

# Centre for Biofuels and Bioenergy Studies (CBBS)

***SCHOOL OF TECHNOLOGY  
PANDIT DEENDAYAL PETROLEUM UNIVERSITY  
GANDHINAGAR***



# Sponsored by GEDA

- Financial Assistance received from GEDA (Ref: GEDA/SOL-SRDC/2014/3/OW/6689 dated March 26, 2014)

# CBBS Activities

## Focus on:

- **Biodiesel**
- Biomass
- Biomass derived fuels and related areas

## The CBBS is working on:

- To contribute research in the growth of biofuels,
- Provide platform for scientific and research community, industry and government to accelerate both in the energy farming and efficient production of bioenergy derived biofuels.

# Specific Objectives

- Design, Development and Fabrication of energy efficient, eco-friendly, and industrially viable technology for biodiesel production.
- Application of locally available non-edible oil feed stocks of non-edible oils [such as Castor, Jatropha, Thumba, Tobacco and Waste cooking oil etc.]
- Determination of optimal process parameters and process standardization
- Create **social awareness** of biodiesel resources available in Gujarat, and demonstration of biodiesel production among **students (UG/PG and PhD) and nearby villagers/farmers through workshops and seminars.**

## List of Instruments procured (B)

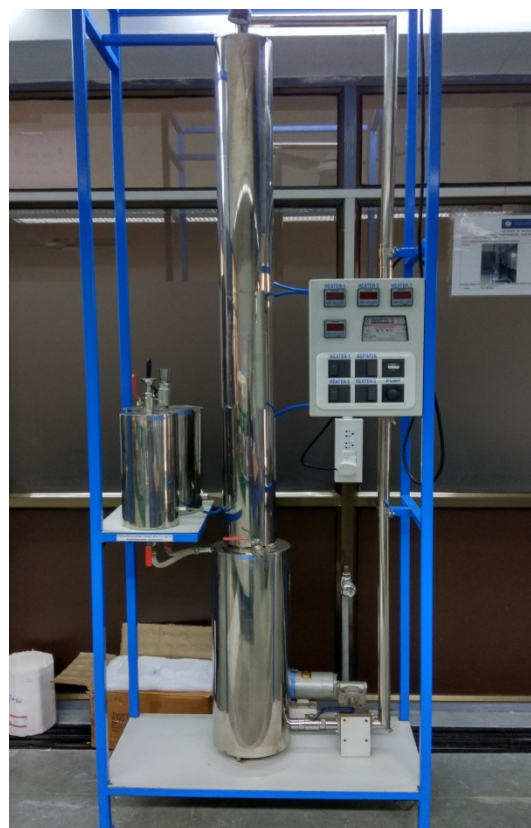
<b>Name of Instrument</b>	<b>Manufacturer</b>
<b>Bomb calorimeter</b>	IKA, USA
<b>Flash point apparatus</b>	Anton paar, India
<b>Oxidation stability test unit</b>	Metrohm, USA
<b>potentiometric auto titrator</b>	Metrohm, Switzerland
<b>brookfield viscometer</b>	Brrokfield, USA
<b>Schimadzu Balance</b>	Schimadzu, Japan
<b>Remi research centrifuge</b>	Remi, India
<b>Digital smoke analyzer</b>	Indus scientific pvt ltd, Bangalore
<b>Multi gas analyzer</b>	Indus scientific pvt ltd, Bangalore



