Journal of Physics and Chemistry of Solids

The upgraded performance of the NiFe2O4 /C electrocatalyst using Co substitution for the oxygen reduction reaction in an alkaline solution

Mphoma S. Matseke[a,b], Hongze Luo[a], Lei Wen[c], Haitao Zheng[a,*]

[a]Energy Centre, Council for Scientific and Industrial Research (CSIR), P O Box 395, Pretoria, 0001, South Africa

[b]Department of Chemical Sciences, University of Johannesburg, PO Box 524, Auckland Park, Johannesburg, 2006, South Africa

[c]Institute of Metal Research (IMR), Chinese Academy of Sciences (CAS), 72 Wenhua Road, Shenyang, Liaoning, 110016, China

https://www.sciencedirect.com/science/article/pii/S0022369722000725

Abstract

NiFe2O4 is one of the most abundant and inexpensive spinels; however, its activity toward the oxygen reduction reaction (ORR) is relatively low. For the first time, Co-substituted Fe partly of the NiFe2O4 electrocatalyst was studied to improve the intrinsic activity of ORR. Spinel-type NiFe2-xCoxO4/C electrocatalysts (x = 0, 0.25, 0.5 and 0.75) were synthesized by the hydrothermal method without further calcination. The well-crystallized NiFe2O4/C nanoparticles remained in a single phase after Co-substituting with sizes of 15–20 nm, characterized by TEM, SEM, XRD, and FTIR. XPS observes mixed valence states in the NiFe2-xCoxO4/C structure are observed, which has a beneficial effect on ORR. Furthermore, NiFe2-xCoxO4/C nanoparticles (x = 0.25, 0.5 and 0.75) show advanced ORR performance over NiFe2O4, particularly, the specific mass activity of NiFe1.75Co0.25O4/C is three times higher than that of NiFe2O4, also, with improved stability. After 4,000s, the NiFe1.75Co0.25O4/C electrocatalyst retained 84% of its initial current density, while the NiFe2O4/C electrocatalyst retained only 38%. The results revealed that Co substitutions have remarkably increased the intrinsic activity of the NiFe2O4 electrocatalyst for ORR by altering the structure, redistributing cations, and improving electrical conductivity.