Synthesis and Characterization of Ternary FeRhRu Alloy Nanoparticles

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Keywords: Nanoparticles; Crystal Structure; Alloy

The crystal structure of metals affects their properties such as the catalytic properties because the electronic structure and surface structure of metals change with their crystal structures. However, most metals do not have multiple crystal structures. Recently, metal nanomaterials with unconventional phases have been developed through bottom-up synthesis methods.[1] For example, fcc and hcp RuIrPt solid-solution alloy nanoparticles (NPs) were selectively synthesized and the hcp alloy showed higher catalytic activity than the fcc alloy.[2]

In this study, we focused on Fe–Ru–Rh alloy system to control the crystal structure because Fe, Ru, and Rh have bcc, hcp, and fcc structures, respectively. We synthesized Fe–Ru–Rh ternary alloy nanoparticles by the liquid-phase reduction method. Then, the obtained NPs were characterized by scanning transmission electron microscopy (STEM), energy-dispersive X-ray spectroscopy (EDS), powder X-ray diffraction (PXRD) and X-ray fluorescence (XRF). Elemental maps suggested successfully mixing the three elements at the atomic level (Figure). The obtained NPs showed the fcc-rich phase containing 20 % hcp fraction and the composition of Fe:Ru:Rh was about 1:1:1. We have confirmed the phase transition from fcc-rich structure to hcp and B2 structure by heating. The structural dependence of their catalytic properties for hydrogen evolution reaction (HER) was investigated in 1M KOH. The fcc-rich alloy NPs showed higher catalytic activity than the hcp and B2 structured alloy NPs, which were superior to commercial platinum catalyst.

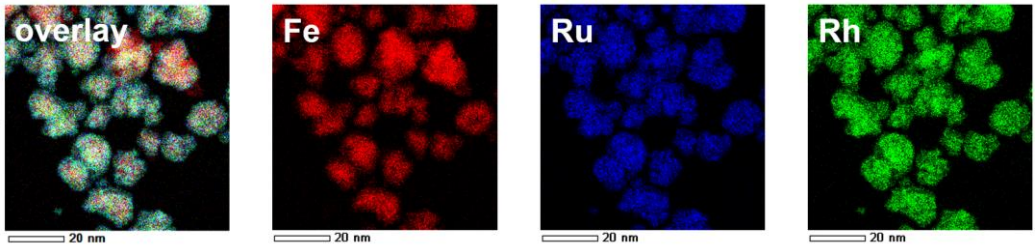

Figure STEM-EDS Maps of Fe–Ru–Rh ternary alloy before heating

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