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Micromodel of a gas diffusion electrode tracks in-operando pore-scale wetting phenomena

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The conversion of anthropogenic CO2 emissions into valuable products in gas-fed electrochemical reactors using electricity from renewable sources is a promising solution to combat global warming. To move the chemical industry towards a closed carbon cycle, the usage of gas diffusion electrodes (GDEs) will help overcome mass transport limitations in electrochemical CO2 reduction.[1][2]
Most gas-fed electrochemical reactors suffer from the flooding of GDEs within a few hours of operation, which effectively prevents stable long-term operation.[3] However, parameters which favor or prevent flooding events are not yet fully understood In addition, investigation and visualization of these parameters is challenging in conventional electrochemical reactors. In this work, we present a microfluidic model structure with multi-scale porosity featuring heterogeneous surface wettabilities to represent the behavior of a conventional GDE realistically. We establish a gas-liquid-solid phase boundary within a conductive, highly porous structure. A literature-known catalyst layer composed of silver nanoparticles and Nafion binder enables the realistic reproduction of conditions at gas-liquid-solid-interfaces seen on GDE surfaces. Especially conditions in which electrodes are partially or fully flooded can be readily investigated by our in-operando visualization method, allowing the study of wetting phenomena with confocal laser scanning microscopy. We show, that wetting of the catalyst layer is not fully reversible and demonstrate the influence of different pore sizes on GDE flooding. Application of electric potential results in the destabilization of the phase boundary and partial flooding of the electrode, thus, electrowetting is shown to have a major influence in the durability of GDEs. The influence of catalyst and binder on the advancing wetting front was investigated seperately using 3D saturation curves. This allows insights into the wetting state of electrodes based on correlations between the course of the saturation curve and the actual visualized wetting state.
Moreover, fluorescence lifetime imaging microscopy facilitates the observation of reactions on the surface of the model electrode, for the first time enabling the identification of active GDE areas, while at the same time visualizing the wetting state of the electrode. The presented results lay the foundation for the optimization of GDEs towards long-term operation of full-scale gas-fed electrolyzers.
With the aid of our microfluidic model, in-depth investigations on multi-phase wetting phenomena as well as reaction mapping are made possible, both of which are challenging or even impossible to obtain in conventional reactors. In addition, our findings may advise the design of and process conditions for larger-scale electrochemical processes. Parts of these results were recently published by our group.[4]

Participation

In-Person

References

[1] O. S. Bushuyev, P. De Luna, C. T. Dinh, L. Tao, G. Saur, J. van de Lagemaat, S. O. Kelley, E. H.Sargent, Joule 2018, 2, 5 825.
[2] P. De Luna, C. Hahn, D. Higgins, S. A. Jaffer, T. F. Jaramillo, E. H. Sargent, Science 2019, 364, 6438.
[3] M. E. Leonard, L. E. Clarke, A. Forner-Cuenca, S. M. Brown, F. R. Brushett, ChemSusChem 2020, 13, 2 400.

[4] A.M. Kalde, M. Grosseheide, S. Brosch, S. V. Pape, R.G. Keller, J. Linkhorst, M. Wessling, Micromodel of a Gas Diffusion Electrode Tracks In-Operando Pore-Scale Wetting Phenomena, Small. 18 (2022) 2204012. https://doi.org/10.1002/smll.202204012.

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