IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title: **The Chemistry of Lanthanum/Nickel Alloy**

Project Number **IMURA0369**

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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?
(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture
2. Infrastructure Engineering
3. **Clean Energy**
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research
7. **Rare Earths**

The research problem

Define the problem

The rare earths have been described as the materials of the 21st century. As China dominates the supply of separated rare earths (97%), there is considerable concern as to the strategic implications given the vital role of rare earths in alloy magnets (cars, computers and military uses), batteries and hydrogen storage, in the glass industry, in safety equipment, and in ceramics, especially supports for exhaust emission catalysts. Both India and Australia have abundant rare earth ores, development of which would alleviate this monopoly situation. New chemistry can underpin new applications, which in turn would encourage development of Australian/Indian ore deposits. The rare earth containing alloy $LaNi_5$ is widely used in batteries and as a hydrogen storage material. Development of its chemistry would provide a better understanding of the material and in turn aid recycling and new uses.

Project aims

Define the aims of the project

The project aims to develop the reactions of $LaNi_5$ with both inorganic and organic substrates. Thus reactions with halogens and chalcogens are to be studied as well as its role as reductant in organic chemistry.

Expected outcomes

Highlight the expected outcomes of the project

A greatly developed chemistry of $LaNi_5$, methods that may beer on recovery of the metals from battery discards, new reactions giving new ternary materials, and new reductive organic chemistry including a degree of selectivity.

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

Batteries and hydrogen storage are significant in the development of clean energy and the $LaNi_5$ alloys relevant to both. Lanthanum is the second most common rare earth element and one of the cheapest, and is a major component of both monazite and bastnasite ores, the primary sources ofr rare earths. Development of the chemical properties of the alloy and of the physical properties of new materials derived therefrom

Batteries and hydrogen storage are significant in the development of clean energy and the $LaNi_5$ alloy is relevant to both. Lanthanum is the second most common rare earth elements and is a major component of both monazite and bastnasite, the two most common rare earth ones. Development of $LaNi_5$ chemical properties and of the physical properties of new materials arising, will form the basis of new potential applications which will encourage development of India and Australian rare earth resources.

Themes for the development include:

1. Reaction with halogens, C_2Cl_6, $C_2H_4Br_2$, CH_2I_2, $C_2H_4I_2$ and other halogenating agents to establish whether separate lanthanum and nickel halides or ternary halides are obtained. Development of methods, complexation, precipitation, extraction, ion exchange, for the separation of lanthanum and nickel from the halides is planned.
2. Reactions with chalcogens particularly sulphur and selenium to establish whether separate element products or ternary species are obtained. Examination of properties of the latter for semiconductor properties is desirable. Reactions with protic complexing agents are to be carried out in order to form either La and Ni complexes or ternary species. Preliminary studies have had a fascinating and contrasting outcome. Reaction with 8-hydroxyquinoline (HOQ) has giving the bimetallic complex $[LaNi_2(OQ)_7]$, the structure of which was determined, whereas the reaction with di(2-pyridyl)amine yielded a lanthanum complex. (G.B.Deacon, C.M.Forsyth, P.C.Junk, S.G.Leary, New. J. Chem., 2006, 30, 592)
3. Reactions with organic substrates
   These would be carried out both in an inert atmosphere (N_2/Ar) but also in the presence of H_2 to examine the effect of H_2 adsorption on the chemistry. Thus, the reduction of aldehydes and ketones will be examined, including the possibility of selectivity. Likewise conjugated and unconjugated double bands will be subjected to similar reductive procedures, as well as the effect of other functionalities on reduction, including competition reactions. These approaches will be extended to alkyl and aryl halides containing other functionalities.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

The candidate should have an MSc in Chemistry with specialisation in Inorganic, Organometallic, or Organic Chemistry. Experience in use of protective atmospheres (Schlenk equipment/Drybox) would be an advantage.