Wettability-Controlled Electrocatalytic Carbon Dioxide Reduction (eCO_2RR)

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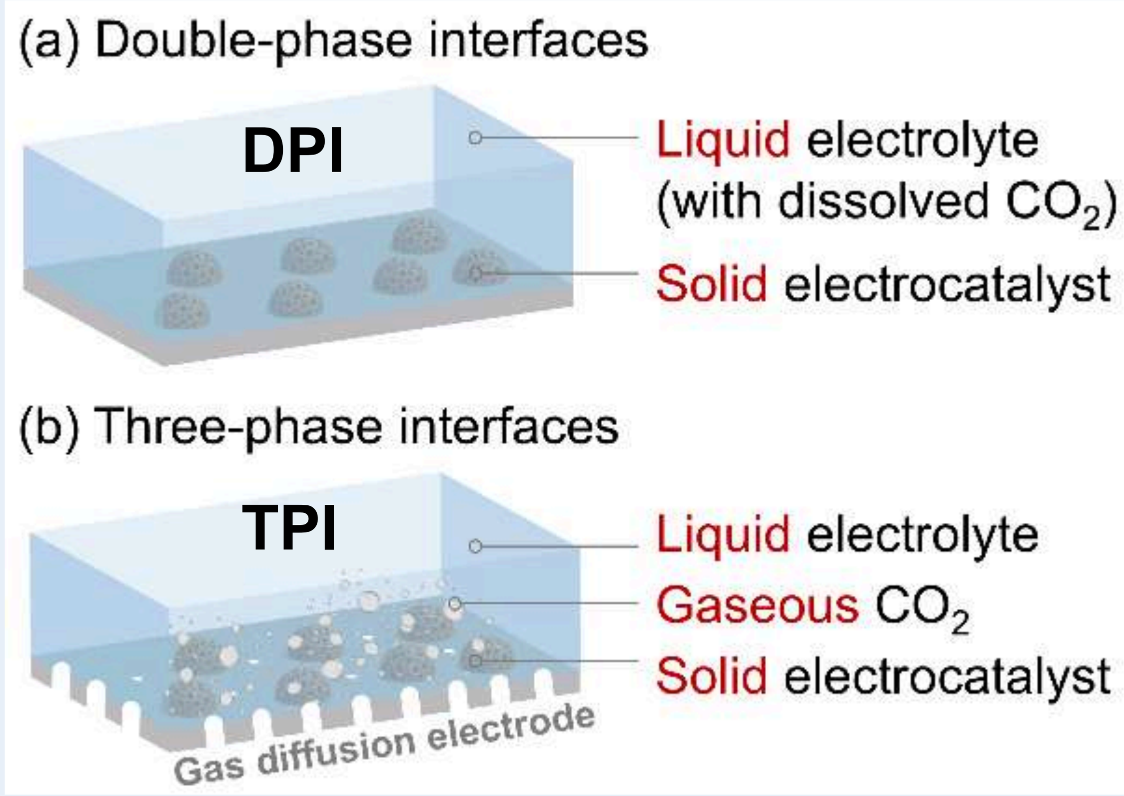
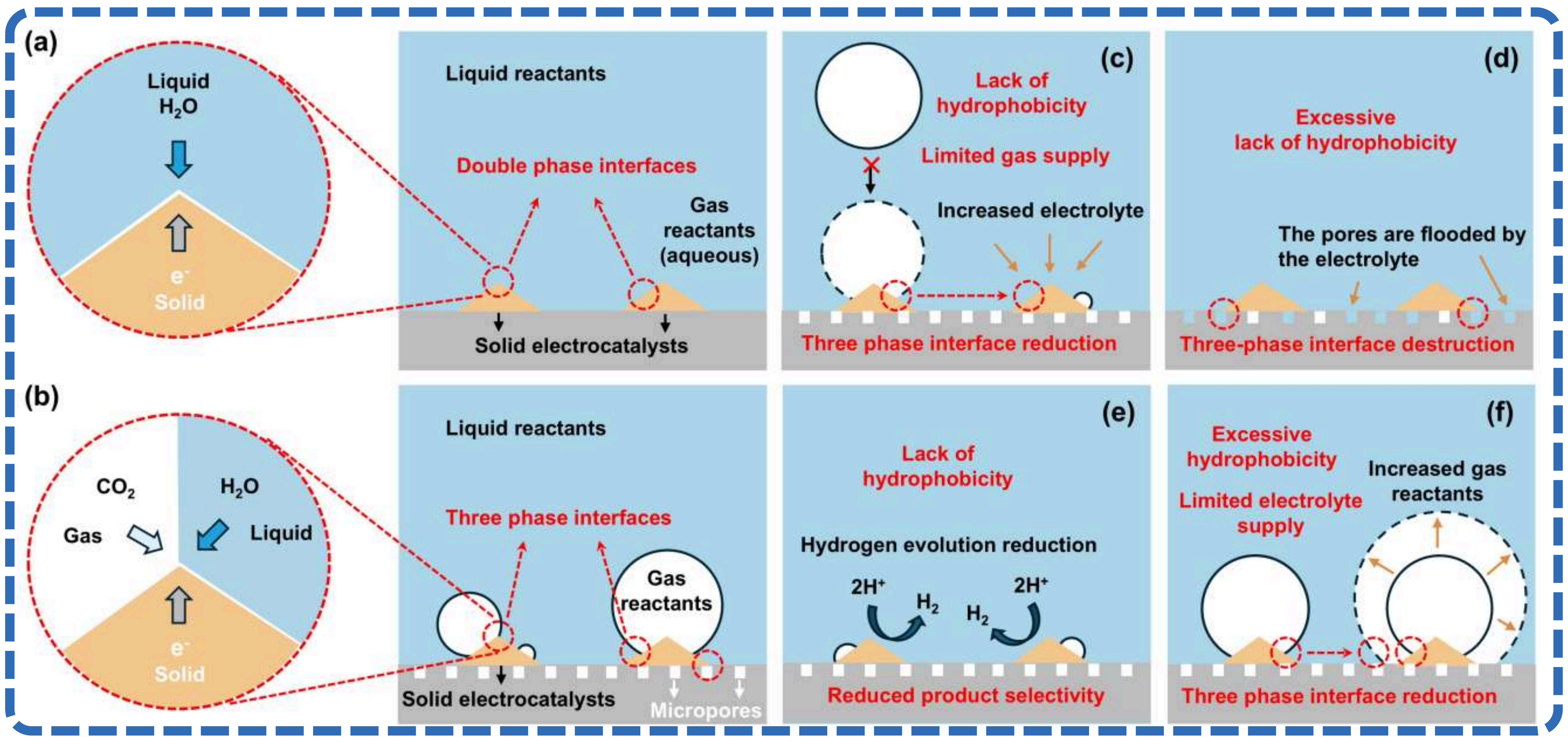
Abstract

