Operando X-ray study of the hybrid Co/$Co(OH)_2$-reduced graphene oxide electrocatalyst for alkaline water splitting

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Abstract

Catalysts for the water-splitting reactions, including hydrogen and oxygen revolution reaction (HER and OER), is the core of renewable energy application for the purpose to decrease the fossil fuel dependence. It is an increasing demand to associate the working mechanism to the specific electrochemical performance, since the catalyst using the transition metal species is devoted to replace the noble metal (i.e. Pt and Pd) for the similar activity but lower cost. Here, we propose to fabricate a hybrid materials using the electrodeposition methods owing to the simple, fast, and controllable synthesis. The nanocrystal Co grown on reduced graphene oxide (rGO) or without rGO surface are discussed for the interfacial effect of chemical coupling and synergetic performance. The *in-situ* liquid cell under *operando* soft/hard X-ray measurement becomes the key to open the involving questions of the metal-based bi-catalyst. The element-specific analysis of X-ray technology recovers the chemical composition of electrodeposition Co divided into metal Co and Co^{2+} state owing to the electron transfer process of electrodeposition from the cathodic electrode to Co^{2+} ions of $CoSO_4$ solution. The undelaying RGO films with the electric conductibility and structural defect can maintain the hybrid chemical structure of Co/$Co(OH)_2$ even under the electric potential treatment in alkaline solution for HER and OER. Higher reduction/oxidation current density and lower onset potential than the pristine hybrid Co/$Co(OH)_2$ are seen in the same hybrid film grown on rGO film for the catalytic enhancement. The unusual catalytic activity is deduced from the unique interaction between Co/$Co(OH)_2$ and rGO, which arises a new level for advanced catalyst in the energy conversion application.

Keywords - Keywords – X-ray absorption, In-situ liquid cell, Extended x-ray absorption fine structure, Hydrogen evolution reaction, oxygen evolution reduction.