Analysis of Current at the Surface of a Rocking Disk Electrode

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Abstract

Surface and solution kinetics for redox systems can be reliably and accurately studied using hydrodynamic electrochemical methods, particularly a rotating disk electrode (RDE). The RDE consists of a disk electrode usually made of glassy carbon or noble metals imbedded in a rod of insulating material like Teflon. Momentum and species conservation (convective-diffusion equation) for the RDE has been solved for rigorously, enabling it to be easily applied for electrochemical analyses. In this work, we introduce a recently developed novel electroanalytical tool, the rocking disk electrode (RoDE). A 'four-bar mechanism' translates the rotating motion into a rocking one, in the RoDE.
We simulate both RDE and RoDE using a finite element solver on COMSOL Multiphysics®: In short, we solve for laminar flow and species transport in a two-dimensional axial-symmetric geometry with the electrokinetics accounted for by the Butler-Vohlmer equation at the surface of the electrodes. In the figure attached below, we show the momentum transport for both the RDE and the RoDE, as setup in COMSOL Multiphysics®. Earlier studies have reported the dependence of mass transport and current with the rocking motion, comparing them to the traditional RDE. The current response at the electrode surface gives an insight into the physical phenomena such as reaction rate and momentum transport at the electrode surface. In this poster, we will compare the current response for an applied direct current (DC) potential, at the RoDE for the back and forth motion due to the 'four bar mechanism' with the RDE, validated by experiments. We observe a harmonic response associated with the four bar mechanism which is absent in the RDE. Higher harmonic responses are of particular interest for electrical and electrochemical engineers as they are useful in quantitative evaluation of currents from impurities, bubbles, etc.

Figures used in the abstract

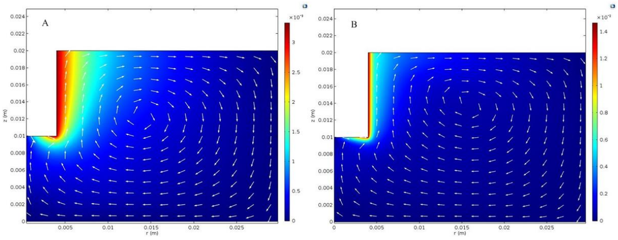

Figure 1: Momentum transport around the RDE (A) and the RoDE (B)