How many electrons are transferred during the electrochemical O$_2$ reduction in a Mg$^{2+}$-free / Mg$^{2+}$-containing ionic liquid?

Johannes Schnaidt$^1$, Thuy Linh Nguyen$^2$, Zenonas Jusys$^2$, and R. Jürgen Behm$^{1,2}$

$^1$Helmholtz Institute Ulm (HIU) Electrochemical Energy Storage$^3$, Helmholtzstr. 11, D-89081 Ulm, Germany

$^2$Institute of Surface Chemistry and Catalysis, Ulm University, Albert-Einstein-Allee 47, D-89081 Ulm, Germany

$^3$Karlsruhe Institute of Technology (KIT), P.O. Box 3640, D-76021 Karlsruhe, Germany

ABSTRACT

Aiming at a better understanding of the air electrode processes in Mg-air batteries, we studied the influence of Mg$^{2+}$ ions on the oxygen reduction (ORR) and oxygen evolution (OER) reactions in the ionic liquid 1-butyl-1-methylpyrrolidinium bis(trifluoromethanesulfonyl) imide (BMP-TFSI) by differential electrochemical mass spectrometry (DEMS). The numbers of electrons transferred per reduced O$_2$ molecule were determined in cyclic voltammetry (CV) and potential step measurements, both in absence and presence of Mg$^{2+}$. The numbers of transferred electrons indicate that in neat BMP-TFSI a transition from superoxide to peroxide formation takes place when applying more negative potentials. In the presence of Mg$^{2+}$, the formation of superoxide can be found in potential step measurements to potentials ≥ -0.4 V and in CV measurements on largely passivated electrode surfaces. In contrast, mainly peroxide is formed when stepping to -1.2 V and at the beginning of the ORR in CV measurements. The formation of superoxide in the presence of Mg$^{2+}$, on the passivated electrode, was found to be partly reversible, as indicated by the evolution of O$_2$ detected via DEMS.

Keywords: DEMS, BMP-TFSI, ORR, Mg$^{2+}$, flow cell

Submitted: 06.04.2018

* Author to whom correspondence should be addressed, email juergen.behm@uni-ulm.de