Catalytic synergies in multimetallic nano and subnanoparticles for hydrogen evolution reaction (HER)

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Key words: Multimetallic, subnanoparticles, hydrogen evolution reaction

Many unexpected catalytic performances between nanoparticles (NPs) and subnanoparticles (SNPs) were found in recent years. It was prospected to discover other unique catalytic performance of SNPs[1,2]. Moreover, it is desired to systematically investigate the differences between NPs and SNPs. HER, due to its simple reaction mechanism, was selected as the probe reaction for investigating intrinsic properties of catalysts. Metals can be categorized into oxyphilic metals and oxyphobic metals, at nanoscale the mixing of bimetals tend to form segregated phase, while phase segregation can be avoided at subnanoscle. If we mix oxyphobic metals and oxyphyic metals that never mix at nanoscale, it is possible we acquire fully alloyed metal and metal oxides with enhanced catalytic performance.

In this work, PtZr SNPs and NPs were prepared. XPS confirmed the existence of Pt and Zr oxides. Combine with STEM images, we determined the successful preparation of fully alloyed PtZr SNPs and phase segregated PtZr NPs and the enhanced catalytic activity of PtZr SNPs were observed. To test the university of this discovery, we systematically investigated a series of multimetalllic SNPs and NPs. To find the rules in all the combinations, we established a hydrogen synergistic effects index(HSI) for evaluating the synergistic effects between different elements. It demonstrated that SNPs can be a series of more potential material for HER than NPs. Among bimetallic combinations, we found that some rules were found when we regulated the HSI of different combinations according to periodic table.

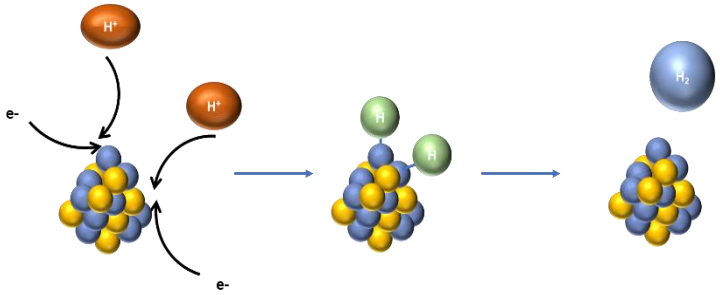

Fig 1. Hydrogen evolution process on bimetallic SNPs.

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