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Direct Observation of Three-dimensional Electroconvective Vortices on a Charge Selective Surface RHOKYUN KWAK, Korea Institute of Science and Technology, JONGYOON HAN, Massachusetts Institute of Technology, TAIKJIN LEE, Korea Institute of Science and Technology, HO-YOUNG KWAK, Chung-Ang University — We present a visualization of three-dimensional electroconvective vortices (EC) by ion concentration polarization (ICP) on a cation selective membrane. The vortices are initiated between two transparent Nafion membranes under no-shear/shear conditions with various applied voltages and flow velocities. Fluorescent imaging and spatial Fourier transform allow us to capture vortex structures. In this 3-D system, EC shows three distinguished structures: i) polygonal shapes with no-shear and ii) transverse and/or iii) longitudinal vortex rolls with shear flow, which is reminiscent of 3-D Rayleigh-Benard instability. Under shear flow, as flow velocity (Reynolds number: Re) increases or voltage (electric Rayleigh number: Ra) decreases, pure longitudinal vortices are presented; in the inverse case, transverse vortices are also formed. It is noteworthy that if we confine EC in quasi 2-D system with high Ra (>10,000), we obtain pure transverse vortices (Kwak et al., PRL, 110, 114501 (2013)); high Ra induces chaotic EC in this 3-D system, instead of 2-D stable transverse vortices. To the best of our knowledge, this is the first direct observation of 3-D EC, which will occur in realistic electrochemical devices, e.g. electrodialysis.

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