

¹ Research Institute in Environmental Engineering, Chemistry and Applied Biotechnology (INGEBIO), Pontifical Catholic University of Argentina (UCA), Av. Pellegrini 3314, (S2002QEO) Rosario, Argentina. E-mail: ezequielluciano@uca.edu.ar

² Centro de Nanociencias y Nanotecnología, Universidad Nacional Autónoma de México (CNyN-UNAM), Km 107 Carretera Tijuana-Ensenada, Ensenada, B.C., C.P. 22800, México. E-mail: aorona@ens.cnyn.unam.mx

³ Millenium Institute on Green Ammonia as Energy Vector, Pontificia Universidad Católica de Chile, Santiago 7820436, Chile. E-mail: laherran@uc.cl

⁴ Department of Mechanical Engineering, Federal University of Paraná (UFPR), Curitiba, Brazil. E-mail: renata.morais@ufpr.br



Preliminary concepts

What is a base metal?

ABUNDANT

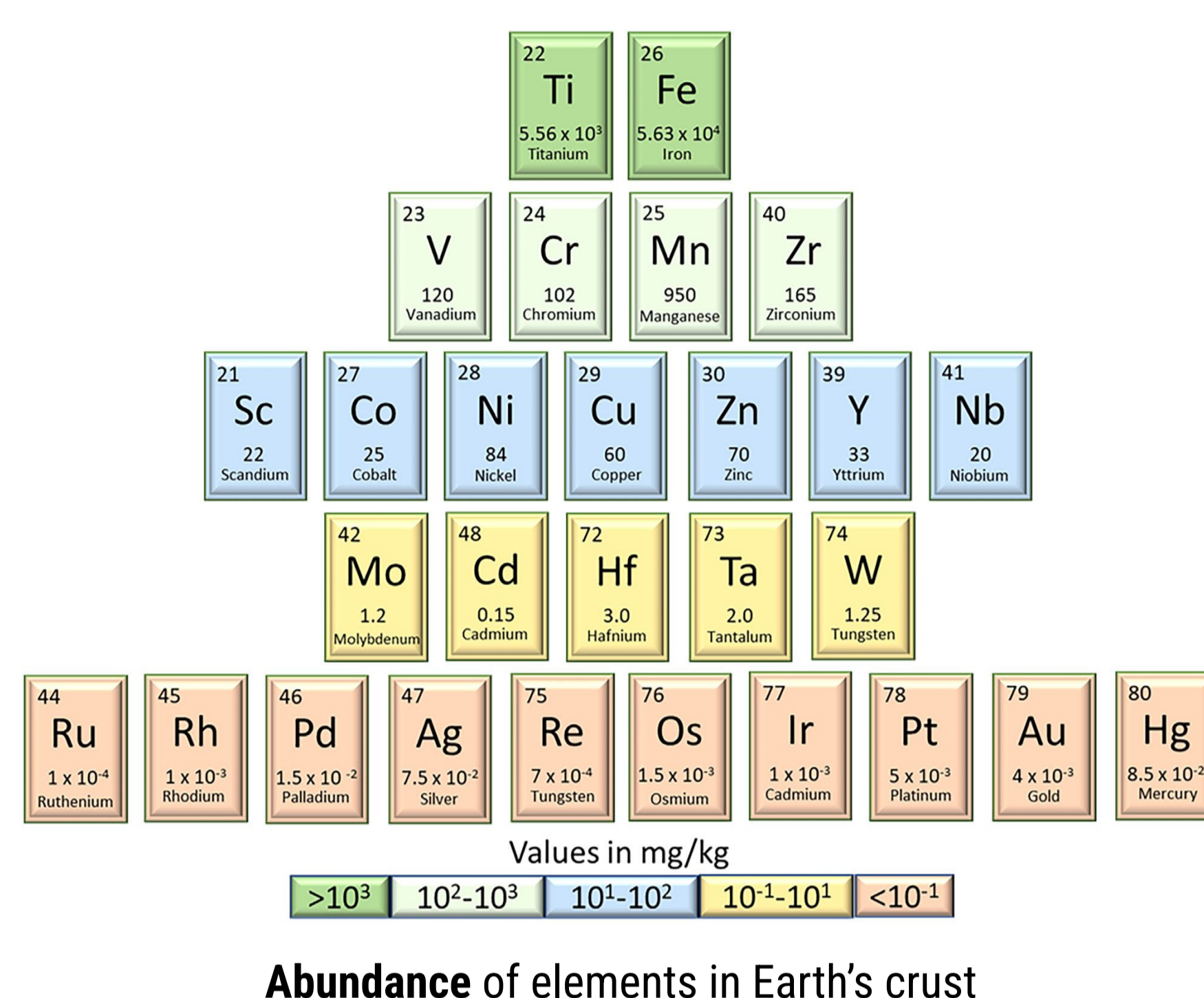
"COMMON"

