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Surface Engineered Pt-Based Core@Shell Catalysts for Durable and High-Performance Heavy-Duty PEMFCs

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○ **초록**

The commercialization of heavy-duty proton exchange membrane fuel cells (PEMFCs) requires oxygen reduction reaction (ORR) electrocatalysts that overcome slow reaction kinetics and transition metal dissolution under harsh operating conditions. Here, we report advanced Pt-based core@shell catalytic architectures engineered through tailored strain, ligand, and surface protection effects. First, PtCo@Pt nanoparticles with atomic layer Pt shells were synthesized via mild hydride transfer using Hantzsch ester, optimizing compressive strain and reducing d-band vacancy to enhance both intrinsic activity and stability. To mitigate severe Pt dissolution and subsequent membrane degradation during heavy-duty operation, trace gold (Au) was incorporated into the shell via pH controlled galvanic replacement and post annealing. The resulting PtCo@PtAu catalyst suppresses surface Pt oxidation and improves mass transport through hydrophobic surface modulation, exhibiting 97% mass activity retention after accelerated durability testing and meeting DOE durability targets. This work provides practical design principles for durable, high power PEMFC catalysts.

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