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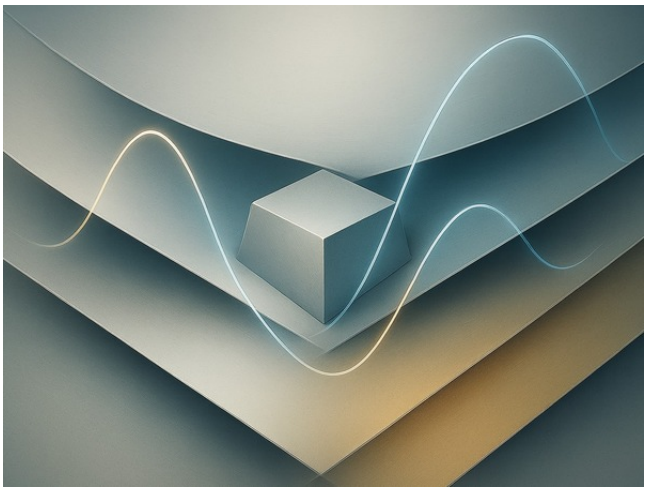
Pt5Ce-Co Intermetallic Nanoparticles as Highly Active Catalyst for Oxygen Reduction Reaction in PEMFCs

Pt_5Ce-Co/C intermetallic nanoparticles deliver higher ORR activity and durability than Pt-only or Pt-Ce baselines, enhancing PEM fuel cell performance.



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Category

Energy & Power Systems/Power Generation
Biotechnology & Life Sciences/Analytical & Diagnostic Instrumentation
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The oxygen reduction reaction (ORR) is an essential chemical process that occurs within a type of electrochemical cell -- the polymer electrolyte membrane fuel cell (PEMFC). PEMFCs demonstrate promise as alternatives to fossil fuel-based energy conversion devices due to their high efficiency and lower environmental impact. However, the high cost and limited durability of current platinum (Pt)-based catalysts limit the commercial viability of these devices. To make PEMFCs a practical alternative to fossil fuel-based devices, more efficient and durable catalysts are needed. Advances in catalyst design have explored alloying Pt with other metals to boost catalytic performance as well as reduce Pt usage. Among these efforts, alloying with rare earth (RE) elements like cerium (Ce) has shown particular promise, as RE elements can alter Pt electronic properties, enhancing activity and stability of the alloys in ORR. Furthermore, the synthesis of Pt-RE alloys has seen great improvements over traditional wet-chemical methods recently, allowing for the development of nanoscale Pt-RE alloys in ambient conditions.

Purdue researchers have developed a PtCe catalyst utilizing cobalt (Co) within the Pt matrix, demonstrating improved electrocatalytic performance to traditional PtCe catalysts. The developed Pt5Ce-Co/C catalyst is synthesized via a two-step reduction method under diluted H2, a method which ensures controlled formation of the desired phases as well as allowing for the modulation of the alloy properties. The developed Pt5Ce-Co/C catalyst demonstrates higher activity for ORR in comparison to other catalysts such as Pt3Co/C and Pt5Ce/C, which can be attributed to the synergetic effects of the Co and Ce when combined with Pt. Furthermore, the Pt5Ce-Co/C catalysts exhibit excellent performance when incorporated into a PEMFC, with a significant portion of the current density remaining after 30,000 cycles. The increased ORR performance and durability of the developed catalyst shows its capacity for use within PEMFC applications, with a specific focus on high-activity applications.

Technology Validation:

-XRD of PtCe and PtCe-Co catalysts was performed, which revealed the packing structure of the alloy as well as the inclusion of the Co within the matrix

-Energy-dispersive X-ray spectroscopy (EDS) mapping confirmed the distribution of Pt, Co and Ce within the nanoparticles as well as the identifying distinct regions corresponding to each element

-Scanning transmission electron microscopy was performed to show particle size of 5 nm as well as confirm nanoparticle shape

-Membrane electrode assembly tests were conducted to evaluate the performance of Pt5Ce-Co/C in PEMFCs, which showed current density of 1876 mAcm^-2 at 0.7 V.

-Cyclic voltammetry and linear potential scan curves were used to determine the ORR of the catalyst in 0.1 M HClO4 solutions

Advantages:

-Enhanced ORR activity when compared to traditional Pt-based catalysts

-Improved durability and long-term stability of catalysts, demonstrating the potential within high-activity applications

-More cost effective when compared to traditional Pt-based catalysts

Applications:

-Fuel cell devices

TRL: 3

Intellectual Property:

Provisional-Patent, 2024-10-04, United States

Utility Patent, 2025-09-09, United States

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