ABSTRACT

Global challenges related to energy security, resource sustainability and the environmental impacts of burning fossil fuels have led to an increasing need for switching from fossil fuel dominated energy uses to a clean and sustainable resource based energy use profile. In this regard, biomass sources can offer an enormous potential to fulfill mankind's energy need as biomass sources are easily available, sustainable and environmentally benign in nature. Biomass is the fourth largest source of energy in the world after coal, petroleum and natural gas, providing 15% of the world's primary energy consumption. Apart from heat generation, biomass is used as raw material for production of biofuels and chemicals through different conversion technologies. Among thermochemical conversions, pyrolysis is considered as a viable option, in which the product selectivity can be controlled and tuned to suite end-use interests by regulating the various process parameters. Liquid product obtained during pyrolysis has been suggested as one of the sustainable alternatives to fossil fuel resources for power generation as well as a feedstock for chemical and biofuel production. Moreover, the solid char co-produced during pyrolysis along with the liquid fraction also shows versatile applications both in the field of agricultural and environmental implication (e.g. as soil amendment, for inorganic pollutant removal).

Energy strategy in India recognizes the increasing importance of biomass which calls for greater mobilization of biomass resources to meet the demand. Indian government's recent biofuel policy is solely based on non-food feedstocks to avoid the possible conflict of fuel vs. food security. Utmost importance is given towards the utilization of waste and degraded forest and non-forest lands for cultivation of shrubs and trees bearing non-edible oil seeds for production of biofuel. India has a vast untapped potential of non-edible oil bearing plant species distributed throughout the country viz. nahar (*Mesua ferrea*), koroch (*Pongamia glabra*), terminalia (*Terminalia belerica*) etc. as feedstock for biodiesel industries. During the processing of feedstocks and subsequent production of biodiesel, a huge amount of bio-waste like seed covers, deoiled cake, etc., are generated as waste materials which are often discarded. Valorization of these waste materials for energy and chemical recovery could become an emerging option towards waste management and enhancing the economics of biodiesel production. Keeping in view, feasibility study for

conversion of *P. glabra* seed cover (PGSC) and *M. ferrea* seed cover (MFSC) to liquid fuel as well as other biomaterials are being carried out. Further, a number of microalgae species are reported as potential source for biofuel production from different parts of India. Among various microalgae species, the current study aims to explore the feasibility of *Scenedesmus dimorphus* genus, since it has the ability to grow and tolerate different environmental conditions, and is more resistant to physiological stress consequent to nutrient starvation and light limitation. Thus, the present investigation deals with the two groups of feedstocks – one group belongs to lignocellulosic biomass (PGSC and MFSC) and another, a microalgae species (*S. dimorphus*) of non-lignocellulosic origin for their pyrolytic conversion potential to fuels and biomaterials.

The content of the thesis is outlined as Introduction, Literature Review, Materials and methods, Results and discussion, and lastly Conclusion. Results and discussion section is further divided into four parts.

Chapter 1 i.e. Introduction, deals with a brief introduction, background of the study and its limitation. The chapter focuses on the importance of biomass as a source of renewable energy. It also discusses the feasibility of pyrolytic valorization of feedstocks into various products and their possible applications. The chapter comprises of justification for the present investigation followed by objectives of the study.

Chapter 2 i.e. Literature Review presents an overview of the related work that has been carried out by various researchers around the world. This chapter helps to understand the earlier research outcomes and their limitations. The chapter focuses on various feedstocks that have been investigated for pyrolytic conversion into liquid and solid fuels.

The third chapter (Materials and Methods) deals with the detail methodologies that were used to carry out all the experiments in the present study. Experimental and characterization techniques adopted for the feedstocks under investigation and pyrolysis products i.e. biooil and biochar are discussed.

The first and second part of the fourth chapter discusses, correspondingly, the results of lignocellulosic group of biomass (PGSC and MFSC) and microalgae species (*S. dimorphus*). Thermo-gravimetric analysis of the selected feedstocks was carried out in order

to evaluate their thermal degradation behavior during pyrolysis. The effect of pyrolysis temperature and heating rate on product yield was predicted by simulation technique named Response surface methodology (RSM) based on Central composite design (CCD) matrix which was again verified by experimental results. The liquid products obtained at optimum condition were further separated by using a liquid column chromatography for categorization of its sub-fractions. Further, the biooil and their sub-fractions were analyzed for different physical and chemical properties by using different chromatographic and spectroscopic technique such as FT-IR, ^{1}H NMR and GC/MS. The solid co-product of pyrolysis i.e. biochar obtained at different temperatures were also investigated for different physical and chemical properties in order to estimate their suitability for fuel and other applications.

The use of biochar as a low-cost sorbent to remove inorganic metal and organic (dye/color) contaminants from aqueous solutions is an emerging and promising wastewater treatment technology.

Chapter 4(c) deals with the removal of Co (II) ion from aqueous solution by using biochar produced during pyrolysis of PGSC, MFSC and *S. dimorphus* while Chapter 4(d) comprises of studies carried out using on removal efficiency of two basic dyes – Methylene blue and Rhodamine B from aqueous solution by using PGSC derived biochar.

Last chapter of the thesis (Conclusions and Future scope), discusses about the summary drawn out from all the respective experiments. Apart from these, limitations for the current study and some important outcomes from MFSC, PGSC and *S. dimorphus* pyrolysis study are recorded. Finally, some recommendations for future work of research in biomass pyrolysis research are suggested.