MICROWAVE Ir OXIDE-ENCAPSULATED SPRAY PYROLITIC MICROSPHERES OF RARE EARTH OXIDES AS AN ELECTROCATALYST FOR OXYGEN EVOLUTION

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Abstract

Water electrolysis, powered by sustainable energy sources, represents a key technology for a green hydrogen production, offering a clean and renewable energy solution. However, the efficiency of this process is primarily constrained by the sluggish kinetics of the oxygen evolution reaction (OER), which significantly increases the overall energy demands. To overcome this limitation, highly active and stable OER catalysts are required to enhance reaction efficiency and reduce energy losses. Among the known OER catalysts, iridium (IV) oxide (IrO_2) is considered the most effective due to its exceptional activity and durability in acidic environments. Nevertheless, given the high cost and scarcity of iridium, optimizing its utilization and catalytic efficiency is crucial. This can be achieved through the development of advanced synthesis strategies and the incorporation of interactive supporting materials that enhance catalytic performance while minimizing Ir consumption. This study presents an innovative synthesis approach that combines ultrasonic spray pyrolysis (USP) for the preparation of rare-earth-based oxide as catalyst carrier with their subsequent microwave hydrothermal encapsulation by IrO_2. Ce/Y (∑M) oxide supports were synthesized using a one-step USP process in which precursor aqueous solutions of $CeCl_3$ and $Y(NO_3)_3$ were mixed in mole ratios of Ce:Y=4:1 and Ce:Y=1:4. The conversion temperature during spray pyrolysis was regulated using a thermostated furnace, ensuring uniform particle formation and phase composition. The nebulization and aerosol formation process was carried out in an oxygen atmosphere, with a controlled carrier gas (oxygen) flow rate of 2 dm^3 min^{-1}, while the synthesis temperature was maintained at 800 °C to promote the formation of CeO_2/Y_2O_3 composite structures with the desired crystallinity and morphology. Following the synthesis of oxide USP powders, the materials were further processed via microwave hydrothermal treatment in the presence of $IrCl_3$ under constant temperature conditions, leading to the formation of composite materials with varying IrO_2 mole ratios (projected to ∑M:Ir=3:7 and ∑M:Ir=7:3). The resulting composites of IrO_2-shelled CeO_2/Y_2O_3 microspheres were systematically characterized to assess their electrochemical properties and catalytic activity for OER. Particular emphasis was placed on evaluating the synergistic effects of CeO_2 and Y_2O_3 within the composite structures, as well as their role in enhancing the catalytic performance of IrO_2. The study provides insight into how the interaction between these oxide catalyst carriers and IrO_2 influences overall OER efficiency, shedding light on potential strategies for improving the sustainability and cost-effectiveness of high-performance water-splitting catalysts.

Keywords: *oxygen evolution reaction; oxygen-evoloving anodes; electrocatalytic powders; electrochemical charaterization of powders.*

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