The University of Queensland - IIT Delhi Academy of Research (UQIDAR) Joint PhD Project Proposal Template

1. Project details

Project title	**Non-oxidative catalytic conversion of methane into aromatics over metal impregnated hierarchical zeolite**
Project ID	**UQIDAR 00159**

2. Supervision team

Please visit the IITD website www.iitd.ac.in and UQ website http://researchers.uq.edu.au/ to highlight potential collaborators that would be best suited for the proposed project. Complete where possible – advise if you'd like assistance establishing contacts.

	University of Queensland	IIT Delhi	External/Industry (if applicable)
Supervisor name and title	***Prof. George Zhao***	***Prof. K.K. Pant***	
School or department (or company, if applicable)	***School of Chemical Engineering***	***Chemical Engineering***	
Phone number	**+61-7-3346 9997**	***+91-11-2659 6172/26596177***	
Email-ID	***george.zhao@uq.edu.au***	***kkpant@chemical.iitd.ac.in***	
URL for more info	***https://researchers.uq.edu.au/researcher/474***	***http://web.iitd.ac.in/~kkpant/***	

3. Other supervisors

Please provide information about other associate supervisors below.

Full name and title(s): Prof.
School/department/company details:
Phone:
Email:
URL:

2. Field Of Research (FOR) codes

Specify up to four four-digit FOR codes for your project – see **here** for more detail on FOR codes.

1. 0904	3. 1099
2. 0301	4. 0307

3. Keywords

Please choose up to 4 keywords for your project. E.g. Nanotechnology, data science, novel batteries, etc. Keywords will assist in classifying project and presenting projects to students on the applications portal.

1. Heterogeneous Catalysis	3 Hierarchical zeolite
2 Methane	4. Intracrystalline

dehydroaromatization	mesopores

4. Discipline background of candidate

Please outline the preferred background of your student. E.g. Organic chemistry, physiology, topology, CFD, etc. This will assist in presenting projects to applicants on the apps portal.

1 Catalysis	3 reaction engineering
2 chemical engineering	4. zeolite synthesis

5. Project description

With continuous increase in the world energy demand and ever-increasing dependency on petroleum, over 86.7 million barrels of petroleum are processed every day in refinery around the world to meet the demand. The declining crude reserves have shifted focus on the natural gas as an alternative supply for fuel. Methane is a major constituent of natural gas and world reserve of natural gas are constantly being upgraded as more and more natural gas reserves are discovered than conventional oil reserves. Presently, most of the natural gas produced as associated gas, particularly at remote locations, there of it is not cost effective to transport huge volume of gas for large distance and methane produced in petroleum refining, and petroleum processes are flared and hence wasted. Both CO2 and CH4 being greenhouse gases, responsible for global warming and hence, emission of methane into atmosphere is to be curtailed as per present EPA norms. Therefore, it is essential to convert natural gas and refinery off gases to value added liquid fuels, which are easily transportable, and reduces the environment footprint. Converting methane to gasoline economically is a very important as it can go a long way in meeting growing energy demand. Fuels obtained from methane does not have any impurities like sulphur etc. and hence is a clean fuel. The Indian chemical industry is an $80 billion enterprise that touches 96% of all manufactured goods. Because of its reliance on petroleum fractions and natural gas liquids as feedstock, the chemical industry is a significant contributor to greenhouse gas emissions in the world: the industrial sector accounts for 21% of total world's greenhouse gas emissions. Thus, use of low-cost, environmentally friendly CH4 as a feedstock for the manufacture of high-value hydrocarbons would revolutionize the chemicals industry. However, controlled reaction of CH4 is difficult. CH4's C—H bonds are very stable and usually require high processing temperatures to break, or "activate," them. In addition, once the bonds are broken, thermodynamics favour formation of low-value products, like CO2 and carbon ("coke"). Current industrial practice is to break down the CH4 molecule in a partial oxidation step to form a synthesis gas mixture of CO and H2, and then to build the desired hydrocarbon products—fuels or chemicals—from the synthesis gas components in a second step. However, use of multiple, high temperature processing steps results in low overall energy and carbon efficiencies and high capital costs. Due to inherent disadvantages of the above-mentioned routes for methane conversion, Single step, or "direct," conversion processes, in which CH4 molecules are coupled to form ethylene (C2H4), ethane (C2H6), or aromatics—without going through a syngas intermediate have been the subject of industrial and academic interest for decade. Non-oxidative conversion over metal doped zeolite (MFI and MWW) can be most commonly used catalyst for production of aromatics along with hydrogen. The physiochemical properties (acidity, topology surface area etc.) of the zeolite have a tremendous effect on the catalytic activity and product selectivity in methane dehydroaromatization. Common to all direct processes is formation of undesired, but thermodynamically favoured side product- CO2 and H2O in oxidative approach and C (coke) in non-oxidative approaches which results in low stability and reactivity of the catalyst. The present aim of the proposal is to study effect off process variables on limiting the formation of by-products during methane dehydroaromatization reaction over the metal doped hierarchical zeolite. Thus, in this regard an integrated approach for synthesis and characterization of hierarchial zeolite (HZSM-5 and HMCM-22) will be developed under supervision of Prof. George Zhao, School of Chemical Engineering, QU, Australia. Subsequently, development of bifunctional catalyst (metal loading over the support synthesized by Prof. Zhao) and its performance over different process parmeters will be done under the supervision of Prof. K. K. Pant. Since both India and Australia are among top 20 oil consuming country, thus development of sustainable technologies for non-oxidative methane valorisation will lead to decrease in crude import dependency for 1.5 billion lives around the world.

6. Project deliverables/outcomes

The overall outcome would be a sustainable technology for methane valorisation to aromatic and platform chemicals. Nevertheless, there would be several direct and indirect deliverables/outcomes of the proposed project. Some of the major outcomes are as follows:

1. Novel catalysts materials for methane dehydroaromatization processes
2. Technology for direct methane conversion
3. Techno-economic feasibility study of the developed process
4. Roadmap for conversion of other stranded natural gas to valuable products

7. Research impact themes

Highlight the research impact theme(s) this project will address. Feel free to nominate more than one. For more information, see http://www.uq.edu.au/research/impact

1. Healthy Ageing
2. Feeding the World
3. Resilient Environment
4. **Technology for Tomorrow** ✓
5. Transforming Societies

8. Type of student

This project is best suited for an:

i-student	✓
a-student	
i- or a-student	

Please note that:

- an i-student will be expected to spend year-1 at IIT-D, year-2 at UQ and the remaining time at IIT-D.
- an a-student will spend year-1 at UQ, year-2 at IIT-D and the remaining time at UQ.
- All students will be required to complete some amount of coursework in their first year.

9. Student capabilities and qualifications

Only students having a fellowship from UGC-NET, CSIR, ICAR, ICMR, DST-INSPIRE are eligible to apply

Essential Capabilities: Heterogeneous catalysts synthesis and characterization

Desirable Capabilities: Experience in working on Fixed bed reactor, FT-IR, Raman, NMR, BET, TPx, TGA, SEM, TEM

Expected qualifications (Courses/Degrees etc): Master Degree in Chemical, Materials engineering or Science