**Supercritical Autoclave**



**Hybrid (Ultrasound and Microwave)  
Reactor**



**Hydrodynamic Cavitation**



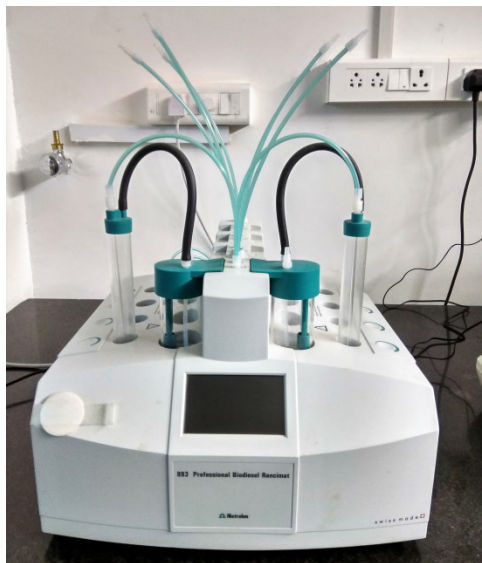
**Mixer Grinder**



**Pure Lab Water Purification  
System**



**Centrifuge (Remi)**



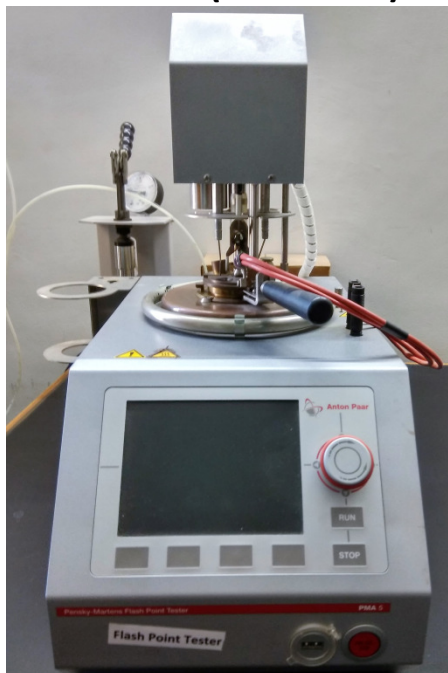
**Professional Biodiesel Rancimat (Metrohm)**



**Bomb Calorimeter (IKA)**



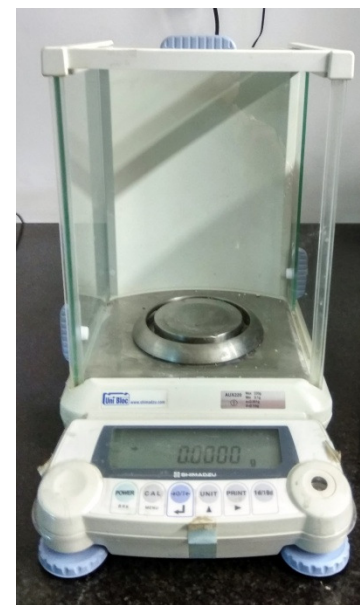
**Potentiometric Auto Titrator (Metrohm)**



**Pensky Marten Flash Point Apparatus**



**Brookfield Viscometer**



**Precision Weighing Balance (Schimadzu)**

Ongoing R & D activities at CBBS



## Limitations of conventional biodiesel production technique in industry

- ❖ Higher reaction time
- ❖ High energy consumption
- ❖ Catalyst requirement (Pollution and contamination)
- ❖ Lower yield of biodiesel
- ❖ Limitations of batch size
- ❖ Costly

## Proposed advanced Technologies working on

- Simple Conventional Reactor with Stirrer
- Ultrasound Test Rig - Horn type (20 kHz to 40 khz)
- Ultrasound Test Rig - Bath type
- Hydrodynamic Cavitation Setup
- Microalgae Reactors
- Supercritical Methanol Test Rig
- Reactive distillation column Technology
- Hybrid Pilot Plant for Biodiesel Production
- Computerized Diesel Engine Test Rig
- Softwares

# PI Techniques developed at CBBS for Biodiesel Production

Techniques	Status	Feature
➤ <b>Ultrasound Assisted Intensification</b>	▪ Developed	<ul style="list-style-type: none"> <li>— Energy efficient</li> <li>— Suitable for small/medium scale</li> </ul>
➤ <b>Microwave Assisted Intensification</b>	▪ Developed	<ul style="list-style-type: none"> <li>— Energy efficient</li> <li>— Suitable for small/medium scale</li> </ul>
➤ <b>Hybrid Technology (microwave+ultrasound)</b>	<ul style="list-style-type: none"> <li>▪ Developed,</li> <li>▪ Scalability and continuous production study in progress*</li> </ul>	<ul style="list-style-type: none"> <li>— Energy and cost efficient</li> <li>— Suitable for medium scale</li> <li>— Wide range of feedstock</li> </ul>
➤ <b>Hydrodynamic Cavitation</b>	▪ Developed and viable at industrial scale	<ul style="list-style-type: none"> <li>— Energy and cost efficient</li> <li>— Suitable for large scale</li> </ul>
➤ <b>Gamma Irradiation</b>	▪ POC ready and detail study to be performed *	<ul style="list-style-type: none"> <li>— <b>Energy and cost efficient</b></li> <li>— <b>Suitable for large scale</b></li> <li>— <b>Catalyst Free</b></li> <li>— <b>Moderate operating conditions</b></li> </ul>
➤ <b>Supercritical Fluid</b>	▪ Developing stage	<ul style="list-style-type: none"> <li>— Energy intensive</li> <li>— <b>Catalyst free</b></li> </ul>
➤ <b>Plasma Assisted Intensification</b>	▪ Future plan*	<ul style="list-style-type: none"> <li>— <b>Catalyst free</b></li> </ul>