ENVIRONMENTALLY FRIENDLY

EASY TO OXIDIZE

Many base metals exhibit low toxicity and are environmentally benign.

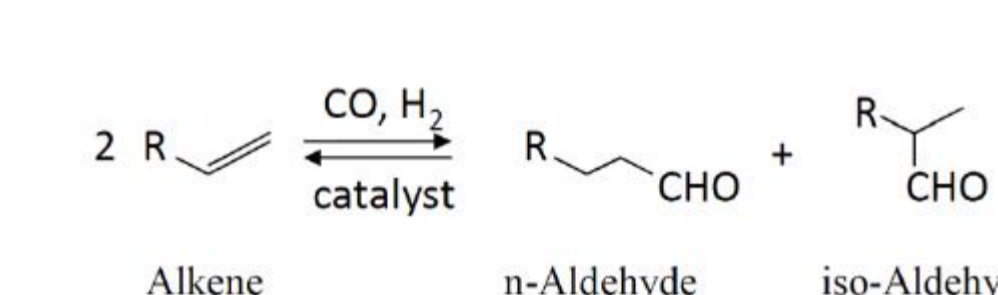
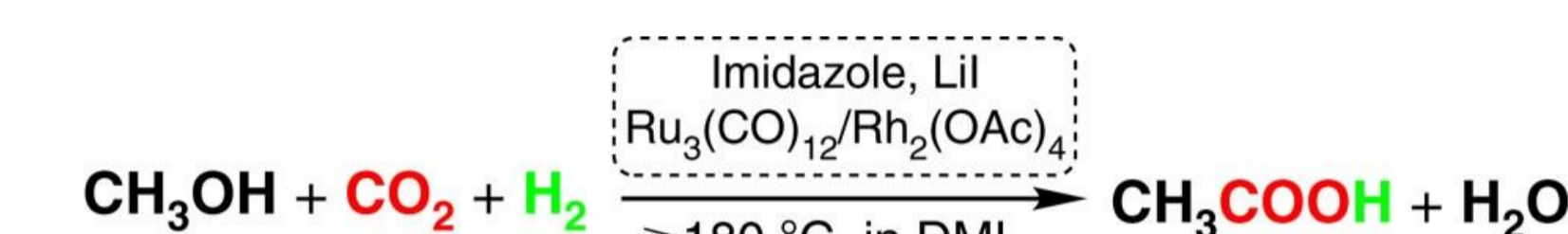
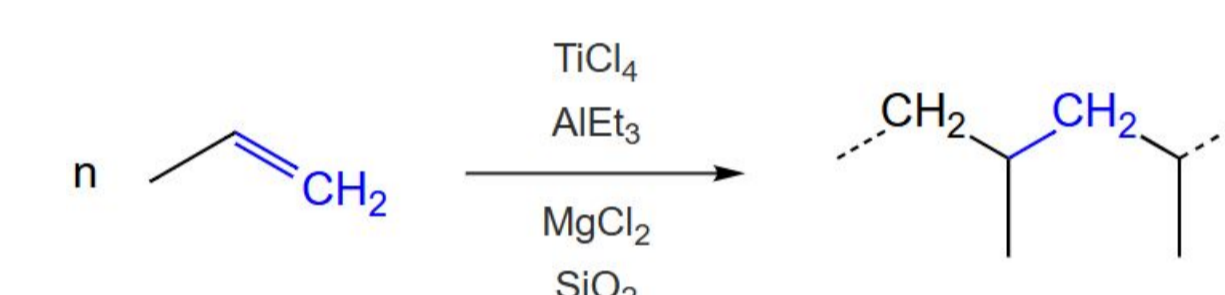
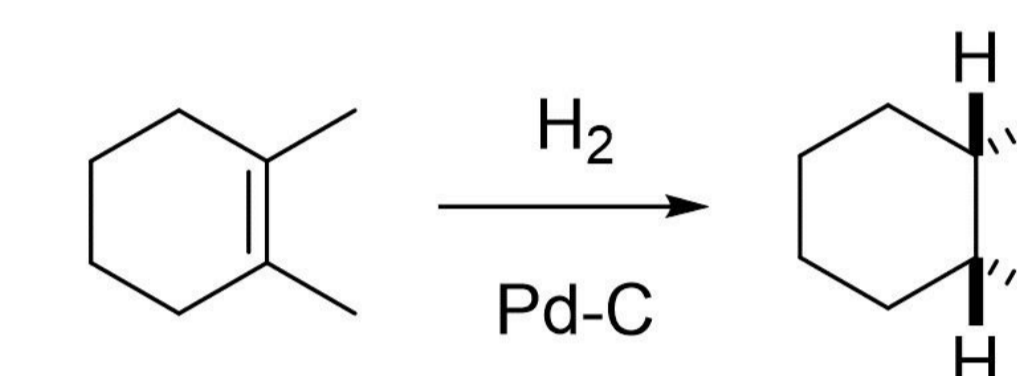
≠ NOBLE ≠ PRECIOUS



