Solid-Phase Mechanosynthesis as a Pyrolysis-Free Production Approach for Single-Atom Catalysts

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Hydrogen technology emerges as a crucial industry to address pressing environmental concerns, with fuel cells standing out as key devices driving its advancement. Nevertheless, the efficiency of fuel cells is impeded by the oxygen reduction reaction (ORR), necessitating efficient catalysts. Single-atom catalysts (SACs), particularly M-N-C configurations, emerge as promising candidates due to their affordability, stability, and enhanced efficiency.[1] However, traditionally, SAC synthesis involves pyrolysis of metal-carbon-nitrogen precursors, presenting drawbacks such as high energy consumption, exhaust of by-products, and structural randomness.[2] Alternatively, liquid-phase doping of carbon matrices with macrocyclic metal complexes, like phthalocyanines and porphyrins, offers better control while maintaining high catalytic efficiency.[3] However, solvent-based approaches suffer from downsides such as excessive solvent use, substantial waste generation, and material consumption.[4]

Herein, we present a novel approach for the production of a highly conjugated metal polyphthalocanine complex derivative based solely on solid-phase mechanosynthesis. This method overcomes the limitations of conventional techniques, ensuring reaction control comparable to solvent-based procedures. The proposed method's straightforward nature, compared to conventional pyrolysis, offers improved sustainability, lowering waste production and improving atom utilization. Furthermore, the solid-phase mechanosynthesis ensures superior structural control compared to pyrolysis and facilitates further enhancements in the catalyst's architecture. The presented method offers a viable solution to the challenges associated with ORR and represents a step forward in green and efficient catalyst synthesis.

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References

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