# Advanced Technology Development @ CBBS

- **Developed in-situ transesterification process for biodiesel production using Castor seeds.**
  - The drawbacks of conventional processes addressed.
  - Process optimization using Process Intensification techniques (reduction in time and catalyst amount, improved yield, Industrially viable)
  - Preliminary studies shows around 50% reduction in overall cost of production compared to conventional process.
- **Developed in situ transesterification process as a novel approach for biodiesel production using Gamma irradiated Castor seeds.**
  - Gamma irradiation modifies the chemical structure of castor oil in seeds.
  - The use of catalyst can be substantially minimized/eliminated.

# In situ Biodiesel production

- **In situ process** or reactive extraction differs from the conventional biodiesel production process in which the grinded oil-bearing seeds reacts with alcohol directly instead of reacting with pre-extracted oil.
- One single step extraction and transesterification process (alcohol acts as an extraction solvent and a transesterification reagent)



Oil seeds

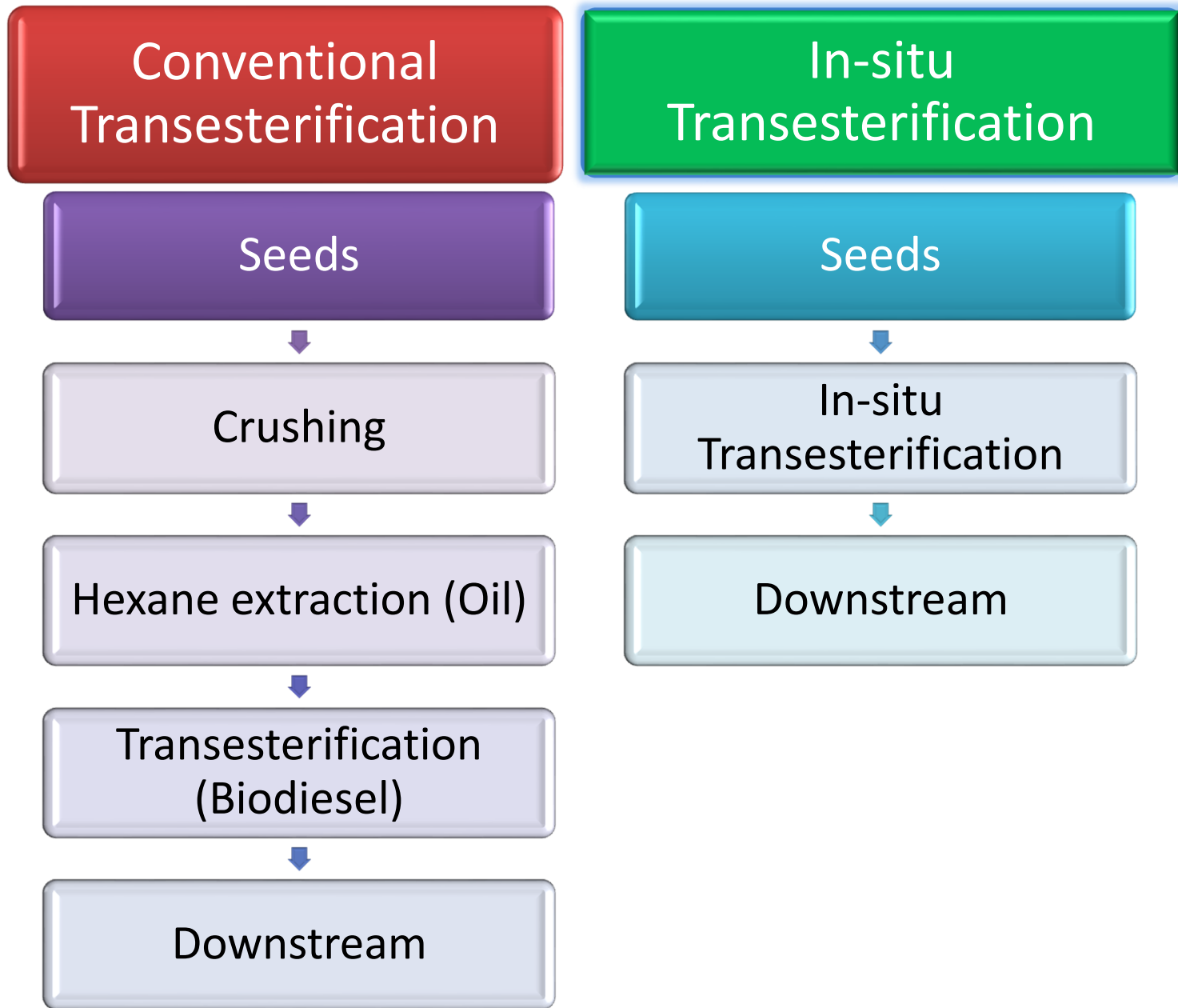


Bio Diesel



- **Advantages**
  - Eliminates the requirement of two separate processes.
  - Reduces processing time.
  - Reduces cost associated with oil extraction.
  - Reduces overall solvent requirement.

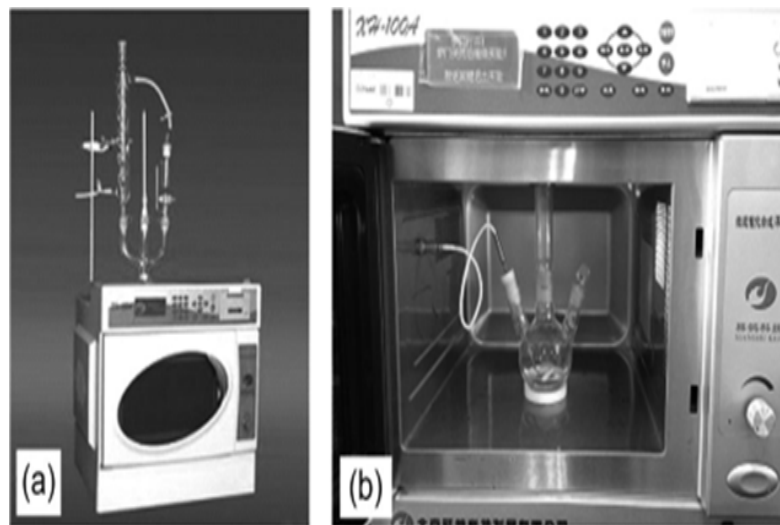
# Cont...



