The Changing Landscape of Heterogeneous Catalysts: Single Metal Atoms as Game-Changers

Novel catalyst designs aiming at the development of energy-efficient, low-cost and sustainable processes are of great interest for applications to fuels and chemicals production, and to environmental pollution abatement. Identification of the active catalytic site and design of catalysts with 100% atom efficiency has been a long-standing goal in heterogeneous catalysis. A promising approach to reaching this goal through the controlled preparation of isolated single-atom heterogeneous catalysts has emerged in the recent literature. For catalytic metals, atomic dispersion affords better utilization, different (often better) selectivity than the extended metal, and new prospects for low-cost and green process development. Isolated supported metal atoms may be viewed as species bonded to a support, the latter serving as a ligand. An analogy between a homogeneous and a heterogeneous single-site catalytic center can thus be made. Single atom sites catalyze some, but not all reactions. It is crucial to understand the mechanisms behind catalysis by single atoms, as this will guide the new, improved catalyst designs.

In this presentation, suitably stabilized catalytic sites as single metal atoms/cations on various supports will be showcased drawing examples from a variety of reactions, including the low-temperature water-gas shift reactions; methanol and ethanol dehydrogenation and steam reforming reactions; the direct methane conversion to oxygenates; and selective hydrogenation reactions on single-atom alloys. Reaction mechanisms involving single metal atoms/cations often transcend support structure and composition, thus allowing flexibility in the choice of the support. A unique “signature” of the metal (Au, Pt, Pd, Ni, etc.) at the atomic state is preserved, distinct however from the corresponding extended metal catalyst. Novel synthesis methods will be discussed as will be the stability of single-atom metal catalysts in various supports and reaction environments.

LECTURE 1: Tuesday, Oct. 23, 2018
Seminar Reception
3:30-4:00 pm  |  Cheney Room/1413 Engineering Hall (1415 Engineering Drive)
Lecture
4:00-5:00 pm  |  Room 1610, Engineering Hall