and design reliable devices, an understanding of the reactions at the electrode-electrolyte interface is of the utmost importance. In contrast to the interface between a metal electrode and an aqueous electrolyte, whose behavior can be described by the classical double-layer theory developed by Helmholtz, Gouy-Chapman and Stern, the behavior of ionic liquids is fundamentally different [3]. Using atomic force spectroscopy, in combination with electrochemical analysis, herein we investigate the structure of the solid-liquid interface between the electrode (graphite, gold or platinum) and model ionic liquids diethylmethylammonium trifluoromethanesulfonate and 1-ethyl-3-methylimidazolium trifluoromethanesulfonate. By measuring force-separation curves using a SiN tip operating in the liquid, we demonstrate that firstly, ionic liquids form a layered interface zone with a thickness of several nanometers. Secondly, we show that an increasing content of the residual water in the ionic liquid will distort the layered interface structure. Ultimately, a transition to the classical double layer behavior occurs. Our results show that the analysis of the fundamental processes taking place in PEMFCs based on ionic liquids is a highly complex task as the intermixing between the electrolyte and water, and must always be taken into account in a fuel cell.

References:

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