Polarity governed selective amplification of through plane proton shuttling in proton exchange membrane fuel cells

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Abstract

Graphene oxide (GO) anisotropically conducts protons with directional dominance of in plane ionic transport (σ IP) over the through plane (σ TP). In a typical H_2–O_2 fuel cell, since the proton conduction occurs through the plane during its generation at the fuel electrode, it is indeed inevitable to selectively accelerate GO's σ TP for advancement towards a potential fuel cell membrane. We successfully achieved ∼7 times selective amplification of GO's σ TP by tuning the polarity of the dopant molecule in its nanoporous matrix. The coexistence of strongly non-polar and polar domains in the dopant demonstrated a synergistic effect towards σ TP with the former decreasing the number of water molecules coordinated to protons by ∼3 times, diminishing the effects of electroosmotic drag exerted on ionic movements, and the latter selectively accelerating σ TP across the catalytic layers by bridging the individual GO planes *via* extensive host guest H-bonding interactions. When they are decoupled, the dopant with mainly non-polar or polar features only marginally enhances the σ TP, revealing that polarity factors contribute to fuel cell relevant transport properties of GO membranes only when they coexist. Fuel cell polarization and kinetic analyses revealed that these multitask dopants increased the fuel cell performance metrics of the power and current densities by ∼3 times compared to the pure GO membranes, suggesting that the functional group factors of the dopants are of utmost importance in GO-based proton exchange membrane fuel cells.

Keywords:
Physicochemical
Graphene Oxide Membranes