Surface Reaction Engineering for Hydrogen Energy Materials in Solid Oxide Cells

The primary obstacle to extending the operational lifespan of solid oxide fuel/electrolysis cells (SOFCs/SOECs) operating at intermediate temperatures lies in overcoming suboptimal initial performance and mitigating performance degradation over time [1]. For instance, SOFC/SOEC oxygen electrode materials are prone to persistent surface degradation caused by intrinsic and extrinsic factors, such as Sr segregation, and various contaminants (mainly Cr and Si), originating from the electrode lattice, metal interconnects, and furnace refractories [2,3]. Despite extensive research, effective solutions have yet to be found, limiting these technologies' durability and commercial viability.

Here, we tackle these barriers simultaneously by introducing selected surface coating additives with controllable acidity/basicity on surface oxygen exchange kinetics (k_{chem}). Surface acidity/basicity of oxygen electrode materials can be tuned through a simple infiltration approach. While the impact of acidity/basicity surface treatment on the k_{chem} of electrodes was demonstrated [4], their utilization for recovering degraded performance and enhancing tolerance against poisoning remains open and holds great potential for practical applications requiring long lifetimes.

In this work, we demonstrate that controlling the surface electrode pH through the application of selected additive coatings can i) significantly reverse performance degradation caused by acidic Cr and Si poisoning [5-7] and ii) substantially enhance the tolerance of k_{chem} to acidic poisoning, thereby extending device lifetimes. This approach not only effectively restores the k_{chem}, area-specific resistance, and fuel cell power density - measured via electrical conductivity relaxation, AC impedance spectroscopy, and I-V-P characteristic, respectively - but also remarkably reduces the degradation rate of the oxygen exchange reactions. These findings highlight controlled surface acidity/basicity as a powerful strategy for reactivating degraded surface reactivity of SOFC/SOEC oxygen electrodes and improving their tolerance to acidic poisonings, thereby accelerating their commercialization.

References

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