## Microwave Reactor System



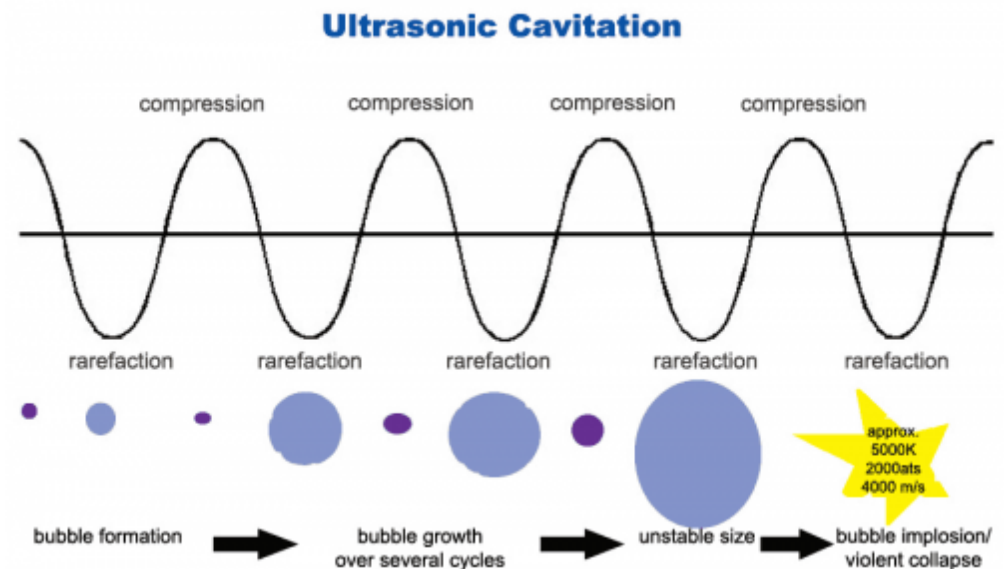
## Hybrid Reactor



- Efficient heating method
- Advantages are simplicity, low cost
- Heat is generated by molecular friction
- Reaction rate increases

# Ultrasound Assisted Intensification

- CBBS is equipped with ultrasonic reactors of 20 kHz frequency.
- Ultrasonic energy can be utilized for faster production of biodiesel compared to conventional mechanical stirring technique.
- **Advantages :**
- Faster reaction (15 minutes) compared to mechanical stirring (2 hrs.)
- Low temperature reaction at atmospheric condition.
- Less energy consumption.





# Hydrodynamic Cavitation

- Cavitations are generated by varying conditions of pressure and velocity with the help of geometries like orifice plates and venturi tubes.
- Temperature of the order 2000 K is generated at the micro level in cavitation bubble which is helpful for the reaction.
- **Advantages**
  - 1) Better scale up possibilities
  - 2) Higher yield in shorter reaction time
  - 3) Less energy consumptions



- **Futuristic development**

- Novel catalyst for glycerol free bio diesel production
- Develop plasma discharge, and germination based biodiesel production Technology
- Biomass to clean biofuels
- Algeal biodiesel production

# Annexure III research outcome and publications

- List of PhD candidates

S. No	Name of the Student	PhD Title	Year
1.	<b>Kartik Thakkar</b>	Some studies on investigation of in-situ transesterification for Castor oil methyl Ester production using PI techniques	July2016 onward
2	<b>Mrs. Anvita Sharma</b>	Study on biodiesel production using hybrid reactor	July 2013 onward

## List of M. Tech. candidates

S. No	Name of the Student	M. Tech. Dissertation Title	Year
1.	<b>Kartik Thakkar (Mechanical)</b>	Development of Biodiesel Production Process using Vegetable oils & Engine Performance Testing	2016
2.	<b>Pavit Bhaveshkumar Shah (Mechanical)</b>	Biodiesel Production from Vegetable oils using Supercritical Method and Engine Performance Studies	2016
3.	<b>Keyur V Shah (Mechanical)</b>	In-situ Transesterification of castor seed oil for biodiesel production using hybrid reactor and engine performance studies	2017
4.	<b>Jigar Patel (Mechanical)</b>	Experimental investigation on catalyst free insitu biodiesel production process through germination	2017
5.	<b>Ravi P. Chaudhari (Chemical)</b>	Optimization of reaction parameters for biodiesel production from mahua oil using supercritical ethyl acetate and hexane as a co solvent	2017
6.	<b>Bhavya Makhania (Chemical)</b>	Investigation study of biodiesel production from non-edible oil using heterogeneous catalyst	2017
7.	<b>Utkarsh Mistry</b>	Biodiesel production from hydrodynamic cavitation using Castor seed oil	2018 onwards

•Sixteen B. Tech students have successfully completed B. Tech. projects in CBBS since July 2014.

