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MA or PhD Student: Doctoral

Department: Voiland School of Chemical Engineering and Bioengineering

College: College of Engineering & Architecture (VCEA)

Campus: Pullman

Proposal Title

The preparation of porous gold nanoparticle catalysts using switchable surfactants

Proposal Description

The cornerstone of my doctoral research is understanding catalysts consisting of well-defined gold nanoparticles. These materials are ranged in the nanoscale, which is the same size difference between a baseball and the Earth! Importantly, they exhibit outstanding catalyst performance, owing to their extremely small size and high surface area that enable the attachment of reagents onto the gold surface, allowing chemical reactions to take place. Gold catalysts are well-known for their high efficiency in chemically transforming aryl alcohol to aldehydes for the chemical, pharmaceutical, and fragrance industries. With their assistance, we can expect to tune chemistry, reduce energy barriers for chemical reactions, and optimize the quantity and purity of desired products.

Traditional methods require chemical modifications of gold, which contaminate the gold and block reagents from contacting the gold surface. Hence, those materials often have poor catalyst performance and are discarded after a few uses. My research introduces an improved technique. It leverages switchable surfactants (soap-like substances) to finely control the gold nanoparticle properties—the switchable nature enables facile removal of these substances from the gold surface at a low temperature. Thus, the purity of gold is preserved, and the entire gold surface can be used to promote chemical reactions! These gold catalysts demonstrate superior efficiency in promoting the production of aldehydes. They also maintain excellent performance over consecutive uses. I characterize the gold nanoparticles' location and size as well as the gold surface's chemical state via microscopic and spectroscopic techniques. The results reveal that with a pristine gold surface and uniform size, the nanoparticles are evenly dispersed along the wall inside tiny pores. This unique pore structure inhibits the nanoparticles' growth under harsh reaction conditions, preserving their fine size and extending their service time. In my follow-up studies, I investigated how the pores alter the reagent movement near the gold surface, which decides how the reagents attach to the gold surface and impacts catalyst efficiency. The results suggest that the pores restrain reagents' random rotation, which aligns them to a uniform direction and promotes their direct attachment to the gold surface. Ultimately, this unique pore structure preserves the small nanoparticle size, maintains the catalyst performance, and enhances the catalyst efficiency by promoting an effective route for chemistry.

I sincerely ask the selection committee to support my travel expenses to the 8th International Conference on Catalysis and Chemical Engineering (CCE) in Boston in February 2024. It is one of the most prestigious catalysis conferences, aiming to advance catalysts' industrial applications. Receiving this grant will support my attendance, which is a great platform to showcase my research, communicate with top-notch industrial specialists, and gain valuable insights from my peers. Beyond this, I desire to deliver an essential message to all industries: research conducted at the university level, besides serving as an efficient 'tool' for training future scientists, is the foundation of the entire catalysis community. The research done by my group provides vital knowledge and guidelines on the preparation, characterization, and optimization for all types of metallic catalysts, which benefit all industries. In essence, my future attendance at the CCE-2024 conference will elevate the quality of my graduate education.

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