Synthesis of 1 nm Platinum-Group High-Entropy-Alloy Nanoparticles by Flow Reactor and Evaluation of Their Hydrogen Evolution Catalytic Activity

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Recently, high-entropy-alloy nanoparticles (HEA NPs) are widely attracted attention because of their superior catalytic performance. For example, 5 nm RuRhPdIrPt HEA NPs showed a remarkably high HER activity compared with commercial Pt[1]. Although the smaller HEA NPs are desirable for catalytic use, most of the reported synthesis techniques of HEA NPs cannot provide ultra-small-sized NPs because they stabilize the solid-solution phase under extreme conditions such as high temperature accelerating the particle aggregation[2]. In this study, we first synthesized 1.5 nm RuRhPdIrPt HEA NPs by a liquid-phase reduction method using an originally developed flow reactor enabling inert synthesis conditions. The obtained NPs were characterized by scanning transmission electron microscopy (STEM) and powder X-ray diffraction (PXRD). Elemental maps suggested the successful mixing of five elements at the atomic level (Figure a). PXRD pattern of the obtained NPs showed very broad peaks indicating a fcc structure with small particle size. Moreover, we investigated their electronic structure and HER catalytic activity that plays an important role in energy conversion for the development of hydrogen-based energy resources. The 1.5 nm HEA NPs showed much higher activity than commercial Pt which is a benchmark catalyst for HER.

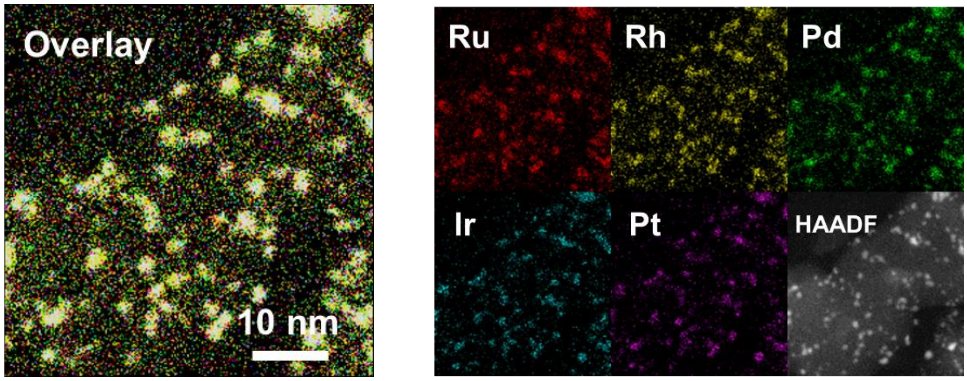

Figure STEM-EDX Maps

1) D. Wu *et al*., *Chem. Sci*., **2020**,11, 12731-12736

2) S. Gao *et al*., *Nat.Commun*., **2020**,1, p. 2016