History and development

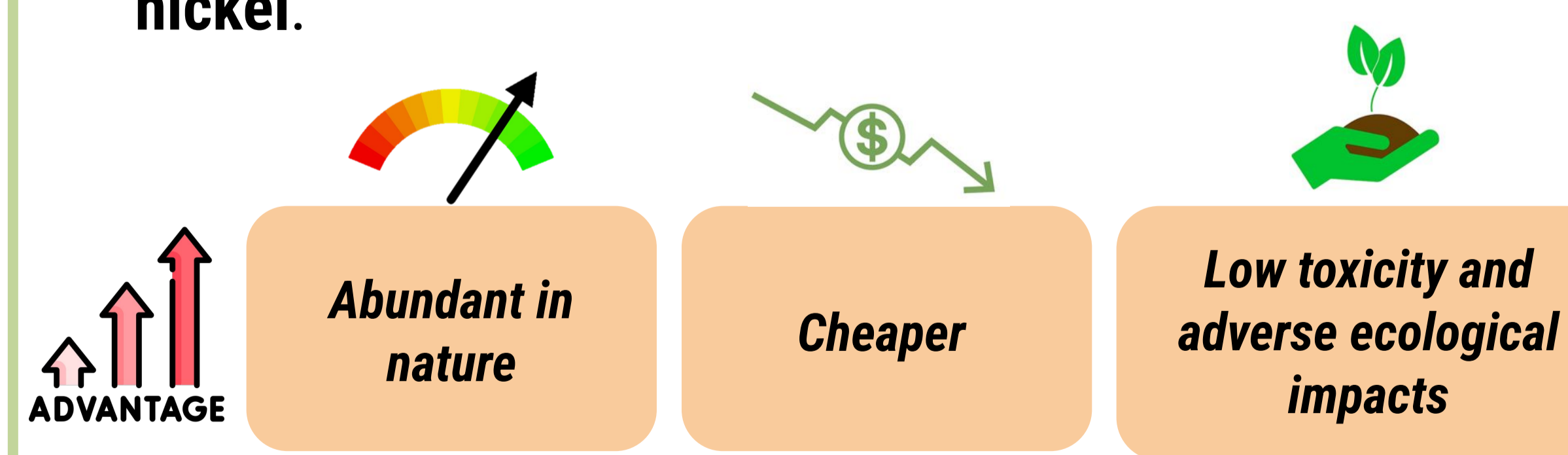
Homogeneous catalysis began to receive significant attention in the early 20th century. Acid-catalyzed refinery reactions were developed, driven by scientists such as Houdry, Ipatieff and Pines, who contributed significantly to the understanding of acid catalysis.

