STUDIES ON THERMAL CRACKING OF PYROGASES FROM BIOMASS

by

KRISHNA RAJ SHRESTHA

A thesis submitted
in fulfilment of the requirements for
the award of the degree of

DOCTOR OF PHILOSOPHY

DEPARTMENT OF CHEMICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY DELHI

NEW DELHI - 110 016 (INDIA)

1997

Dedicated

to

My Mother

CERTIFICATE

This is to certify that the thesis entitled **'STUDIES ON THERMAL CRACKING OF PYROGASES FROM BIOMASS'** being submitted by Mr.Krishna Raj Shrestha to the Indian Institute of Technology, Delhi, for the award of the degree of **Doctor of Philosophy** is a record of bonafide research work carried out under our guidance and supervision and has fulfilled the requirements for the submission, which, to our knowledge has reached the requisite standard.

The results obtained in this thesis have not been submitted in part or in full to any other University or Institute for the award of any degree.

Prof. P.D. Grover
(Supervisor)

Dr. P.V.R. Iyer
(Supervisor)

ACKNOWLEDGEMENTS

It is with a deep sense of gratitude and indebtness that I would like to thank Prof. P.D.Grover, former Head of Chemical Engineering Department and Dr. P.V.R.Iyer,Associate Professor, Chemical Engineering Department, Indian Institute of Technology Delhi, for not only guiding me but also for the encouragement, inspiration and motivation throughout the course of this work.

I am deeply indebted to the other former heads of Chemical Engineering Department, Prof.K.Vasudeva and Prof. D.Subba Rao and the present head, Prof. D.P.Rao, for providing facilities in carrying out my research work during my six years tenure in this department.

I would like to thank all the faculty of the Department of Chemical Engineering, particularly Dr. T.R.Rao, Dr. V.K.Srivastava, Dr. S.C.Dhingra, Prof. A.K.Gupta,Prof. K.D.P.Nigam, Prof. B.K.Guha and Prof. B.Pitchumani for their encouragement and concern about my work.

I wish to thank Dr.S.S.Sambi and G.S.Sundaram for their help in the analyses of the samples. Thanks are also due to Dilbagh Singh, Subhash, Sandeep, Ajay, Ram Dev, Badri and Ranjit for their help in the experimental work.

I thank all my friends Ahuja, Atul, Pandit, Gopi, Pushpa, Navneeta, Deepak, Dr. Anil Jain and Dr. S.K. Mishra for their help and motivation throughout my research work. I am indebted to my friend Shova for her generous help, particularly during the writing of this thesis. Her constant involvement became my responsibility to complete this work.

Dr. Sita Kaushik's affection was always a morale booster. I am also thankful to my brother-in-law, Dr. B.M.Kaushik for his kind advice and moral support. In those moments when things used to turn dark, his encouragements had a soothing effect.

I am thankful to Prof. Madhav Sharma, former Executive Director, Research Centre for Applied Science and Technology and presently Rector of Tribhuvan University, Kathmandu, Nepal for providing me the opportunity to pursue this research work under the auspices of the Memorandum of Understanding (MOU) between Tribhuvan University ,Nepal and IIT-Delhi and to the authorities of IIT-Delhi for providing me the financial assistance and facilities to carry out this research work.

I would like to place on record my sincere gratitude to my father, Mr. Mohan Raj Shrestha and other family members for their blessings, perpetual support and constant encouragement which enabled me to carry out this work successfully.

Finally, I would like to express my indebtness to my wife Sonee, for her patience, understanding and support throughout the course of this work. Without her encouragement and sheer endurance, probably I wouldn't have completed this work. It will be unfair on my part, if I forget to thank my daughters, Shreetu and Neha for their patience and understanding during those long years of my absence from home.

K R Shrestha

(KRISHNA RAJ SHRESTHA)

ABSTRACT

Among the various non conventional energy sources, biomass has emerged as one of the most potential renewable energy sources. Biomass, specially, rice husk, sugar cane bagasse, cotton and mustard stalks, coffee husk, ground nut shells, coconut coir, etc. are abundantly available. These agro-residues, however, are either grossly under utilised or completely unutilised by burning in-situ in the fields as a means of disposal. One of the promising routes to utilise biomass in an integrated manner is through thermochemical conversion processes such as direct combustion, pyrolysis with or without partial oxidation and gasification which are used for getting energy and value added products.

Pyrolysis is one of the major steps during combustion and gasification of biomass. During these processes, a fraction of biomass is always converted into tars,which are complex mixtures of easily condensable viscous compounds. Cleaning of Pyrogases during carbonisation or gasification can be done effectively by thermal cracking of the tars. By this process tars can be converted into lighter gaseous components to get a clean gas for clean combustion or for its use in I.C engines for power.

In the present work, thermal cracking of tar laden gases obtained by the pyrolysis of rice husk is studied at different cracking temperatures. Effect of temperature of cracking on the yield and quality of gas are studied. Cracking is done in a fixed bed of ceramic beads, dolomite, refractory pieces and charcoal pieces. Results obtained at different cracking temperatures indicate promising tar conversion particularly at higher temperatures. Cracking over charcoal surface at 1000°C resulted in almost complete decomposition of tar and pyroligneous liquor into combustible gases. A detailed comparative study on cracking over refractory and charcoal surface is presented.

CONTENTS