## Publications (Journals/Conferences)

- Kartik Thakkar, Keyur Shah, Pravin Kodgire, Surendra Singh Kachhwaha, 'In-situ reactive extraction of castor seeds for bio diesel production using the coordinated ultrasound-microwave irradiation: Process optimization and kinetic modeling' **Ultrasonics Sonochemistry Journal 50, 2019, 6-14**(Elsevier publication, Thomson Reuters Impact factor = 6.0).
- Anvita Sharma, P Kodgire, S S Kachhwaha, H B Ragvendra 'Application of Microwave Energy for Biodiesel Production using Waste Cooking Oil', Materials Today: Proceedings, pp. 23064–23075, Nov 2018.
- Pravin Kodgire, Kartik Thakkar, Surendra Singh Kachhwaha, Seshasai Srinivasan 'Experimental investigation of in-situ biodiesel production from Castor seeds (*Ricinus Communis*) using combination of microwave and ultrasound irradiation', IAPE'19 Management chair, Director of Corgascience Limited, UK, pp. 1-8, 14 Mar 2019 (to be presented)
- A. Sharma, P. Kodgire, S. S. Kachhwaha, Comparative analysis of mechanical stirring and process intensification techniques for biodiesel production using waste cotton-seed cooking oil' 12<sup>th</sup> International Conference on Thermal Engineering: Theory and Applications (ICTEA), February 23-26, 2019, PDP, Gandhinagar, India. **(WON BEST PAPER AWARD)**
- Kartik Thakkar, Surendra Singh Kachhwaha, Pravin Kodgire, Seshasai Srinivasan, Experimental Investigation on In-Situ Biodiesel Production using Hybrid Intensification and CI Engine Testing, 12<sup>th</sup> International Conference on Thermal Engineering: Theory and Applications (ICTEA), February 23-26, 2019, PDP, Gandhinagar, India.
- Utkarsh Mistry, Kartikkumar Thakkar, Pravin Kodgire, Surendra Singh Kachhwaha, Biodiesel Production from Castor Seeds (*Ricinus communis*) oil using Hydrodynamic Cavitation, 12<sup>th</sup> International Conference on Thermal Engineering: Theory and Applications (ICTEA), February 23-26, 2019, PDP, Gandhinagar, India.

## Publications (Journals/Conferences)(Contd.....)

- Kartik Thakkar, Keyur Shah, Pravin Kodgire, S.S Kachhwaha, H. B. Raghavendra, “Experimental investigation of in-situ biodiesel production from Castor seeds (*Ricinus Communis*) using combination of microwave and ultrasound intensification”, *accepted for oral presentation and Springer conference proceedings of ICAER 2017* to be held at IIT, Bombay (Dec., 2017).
- Pravin Kodgire, Kartik Thakkar, Keyur Shah, S.S Kachhwaha, H B Raghavendra, “Experimental investigation of *in situ* transesterification of castor seeds (*ricinus communis*) for methyl ester production using hybrid reactor” at **ACS 254<sup>th</sup> Annual Meeting**, Washington DC, USA, Aug 2017.
- Anvita Sharma, P Kodgire, S S Kachhwaha, H B Ragvendra, “Application of Microwave Energy for Biodiesel production using Waste cooking Oil”, Proceedings of the **V<sup>th</sup> International Conference on Advances in Energy Research, ICAER 2015** December 15-17, 2015, IIT Bombay, India.
- A Kumar, P Kodgire, S S Kachhwaha, H B Ragvendra, “Process Design for Biodiesel Production using Reactive Distillation: Simulation Studies Using ASPEN”, Proceedings of the **V<sup>th</sup> International Conference on Advances in Energy Research, ICAER 2015** December 15-17, 2015, IIT Bombay, India.
- Himanshu Choksi, Pravin Kodgire & Surendra Singh Kachhwaha; ‘Biodiesel Production Using Supercritical Alcoholysis: A Review’, Proceedings of International Conference on Chemical Industry (**ICCI 2014**); Bharti Publication, New Delhi (ISBN 978-93-81212-84-4), pg 1-6, 2014 (Won the Best paper presentation award).
- Anvita Sharma, Dr. Pravin Kodgire & Dr. Surendra Singh Kachhwaha; ‘Review on Biodiesel Production using Process Intensification Techniques’, Proceedings of International Conference on Chemical Industry (**ICCI 2014**); Bharti Publication, New Delhi (ISBN 978-93-81212-84-4),pg. 7-18, 2014.

# CBBS Team @ PDPU

- Prof. T P Singh [Director (SoT)] (Head, CBBS, PDPU)
- Prof. Surendra Kachhwaha (In charge and Member CBBS)
- Dr Pravin Kodgire (Member, CBBS)
- Research Scholars: Mr Kartik Thakkar; Mrs. A Sharma; Mr. Utkarsh Mistry

*THANKS !*