Indian Institute of Technology Delhi

School of Interdisciplinary Research (SIRe)

Project Proposal for Ph.D.

SIRe Project Number

2025-01-23

(will be assigned by SIRe)

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)	
Project Title	**Design and Development of a Reactor for Green Hydrogen Production**
Project Summary (Minimum 500 and maximum 2000 characters)	This project aims to develop an advanced thermochemical reactor integrated with an Ultra-High Temperature Solar Concentrator (UHTSC) for efficient green hydrogen production. With the shift toward renewable energy, solar-driven thermochemical water splitting has emerged as a promising method. The UHTSC, designed to achieve concentration ratios over 1300 and temperatures above 1400°C, will supply the thermal energy needed for high-temperature reactions. A key innovation is integrating metal-doped lanthanide perovskite materials, which are known for their excellent catalytic properties and high thermal stability. Strategic doping enhances redox performance, improving hydrogen production efficiency. A major challenge in solar thermochemical reactors is maintaining ultra-high temperatures while ensuring stable operation. To address this, the system will incorporate advanced heat transfer mechanisms to optimize energy distribution and minimize losses. Computational simulations will model heat transfer dynamics, reaction kinetics, and system efficiency, guiding reactor design, material selection, and optimal operating conditions. Various solar irradiation levels, cooling strategies, and reactor geometries will also be explored. To validate theoretical models, a prototype UHTSC will be developed and integrated with the thermochemical reactor. Real-time testing under solar conditions, achieving a heat flux up to 1.45 MW/m², will provide empirical data to refine system parameters. The reactor's hydrogen production rate, thermal efficiency, and stability will be analyzed. Expected outcomes include a functional UHTSC prototype, an optimized thermochemical reactor, validated models, and advancements in lanthanide perovskite materials. This research will offer key insights into large-scale solar thermochemical hydrogen production, supporting clean energy transitions. By integrating high-efficiency solar concentration technology with advanced catalytic materials, the project aims to exceed 40% hydrogen production efficiency, paving the way for industrial deployment and global decarbonization.

Ph.D. Supervisors
(Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)

Role	Name of Faculty	Academic Unit in IITD/Institute/University	Email ID (Official)
Supervisor 1	Dr. K Ravi Kumar	DESE	krk@dese.iitd.ac.in
Supervisor 2	Dr.Suryanarayana Vikrant Karra	DMSE	ksnvikrant@iitd.ac.in

Project requirements (Student qualifications, experience required, etc)
***The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)**

- M.Tech. Mechanical or Materials Science Engineering

Source of fellowship/funding and project number
(CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)

Institute/MHRD Fellowship

Role of Faculty Members Involved:	
Supervisor-1	Dr. K Ravi Kumar will provide expertise in solar flux modeling, heat transfer optimization, and reactor design for high-temperature thermochemical processes.
Supervisor-2	Dr. Suryanarayana Vikrant Karra will contribute his expertise in modeling and characterization microstructure of advanced catalytic materials, including metal-doped lanthanide perovskites, and their effect on macroscopic properties.