The Structure Transformation of Electrocatalysts in Anodic Oxidation Reaction

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Abstract. The impact of structural transformations on electrocatalytic reactions is significant and can greatly influence the efficiency and performance of electrochemical processes. Structural transformations refer to changes in the composition, morphology, and configuration of the catalyst material. Revealing structural transformations could involve changes in surface morphology, active sites exposure, or electronic structure modification, resulting in enhancing the catalytic activity of materials, leading to optimize electrocatalytic performance. Moreover, changes in the catalyst's structure may influence electron transfer pathways, affecting the kinetics of the electrocatalytic reaction. Optimizing these pathways can enhance electron transport and reduce energy losses, leading to improved overall efficiency. Recently, we found that under electrochemical reaction, the structure of various materials, including metal-organic framework (MOF) and amorphous binary metal oxide are so sensitive to be changed in alkaline electrolytes, which were characterized by in-situ synchrotron techniques, including high-resolution X-ray diffraction and X-ray absorption spectroscopy, etc. In water splitting reaction, Co-Mo-MOFs as electrocatalysts for oxygen evolution reaction (OER) will be reacted in alkaline electrolyte to form highly porous gyroid morphology with large surface area, resulting in demonstrating a superior OER electrocatalytic activity with a low overpotential of 210 mV at a current density of 10 mA cm^{-2} and small Tafel slope of 50 mV dec^{-1} in alkaline solution. In other case on urea electrooxidation reaction, High-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM), corresponding energy-dispersive X-ray spectroscopy (EDS), and in-situ X-ray absorption spectra (XAS) were employed to elucidate the structural transformation from Co-Ni hydroxide to blending CoOOH-$Ni(OH)_2$ nanoclusters during the reaction. The blending CoOOH-$Ni(OH)_2$ nanoclusters exhibited superior electrocatalytic activity for UOR in alkaline environment, achieving low onset potential of 1.24 V (vs. RHE) in 1M KOH with 0.5M urea. Overall results indicated that the impact of structural transformations on electrocatalytic reactions is multi-faceted, influencing catalytic activity, durability, selectivity, and overall performance. Controlled and strategic modifications of catalyst structures are essential for advancing the field of electrocatalysis and developing more efficient energy conversion technologies.

References

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