

CeO_x Modified NiFe-Layer Double Hydroxide for Oxygen Evolution Reaction in Alkaline Solution

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Abstract

Nowadays, Electrical vehicle and metal-air battery has blossomed and attracted various of attention among people and these technologies usually require high efficiency on water splitting reaction. Water splitting($\text{H}_2\text{O} \rightarrow \text{H}_2 + 1/2 \text{O}_2$), ideally driven by solar power, is one of the most efficient and sustainable ways to produce molecular hydrogen(H_2) and oxygen (O_2) gases in high purity. If available, water splitting would have the potential to solve the global urgent energy needs of future societies without any environmental cost. Water oxidation also known as oxygen evolution reaction(OER), one half-reaction of water splitting, has long been the bottleneck due to its four proton-coupled electron-transfer process that requires such a high redox potential.

Herein, we report a newly designed OER nanocatalyst, NiFe LDH(Layered Double Hydroxide) based electrochemical catalyst is decorated by CeO_x (CeO_x/NiFe LDH), to improve its site activity and further the whole catalyst activity. Ni and Fe are earth abundant elements and their product NiFe LDH has been proved as a new benchmark in OER. Meanwhile, having little activity in OER, CeO₂, still could be a nice synergistic catalyst and accelerate the dispersion rate of oxygen in OER revealed from some literatures. In this work, we try to combine these two composites and investigate how partial reduced CeO₂ affect the activity of NiFe LDH.

The 6.28%CeO_x /NiFe LDH derived from the hydrothermal method, has an excellent specific activity($1 \text{ A/cm}^2_{\text{Ni}^{2+}/\text{Ni}^{3+}}$) under 0.1M KOH, almost 5 folds higher than pure NiFe LDH. The XPS results show that there is a strong electronic interactions between NiFe LDH and CeO_x and it leads to an enhanced OER performance. The stability of this catalyst could also be good for its 94% retention under 1M KOH for 24h. Nevertheless, due to the structural damage in NiFe LDH from the second hydrothermal treatment, mass activity of this catalyst is less satisfying.

To further optimize the mass activity, we developed a catalyst, synthesized by the microwave method(6.4%CeO_x/NiFe LDH). In this case, both better mass activity(40.3 mA/mg_{NiFeLDH} at 1.54V_{RHE}) and specific activity(0.33A/cm²) could be achieved. The XAS result reveals that the decoration by CeO_x could decrease the coordination number between Ni-O and Ni-M, creating a more loose structure and larger amount of oxygen vacancies. Finally, 6.4%CeO_x/NiFe LDH with enhanced activity and long-time stability was successfully prepared.

Keywords: Layer double hydroxide(LDH), NiFe LDH, Cerium oxide, Oxygen Evolution Reaction, Water splitting