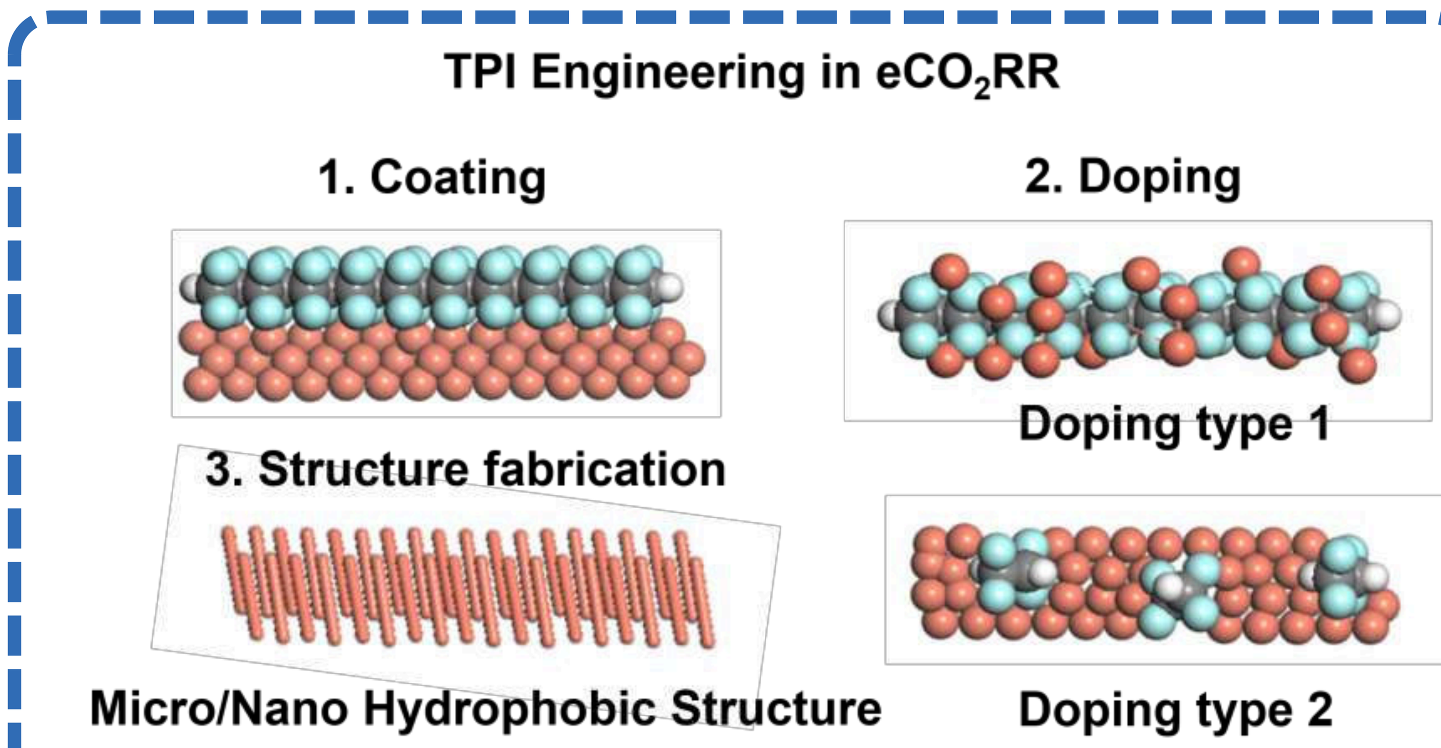
eCO_2RR converts greenhouse gases into valuable products using renewable energy. Optimizing the gas–liquid–solid three-phase interface on the catalyst surface, compared to the traditional liquid-solid two-phase interface, improves CO_2 transport and proton-electron transfer efficiency. This enables high current densities (>100 mA cm^{-2}) and supports large-scale applications. Achieving a balance between hydrophobicity and hydrophilicity is crucial for enhancing electrocatalytic performance.



