

Study on Bimetallic Alloy/Carbon Composite Synthesized by One-step Molten Salt Method for Oxygen Evolution Reaction

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論 文 名	Study on Bimetallic Alloy/Carbon Composite Synthesized by One-step Molten Salt Method for Oxygen Evolution Reaction (酸素発生反応のためのワンステップ熔融塩法で合成された二金属合金/炭素複合体の研究)			
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論 文 審 査 の 結 果 の 要 旨

The increasing demand for energy conversion technologies is driving the advancement of renewable energy solutions. Among them, water splitting has emerged as a clean and reliable method to convert electricity generated from solar or wind energy into chemical energy stored as hydrogen. This process involves two half-reactions: the hydrogen evolution reaction (HER) and the oxygen evolution reaction (OER). However, large-scale implementation remains challenging due to the low efficiency and high energy requirements of the OER, highlighting the need for innovative electrocatalysts specifically designed to enhance OER performance. Noble metal-based oxides, such as IrO_2 and RuO_2 , are currently considered the benchmark electrocatalysts for the OER. However, their high cost significantly limits their large-scale practical application.

Non-precious metal/carbon-based composites have attracted significant attention due to their low cost and structural advantages. However, several challenges persist, including complex and time-consuming synthesis procedures, poor catalyst uniformity, limited surface modification potential, and excessive oxidation of metal particles. In this dissertation, an FeNi/carbon composite catalyst was synthesized using the molten salt synthesis (MSS) method to address these issues.

The main findings obtained in this dissertation are as follows.

1. FeNi/carbon composites were successfully synthesized using the MSS method, with glucose serving as the carbon source. The resulting product exhibited a uniform distribution of FeNi particles on the carbon substrate. X-ray diffraction analysis confirmed that the FeNi particles were in the metallic phase. To optimize the OER performance, various ratios of (a) Fe to Ni and (b) precursor to molten salt were investigated, with the optimal ratios determined to be 1:2 and 1:5, respectively.
2. The OER performance of the MSS-prepared composite was investigated and compared with that of a composite synthesized via conventional pyrolysis. The MSS-prepared composite exhibited a significant improvement in OER activity, driven by multiple factors. These include the enhancement of specific surface area and the introduction of surface defects

induced by the molten salt environment. Furthermore, X-ray photoelectron spectroscopy analysis revealed an increased presence of M–O and M–OH species on the surface of the metallic particles, likely resulting from the molten salt synthesis process, which further contributes to the improved OER performance.

3. The effect of synthesis temperature on the OER performance of the FeNi/carbon composite electrocatalyst was further investigated. As the synthesis temperature increased, the morphology of the carbon substrate evolved from a polymer-like framework to a structure composed of graphene-like nanosheets. Higher temperatures promoted the graphitization of the carbon substrate and also led to more favorable surface oxidation states of the metal particles. These structural and chemical changes collectively contributed to the enhanced OER performance of the composite.

In summary, this dissertation explores the development of FeNi/carbon composites synthesized via the MSS method as efficient electrocatalysts for the OER. The effects of key synthesis parameters, including the Fe/Ni ratio, precursor-to-salt ratio, and synthesis temperature, were systematically studied, and the underlying factors influencing performance were thoroughly analyzed. The resulting electrocatalyst exhibited excellent OER activity and stability. These findings offer valuable insights and make a significant contribution to the advancement of electrocatalyst design and development. Therefore, this dissertation is deemed worthy of the degree of Doctor of Engineering.