



### Abstract of the Thesis



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Faculty: Engineering

Discipline: Chemical

Title of Thesis: Process Intensification for Biodiesel Production

India has set a net zero emission goal by 2070 and as India's growth unfolds and the need for energy is going to rise dramatically, not only in country but across the globe. Biodiesel is one of the strongest competitors in the race of renewable energy especially, as the alternative fuels, for sufficing the energy needs globally. In parallel research, process intensification techniques have been identified as the best suited methodology for energy savings, environment-friendly and cost savings. In this research work we have addressed the issues associated with biodiesel manufacturing like wastewater generation and energy consumption in conventional biodiesel manufacturing, longer reaction times, separation of catalysts and alcohol used, production inefficiencies due to raw material variance and likewise. Moreover, we have used Reactive Dividing Wall Distillation Column, modified for ease of fabrication and operation, working under batch and/or semi – batch conditions, for successful conversion of non-edible oils such as neem oil into biodiesel using simultaneous dual step esterification and trans-esterification reactions with homogeneous and heterogeneous catalysts, further purified by simple settling to achieve desired standards of biodiesel. The project begins with design of RDWC which includes identification of reaction kinetics computed in MS Excel, VLE/VLLE property determination using ASPEN Property Toolbox and column design in both MATLAB and ASPEN. The equipment was fabricated as an assembly of laboratory scale borosilicate glassware, in association with the accessories such as submersible pumps, tubes, motor with shaft for agitation and heating mantle. Next, ASPEN based simulations were done on individual fatty acids present in the neem oil for transesterification reactions and property determinations. Further, experiments were conducted on the fabricated equipment, wherein, oil: molar ratio, presence of alkali, catalyst loading, and catalyst type were chosen as varying parameters, under the atmospheric isobaric conditions. Lastly, the experimental results were tested for product

compositions using titration and analytical methods. It was found that the maximum yield of  $96.61 \pm 0.05\%$  was obtained for 1:10 O:M ratio, 4.6 wt.% acid catalyst and 1 wt.% base catalyst. The current study is a huge step towards the practical use of RDWC for production of biodiesel which was so far limited to only simulations or low molecular weight acid esterification. Further, this work opens the door for commercial scale production of biodiesel using non-edible oils using RDWC and also for more large scale applications of RDWC.

**This Ph.D. thesis will be useful for anyone who is associated with Biodiesel Production, Process Development, or Intensification and for any researcher working on Process Intensification or Biodiesel Production.**

## **Published Work**

### **Journal Publication**

1. Banka Samidha, Parikh S. P., “Non-edible oil biodiesels: The cutting-edge future of renewable energy in India”, Asia-Pacific Journal of Chemical Engineering, e2310, Vol. 14, Iss. 2, John Wiley & Sons Ltd., Curtin University, April 2019. <https://doi.org/10.1002/apj.2310>
2. Banka Samidha, Parikh S. P., Pandaya H. N., “Pongamia pinnata biodiesel production using cobalt doped ZnO nanoparticles—An analytical study”, Environ Prog Sustainable Energy. 2022;e13814. doi:[10.1002/ep.13814](https://doi.org/10.1002/ep.13814)

### **Conference Proceedings**

1. Banka Samidha, Parikh S. P., “Reactive Distillation and Reactive Divided Wall Distillation Column Control Structures – Problems Associated and Mitigation”, Proceedings of International Conference on Green Technologies for Sustainable Development – 2021, DDIT, Nadiad and GUJCOST, Gandhinagar, ISBN: 978-93-5457-142-8.

### **Books Published**

1. Samidha Banka Agrawal and Dr. Sachin P. Parikh, जैव ईंधन - भारत के अत्याधुनिक ऊर्जा का स्रोत (Jaiv Indhan Bharat ke liye atyadhanuk urja ka srot) (Biodiesel – Source of Advanced Energy for India), 1st ed. Bengaluru : The Write Order, 2022, ISBN: 978-93-5776-052-2

### **Patents Granted**

1. Samidha Banka, Dr. Sachin Parikh, “Method For Production Of Methyl Esters From Commercial Grade Azadirachta Indica Oil”, Patent No.: 436239 Grant Date: 28/6/2023, Pub. No.: 49/2022, App. No.: 202221066848, Pub. Date: 9/12/2022.
2. Samidha Banka, Vachan Suthar, Hiral Pandya, Dr. Sachin Parikh, L. D. College of Engineering, “Biodiesel Preparation Device And Method Using Co Doped Zno Catalyst”, Patent No.: 401586 Grant Date: 19/7/2022. Pub. No.: 44/2021, App. No.: 202121046521, Pub. Date: 29/10/2021.