Current Challenges of TPIs in eCO_2RR



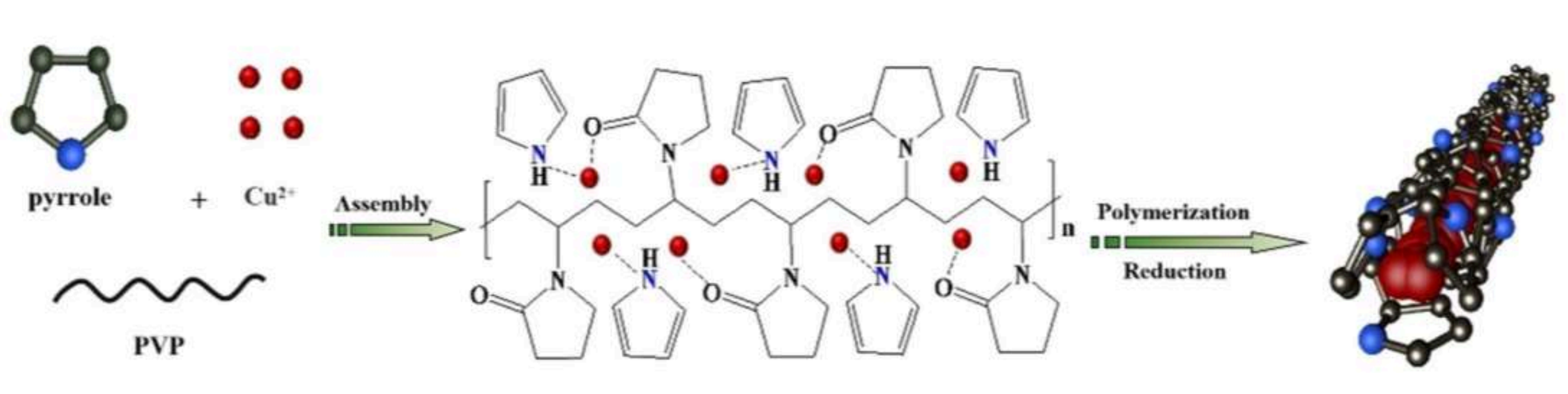
TPI Engineering



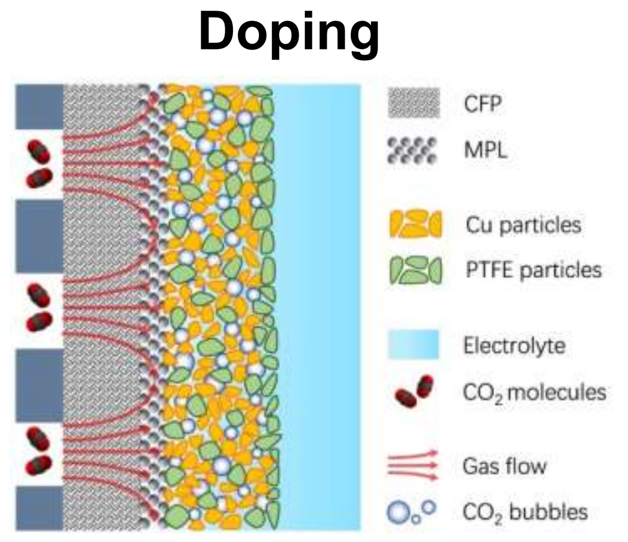
Utilizing interactions between hydrophobic polymeric or molecular species and catalyst surfaces has been demonstrated as an effective strategy for introducing hydrophobicity into gas-diffusion layers.

