Disordering by Design: High-Entropy Alloy Nanocrystals via Galvanic Replacement Reactions for Catalytic Applications

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High-entropy alloy (HEA) nanocrystals, composed of multiple metallic elements randomly distributed within a single crystalline phase, represent a powerful platform for catalysis. However, achieving uniform composition, well-defined morphology, and single-phase character under mild (room temperature) synthetic conditions remains a significant challenge. Building on our previous work employing galvanic replacement reactions (GRRs) for the synthesis of hollow nanocrystals[1-5], we present a sequential GRR strategy that enables spatially and temporally controlled incorporation of diverse metal precursors into a sacrificial template. The approach capitalizes on the high enthalpic penalty associated with phase segregation at the nanoscale, where the formation of internal interfaces and segregated domains is energetically disfavored due to high surface and interfacial energies[6]. To direct this transformation, the protocol systematically optimizes surfactants and co-reducing agents to finely tune reduction kinetics, suppress secondary nucleation, and promote controlled transformations. As a result, robust solid templates evolve into porous, anisotropic, and compositionally homogeneous HEA nanocrystals which exhibit significantly enhanced catalytic activity and durability. The work establishes a versatile and generalizable route for synthesizing architecturally complex, compositionally tunable HEA nanocatalysts, providing a foundation for the rational design of multimetallic materials.

References

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