## ABSTRACT:

# Molecular Precursor Strategies for Compositionally Complex and High-Entropy Electrocatalysts

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Controlling the properties of nanomaterials has traditionally relied on size regulation; however, precise size control often requires complex synthetic protocols, costly stabilizing agents, and can present challenges for scalability. An emerging alternative paradigm is to tailor material properties through compositional engineering, enabling the development of solid solutions and compositionally complex materials with tunable functionality.

In this talk, I will present our approach using molecular precursors as a versatile platform for the rational design and synthesis of multicomponent nanomaterials. A key challenge in forming homogeneous solid solutions lies in balancing the relative reactivity of different precursors, as mismatched reaction kinetics often lead to phase segregation rather than uniform substitution. By systematically exploring precursor chemistries and synthetic conditions, we demonstrate the controlled preparation of a range of cationic and anionic solid solutions with tunable composition, structure, and physicochemical properties. Building on this strategy, we further extend the approach to the synthesis of medium- to high-entropy materials derived from carefully selected precursor combinations, where configurational entropy contributes to the stabilization of complex multicomponent phases. Electrochemical investigations reveal that these compositionally engineered electrocatalysts exhibit promising activity toward key energy conversion reactions, including the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER). Importantly, tuning composition provides an effective route to optimize catalytic performance without relying solely on nanoscale size effects [1–4].

This composition-driven strategy highlights a scalable and versatile pathway for designing advanced functional nanomaterials, offering new opportunities for the development of efficient and sustainable electrocatalysts.

[1] Khan et al. ACS Applied Energy Materials 3 (2), 1448-1460.
[2] Malima et al. RSC advances 11 (49), 31002-31014.
[3] Malima et al. Scientific Reports 13 (1), 22179
[3] Shombe et al. RSC advances 12 (17), 10675-10685