Hydrogen storage and delivery: stoichiometric and catalytic adventures in splitting H_2 into protons and hydrides

Abstract:

The controlled heterolytic splitting of H_2 into protons and hydrides is central to hydrogen storage and production. In this talk, I will present complementary stoichiometric and catalytic perspectives on how this partitioning can be understood and directed. In the first part, mechanistic studies of sodium borohydride show that reductions proceed via transient BH_3 species, enabling coupled H^+/H^- transfer in protic media rather than direct hydride delivery from BH_4^-. These insights are translated into a simple undergraduate experiment in ethanol, emphasizing the decisive role of the reaction medium in governing reactivity. The second part focuses on Cp*Rh systems for amine–borane dehydrogenation, where metal–ligand cooperativity enables efficient H_2 release. Pyrazole-derived ligands promote proton-responsive pathways by positioning proton and hydride acceptors in close proximity, whereas studies of Cp* "non-innocence" reveal competing ligand-centered reactivity that can divert productive pathways and lead to catalyst degradation. Together, these results highlight the importance of deliberately controlling H^+/H^- partitioning. Using a computation-guided approach, the design-strategies for the next-generation hydrogen storage and delivery systems will be presented.

Bio:

Dr. Shrinwantu Pal obtained his BSc Honours in Chemistry from the University of Calcutta, India and MS in Chemical Science from the Jawaharlal Nehru Center for Advanced Scientific Research, India. Shrin then moved to the University of Maryland where obtained his PhD in 2013 on the development of borate ligands for platinum chemistry. After postdoctoral stints at UBC (*with* Jennifer Love) and UTokyo (*with* Kyoko Nozaki) and experience in Carbon Capture industries across Canada, Shrin joined Brandon University in 2023 where he is an Assistant Professor teaching Inorganic Chemistry. Recently, Shrin is the recipient of an NSERC Discovery Grant through which he is investigating strongly-electron-donating borate ligands for organometallic complexes that can catalyse bidirectional hydrogen storage and delivery in protic solvents. Shrin is visiting Kingston as a faculty fellow for the Invention to Innovation (i2i) program, instituted by SFU and this year, was hosted at Queen's University.