- ❖ Hydrogenation Reactions Catalyzed by Transition Metal Complexes
- ❖ Polymerization of Alkenes with Ziegler-Natta Catalysts
- ❖ Carbonylation of Methanol to Acetic Acid
- ❖ Hydroformylation



Green and Sustainability Chemistry

- ❖ The most widely used metal catalysts are **noble metals** (e.g., platinum, palladium, and iridium) due to their desirable catalytic properties, such as **high stability** and **temperature tolerance**.
- ❖ However, the use of **noble metals** is hindered by their **high cost**, limited **availability**, and the fact that their extraction process **consumes a significant amount of energy** and causes **environmental damage**.
- ❖ In response to these challenges, more **sustainable alternatives** are being explored. One such alternative is the **substitution** of **noble metals** with **non-noble transition metals**, such as **titanium, iron, cobalt, and nickel**.



Advantages and disadvantages

- ❖ Homogeneous catalysis allows the processes to occur under relatively mild conditions and at the same time advances our understanding of reaction mechanisms at the molecular level, thus providing remarkable opportunities to improve the catalytic processes.
- ❖ The first-row transition metals, including Ti, V, Cr, Mn, Fe, Co, Ni and Cu, represent base metals that offer additional advantages such as **low cost**, **global availability**, **low toxicity** and their **environmentally benign character**.

