El Salvadoran Co-encapsulated Photonics High Temperature Resistance

Overview

Photonics roadmap for ultra-high-temperature thermophotovoltaics. In this perspective, we present a new approach to ultra-high temperature thermophotovol.

Key Takeaways

Encapsulated Co–Ni alloy catalysts exhibit exceptional high-temperature resistance, maintaining 90% energy efficiency and over 2,000 hours of stable operation at 800 °C.

Material Composition and Structure

The high-temperature resistant system consists of a cobalt–nickel (Co–Ni) alloy core encapsulated in a Sm_2O_3-doped CeO_2 (SDC) oxide shell. This encapsulation provides multiple benefits: it prevents metal agglomeration, enhances CO_2 adsorption, and moderates CO binding, which collectively improve both catalytic activity and thermal stability at elevated temperatures (up to 800 °C). The Co–Ni alloy is typically synthesized in a 1: 1 ratio, and the oxide shell is engineered to optimize the interface for strong CO_2 binding while maintaining selectivity for CO production.

Synthesis Method

The encapsulated Co–Ni system is prepared using a sol–gel method. The process involves dispersing SDC powder in water, adding Co and Ni precursors, and forming a sol with citric acid and ethylene glycol. The mixture is then heated to remove water, followed by calcination at 600 °C to achieve the final encapsulated structure.

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This method ensures uniform coating of the oxide shell and precise control over particle size, which is critical for high-temperature performance.

High-

Temperature Performance

The encapsulated Co–Ni catalyst demonstrates: Energy efficiency: 90% at 800 °COperational lifetime: over 2,000 hours at 1 A cm^{-2}Selectivity: nearly 100% conversion of CO_2 to COSingle-pass yield: up to 90% These properties make it suitable for solid oxide electrolysis cells (SOECs) and other high-temperature electrochemical applications, where maintaining activity without degradation is a major challenge.

Mechanistic Insights

Density functional theory (DFT) simulations reveal that the metal–oxide interface is crucial for performance. While isolated metal or oxide surfaces show weak CO_2 adsorption, the interface facilitates strong carbonate formation, which enhances CO_2 reduction. The oxide shell also moderates CO adsorption, preventing catalyst deactivation over long-term operation.

Potential Applications

Such high-temperature resistant Co–Ni systems are promising for: Industrial CO_2-to-CO conversion for chemical feedstocksEnergy storage and carbon recycling in high-temperature electrochemical cellsPhotonic or catalytic devices requiring thermal stability and long-term operational reliability The combination of co-encapsulation and alloy optimization provides a strategy to overcome the typical trade-off between activity and stability in high-temperature catalytic systems. In summary, co-encapsulated Co–Ni alloys with Sm_2O_3-doped CeO_2 shells represent a robust approach for high-temperature photonic or catalytic applications, offering both thermal resistance and high efficiency suitable for industrial-scale processes.

Article Content

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