IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Novel CO2 Capture and Conversion Process Technology Development**	
Project Number	**IMURA1034**	
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Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1	*Material Science/Engineering (including Nano, Metallurgy)*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research 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	*Artificial Intelligence and Advanced Computational Modelling*
2	*Circular Economy*
3	*Clean Energy*
4	*Health Sciences*
5	*Smart Materials*
6	*Sustainable Societies*
7	*Infrastructure*

The research problem

Define the problem

The rapid growth of population and continuous improvement in the life quality has fueled an alarming growth in the global CO_2 emission. India is leading the pack with a steady growth of ~5% in CO_2 emission over the past decade. Following the Paris accord 2015, India has taken the pledge to cut down the annual CO_2 emission by 30% by 2030, acknowledging the negative impact of the ever-growing aerial CO_2 concentration. The conventional coal-driven energy sector, steel-iron plants, and cement factories are the major contributors to industrial CO_2 emission in India, accounting for ~80% of the anthropogenic CO_2 production. Over the years, several CO_2 capture techniques have been deployed in the industrial establishments, including pre-combustion, post-combustion, and oxy-fuel methods to mitigate the direct CO_2 emission to the atmosphere. However, the high cost associated with the existing CO_2 capture methods and the absence of any sustainable and pragmatic long-term utilization plan for the stored CO_2 has severely impeded the natural growth of the heavy CO_2-producing industrial sectors.

In this concept note, we are depicting a fresh approach to CO_2 capture and utilization. We propose a multi-modular assembly that will consists of a direct air capture unit for rapid removal of CO_2 from atmosphere. In the captured CO_2 will be accumulated in an aqueous solution to generate bicarbonate (HCO_3^-) by deploying a carbonic anhydrase-inspired synthetic catalyst. Next, the bicarbonate will be converted to either (i) C-based derivatives (CO, CH_3OH, CH_4) (by using in house developed synthetic catalysts) or (ii) CO_2 will be regenerated for permanent storage purpose (Pre-feasibility study will be performed).

Project aims

Define the aims of the project

1. Developing a viable Direct Air Capture (DAC) unit
2. Establishing an aquo-based solution for rapid CO_2 capture
3. Connecting a CO_2 conversion unit to the capture module
4. Pre-feasibility study for CO_2 storage using this multi-modular assembly

What is expected of the student when at IITB and when at Monash?

Highlight how the project will gain from the students stay at IITB and at Monash

IITB:

1) Student will conduct a literature search develop several CO2 capture and conversion catalyst candidates for further study.
2) Execute chemical and electrocatalytic studies to optimize the catalysts.
3) Developing appropriate CO2 conversion and capture units for assembling them with DAC unit.
4) Perform the pre-feasibility study for the CO2 storage in specific sub-surface samples.

Monash University:

1) Student will conduct a lit review in direct air capture
2) Student will design new adsorbent systems for DAC use
3) Student will test and model the DAC performance and integrate with the conversion process

Expected outcomes

Highlight the expected outcomes of the project

1. Developing multi-modular CO_2 management assembly.
2. Design a catalyst library for CO_2 capture and conversion.
3. Providing a complete aerial CO2 to stored/converted C-based material management outline.

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.

This project will create a unique approach to implement negative carbon footprint by direct removal of CO_2 from atmosphere. This process will also aid the sustainable development by creating routes for circular economy (c-based feedstock for other material development. This project will also provide us an insight on handling large-scale CO_2 by the strategic inclusion of CO_2 storage module.

Potential RPCs from IITB and Monash

Provide names of the potential research progress committee members (RPCs) and describe why they are most suited for the proposed project

IITB:

Monash University: Assoc Prof Andrew Hoadley – expert in process systems modeling

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.

Students with the following background are encouraged to apply:

1. Postgraduate degrees in Materials Science and Engineering/Chemical Engineering/ Chemistry/Physics. In exceptional cases, students with bachelor's degree in these disciplines may be considered.
2. Students that have carried out research intensive projects as part of their UG/PG programmes in chemical synthesis, nanomaterials synthesis, characterisation and application will be preferred.
3. Familiarity with analytical techniques such as XRD, FTIR, SEM/TEM, UV-vis spectroscopy will be an added advantage.
4. We are looking for highly motivated students who are excited about working on a global challenge in a highly interdisciplinary environment.

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

1. Direct Air Capture unit
2. CO_2 capture and conversion
3. Bio-inspired synthetic catalyst development
4. Water, Climate Change (Carbon capture, sequestration and utilisation)