Strategy Example

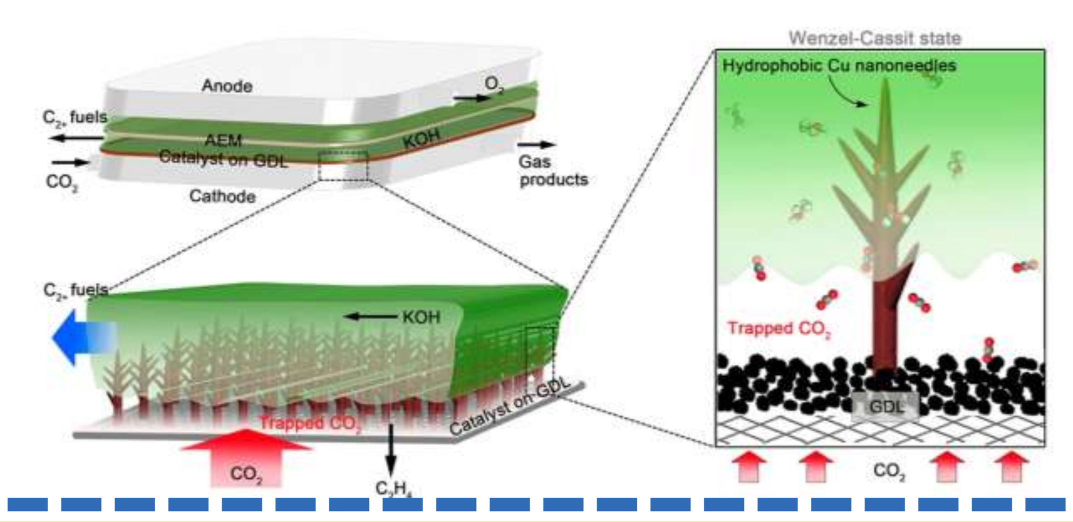
Coating



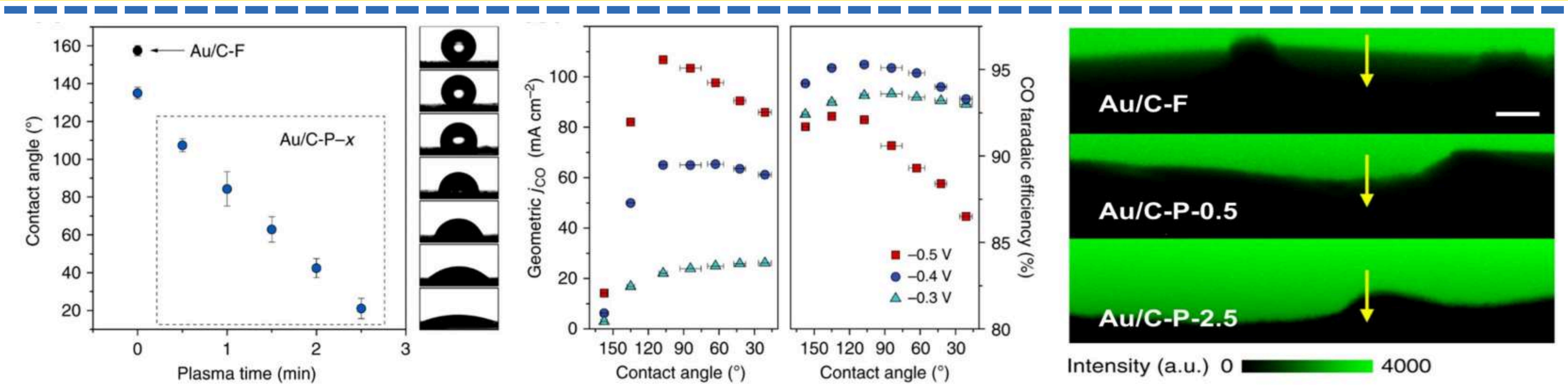
Doping



Hierarchical structure fabrication



Summary and Perspective



(1) Prioritize maximizing TPI over just enhancing hydrophobicity, HER suppression, or CO_2 concentration; a combined strategy may be more effective. (2) Treat wettability changes as direct variables, not linked to hydrophobic material content. (3) Use wettability modulation to improve TPI and control product selectivity by optimizing the CO_2/proton ratio. (4) Account for dynamic TPI wettability changes during electrocatalysis and ensure stability with consistent catalytic performance.

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