화공생명공학과 BK4 세미나

“Catalyst Design and Tunable Properties: Charging and Regenerating Catalyst”

Tzia Ming Onn, Ph.D.
University of Minnesota - Twin Cities

Advancement in heterogeneous catalysis is essential in solving global sustainability related problems such as reducing emissions, repurposing plastic, valorizing biomass, and more. One possible approach is through rational design of solid-state catalyst that will enable optimal catalyst-promoter interactions for tunable chemical-structure properties and, more importantly, enable the utilization of renewable stimuli such as electrons/photons for rate and selectivity enhancements in chemical reactions. However, such an approach by conventional preparation methods is not trivial especially for complex multi-component systems. These methods have limitations in scalability, and they typically lead to structural irregularities such as large crystallite formations, segregation of components, multi-faceted surfaces, mixed/multi structural phases, and more. My approach adopted and modified thin film processes such as Atomic Layer Deposition or layer-by-layer deposition to engineer non-metals and metals on support materials with atomic-level precision and exceptional compositional control. This has allowed for hierarchical nanostructures of complex oxides such as LaFeO3 to be fabricated with ease under mild conditions owing to the precise positioning of the atoms. When these film structures were used to support metal nanoparticles, for example in the case of Pd supported on LaFeO3 film, the catalysts displayed excellent regenerative capabilities and resilience to deactivation such as coking and sintering for emissions control applications. Additionally, introducing conductive thin films (such as graphene, etc.) on dielectric-based support materials allowed charge density manipulation of active sites; this reprogrammed the catalytic sites to affect activity and selectivity for chemical reactions.2,3 Unlike electrochemical processes, which relies on ion transport through a liquid electrolyte, my work here is centered on condensing charges on a solid-state thermocatalytic capacitor platform (aka “a catalytic condenser”) that can be used in gas and liquid phase reactions at higher temperatures (T > 200°C) and pressures. These catalytic condensers, for example in the case of Pt on graphene, accumulated and depleted charges on the Pt active sites that modulated the adsorbate (CO) binding energy reversibly in temperature programmed desorption experiments. In addition, the use of electrons/charges, having higher mobilities than ions, enables the concept of ‘catalyst dynamics’ with tunability and operations at time scales of microseconds (1,000,000 Hz), 1000 times faster than ‘reactor dynamics’, developed in the 1970s, that relied on changes in reaction operation parameters such as pressure and temperature. This concept of catalytic promotion is important because it could theoretically enhance rates of important reactions such as ammonia synthesis or carbon dioxide hydrogenation by orders of 103 times or more above the Sabatier limit.

일시: 4월 5월 수요일 오전 10시 30분
장소: 화공생명공학과 학과회의실

*세미나 후 ’피자’가 제공됩니다.