Biomass has emerged as an attractive renewable carbon-containing feedstock for the production of fuels and chemicals. However, its complex chemical diversity has created daunting challenges that require the implementation of robust, active, and selective catalysts to effectively transform it into useful products. For instance, biomass fast pyrolysis and catalytic fast pyrolysis are potentially viable technologies for large-scale production of aromatics and olefins. However, the bio-oils obtained from fast pyrolysis are not fungible with current refinery streams without undergoing hydrodeoxygenation (HDO)—a process that not only employs expensive platinum group metals, but also requires large excesses of molecular H₂. The key challenges faced by the HDO processes are achieving a high degree of oxygen removal, minimizing carbon loss through cracking, and diminishing hydrogen consumption. Importantly, the development of more cost effective HDO processes hinges on finding suitable replacements for precious metal catalysts.

In this seminar, new developments in the synthesis and use of transition metal oxides and carbides for the conversion of biomass-derived oxygenates will be presented. Specifically, coupled kinetic and characterization investigations will show how the reactivity of surface vacancies in reducible metal oxides is used to activate and selectively cleave carbonyl and hydroxyl functional groups in a variety of model compounds, transforming linear ketones and cyclic ethers to olefins, and cyclic ketones and phenolics to aromatics with high yields and remarkable selectivity. Structure-activity descriptors can then be used to guide the design of new catalytic materials. To this end, a new method for the synthesis of multimetallic transition metal carbide/nitride nanoparticles and their use in HDO chemistry will be introduced.