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"The Domestic Shale Gas and Tight Oil Boom in Recent Years not only Changes our Dependence on Imported Energy, but it also Potentially Increases the Availabilty of C1-C3 Lower Alkanes and Alkenes"

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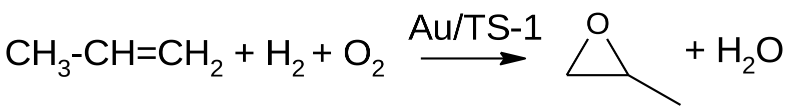
Project Summary

The domestic shale gas and tight oil boom in recent years not only changes our dependence on imported energy, but it also potentially increases the availability of C_1-C_3 lower alkanes and alkenes. Lower alkane and alkenes are important fuel sources and building blocks for many polymers and a number of chemical intermediates. It is necessary to develop energy efficient and environmentally friendly processes for the conversion of lower alkane and alkene to value-added chemical products. For example, propylene oxide (PO) derived from propylene (C_3H_6) are a key chemical intermediate for the production a number of commodity chemicals including polyol, propylene glycol and glycol ethers. However, current industrial methods that produce propylene oxide from propylene either are either environmentally unfriendly because of the production of chlorinated or peroxycarboxylic waste or are not profitable for industrial scale production.

As shown in the chemical equation (1) below, using supported gold-based nano-catalysts to produce propylene oxide directly from propylene using molecular oxygen as the oxidant provides an alternative, clean, and potentially more efficient route to the current methods. Although the selectivity is very high (>90%), even the best catalysts found to date still suffers from multiple major challenges, including low propylene conversion (<10 %), poor stability and inefficient usage of H_2 (< 50%). Therefore, significant improvement with regard to these issues is necessary.



(1)

The key for improving catalyzed transformation is to build the catalysts structure/performance relationships. We believe that substantial gains can be achieved by combining precise synthesis and state-of-the-art characterization techniques. New synthetic and stabilization methodologies, based on atomic layer deposition (ALD) will be developed for achieving highly active and stable catalysts. Advanced techniques using one of the brightest artificial X-ray and Neutron beams at Department of Energy (DOE) national facilities will be employed to understand the catalyst active sites and local structure in real time under working conditions.

The research will integrate efforts in: 1) synthesis and stabilization of uniform, supported catalysts; 2) characterization of geometric and electronic structure of catalysts during synthesis; 3) investigation of catalytic and chemical events on the catalysts that are relevant to propylene oxide production. Student will be involved in the frontier research of material science and surface science and experience the state-of-the-art scientific equipment and techniques.

Student Duties

Soak up as much knowledge as you can – provide enthusiasm in return.

The perspective student will work closely with a graduate student Mr. Zheng Lu on his PhD thesis project. The perspective student's responsibilities, as described in the Project Summary, can be divided into three parts, namely catalyst synthesis, characterization and performance testing. Specifically, the student will optimize synthesis conditions of atomic layer deposition (ALD) for preparing nanostructured catalysts. Moreover, the student will learn a full range of thin-film characterization tools, especially *in situ* quartz crystal microbalance (QCM), which provides detailed information of the growth rate under practical ALD conditions in real time. In addition, the student will help evaluate the performance of the catalysts for propylene epoxidation.

The perspective student is also expected to become familiar with the literature that is relevant to this project and with the wider literature in general.

There may be experiments scheduled in DOE national facilities during the summer. The student may have the opportunity to travel with the group to Argonne National Laboratory (Chicago) and/or Oak Ridge National Laboratory (Oak Ridge, TN) to perform experiments. Information on our group field trip to Oak Ridge National Laboratory can be found on UAH Research News: http://www.uah.edu/news/research/uah-student-team-tests-catalysts-at-oak-ridge#.U5C-n_mwJFb.

In summary, this project will be a great learning experience for developing scientific skills and teamwork spirit.

Mentor Supervision and Interaction

The perspective student is encouraged to see the mentor if there is anything he/she wants to discuss, science or otherwise.

Lab Visit. The mentor will work in the lab with students when it is necessary. This will allow students to have access to qualified, expert advice when it is needed.

Individual Meeting. A definite schedule of individual meetings and team meetings is adopted weekly in our group. The group member will meet with the mentor in an informal fashion to discuss recent progress.

Group Meeting. Our group has weekly group meetings together with Professors George Nelson and Eunseok Lee of Mechanical and Aerospace Engineering Department. Each group meeting can be divided into two parts: literature survey and research progress. The perspective student will participate in our weekly group meeting and be able to interact with graduate students and faculty members. He/She will also present a literature survey in the area of ALD, nanotechnology and catalysis during the summer. At the end of the summer, the student will present research progress made during the period of this project at UAH.