CHALLENGES

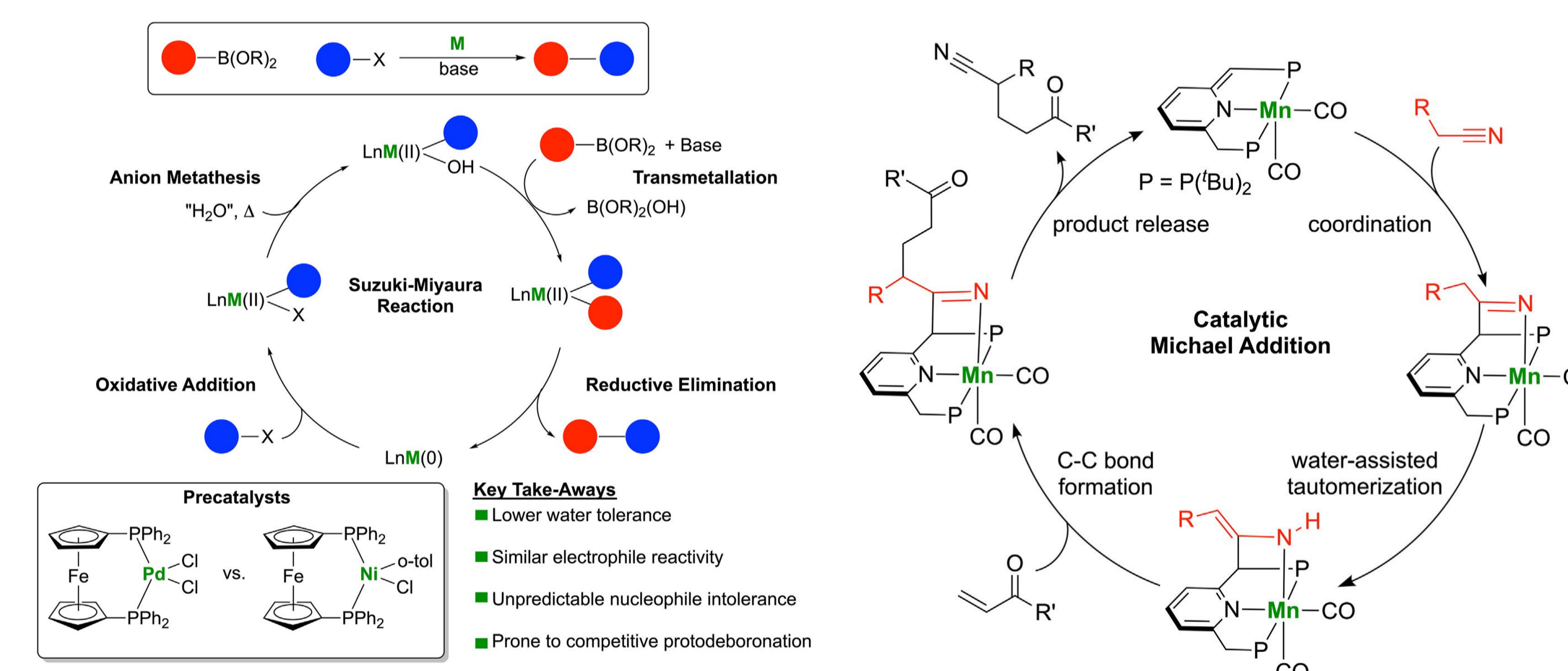
Stability

Oxidation-state changes

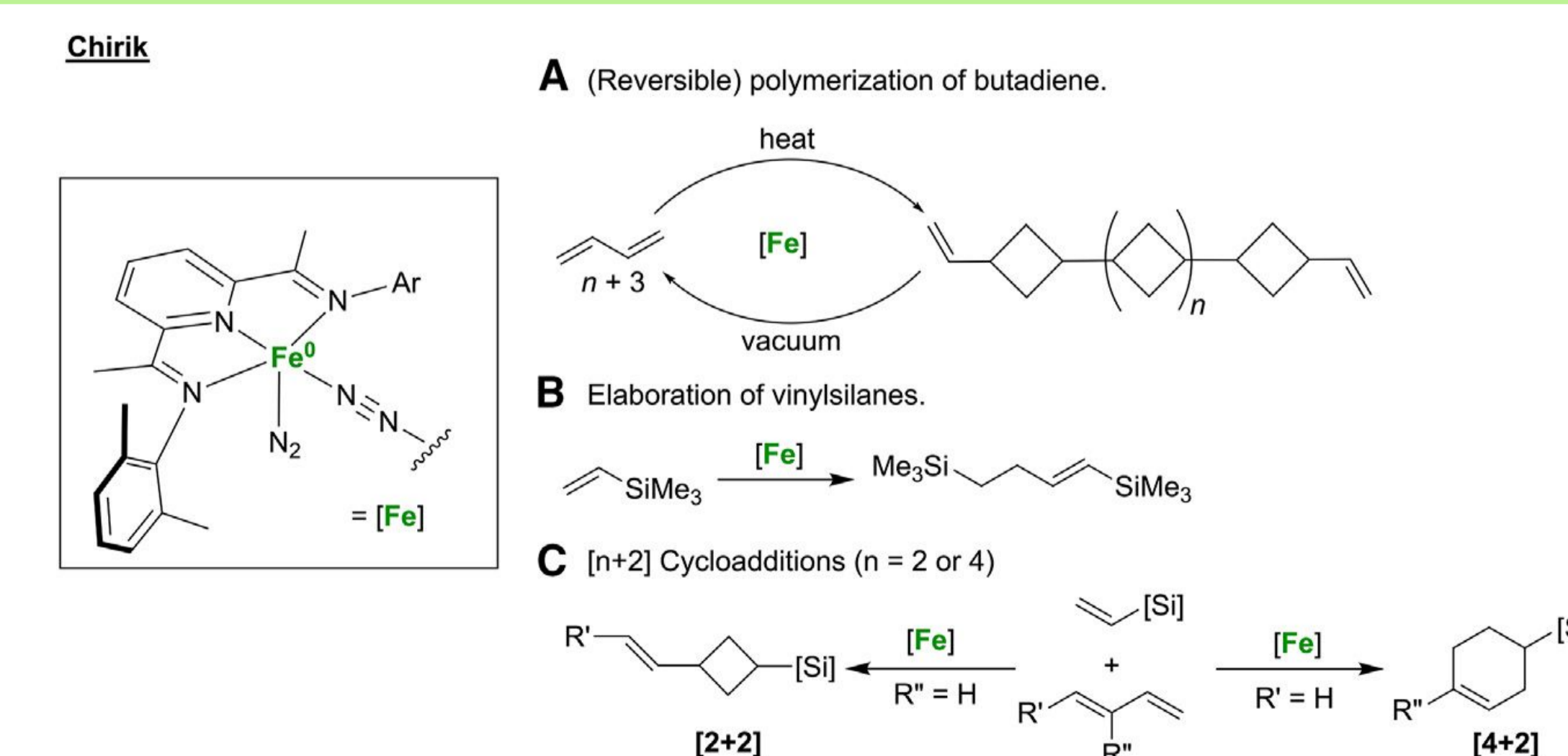
Selectivity

Characterization

Examples of use



Well known reactions using a greener alternative with Fe, Ni, and Cu catalysis



References