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Case ID:M20-016P^
Published: 5/19/2020

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Functional Nanoglues for Stable Metal Single-Atom and Cluster Catalysts

Background

Recent advances in catalysis by single-atom catalysts (SACs) and cluster catalysts have highlighted the unique catalytic properties of highly dispersed metal species. The use of single metal atoms or small clusters for catalysis is not only cost-effective but also significantly enhances the selectivity of a targeted reaction, resulting in more sustainable development. A critical challenge to practical catalytic applications of supported metal atoms or clusters (such as automotive emissions control) is the lack of stability of these highly dispersed metal species during reaction. This is especially pronounced at high reaction temperatures. Therefore, development of sintering-resistant supported metal atom or cluster catalysts becomes a key avenue for investigation. Most of the recent developments in stabilizing metal atoms or clusters focus on strongly anchoring them to defect sites on support surfaces. Inert refractory materials can be used as sintering-resistant high-surface-area supports but generally do not strongly anchor metal atoms or clusters. Conversely, many reducible metal oxides have high anchoring strength but sinter at elevated temperatures and thus are also not suitable as high-temperature high-surface-area supports.

Invention Description

Researchers at Arizona State University have developed a method by which reducible metal oxide nano-islands act as nanoglues to strongly anchor the metal atoms and clusters to a high-surface-area support. These nanoglues not only stabilize metal atoms and clusters during a catalytic reaction at high temperatures but also provide desirable functions to enhance the activity of a desired catalytic reaction. The manufactured stable catalysts have been tested for CO oxidation, water-gas-shift reaction, reforming of CO2 and methanol, and oxidation of natural gas. Suitable metal atoms include any transition metal (preferably precious metals), while candidates for reducible metal oxides include CeO2 (CeOx), Co3O4 (CoOx), Fe2O3 (FeOx), TiO2 (TiOx), and CuO (CuOx). Materials for high-surface-area refractory support include SiO2 and Al2O3.

Potential Applications

- Automotive or stationary emission control catalysts
- Carbon capture

- Fuel cell catalysts

Benefits and Advantages

- Enhances activity of catalytic reaction
- Enables high-temperature sintering-resistant supports
- Reduces usage of expensive metals for catalysis
- Uses a cost-effective, facile, and scalable wet chemistry method