

**Catalytic Investigations on Hydroformylation of Lower Alkenes
by Selective Metal/Metal Complex Based Catalysts**

A Thesis

Submitted to

Bhavnagar University

for the degree of

Doctor of Philosophy

in

Chemistry

by

Vivek Kumar Srivastava

Silicates & Catalysis Discipline

Central Salt & Marine Chemicals Research Institute

Bhavnagar-364002, India

December - 2004

22nd December 2004

Candidate's Statement

I hereby declare that the works incorporated in the thesis entitled “*Catalytic Investigations on Hydroformylation of Lower Alkenes by Selective Metal/Metal Complex Based Catalysts*” are original and has not been submitted to any university / institution for the award of a diploma / degree.

I further declare that the results presented in the thesis and the considerations made therein, contribute in general to the advancement of knowledge in chemistry and in particular to applications of metal/metal complex catalysts in the hydroformylation reactions of lower alkenes.

(Vivek Kumar Srivastava)

22nd December 2004

Certificate by the Ph.D. Supervisors

This is to certify that the contents of this thesis entitled *“Catalytic Investigations on Hydroformylation of Lower Alkenes by Selective Metal/Metal Complex Based Catalysts”* are the original research work of **Mr. Vivek Kumar Srivastava** carried out under our supervision.

We further certify that the work has not been submitted either partly or fully to any other university / institution for the award of any diploma / degree.

(Raksh Vir Jasra)

(Guide)

(Ram Sambhar Shukla)

(Co-Guide)

Dedicated to,

My parents & adored brother

Acknowledgement

First of all, I would like to articulate my colossal and cavernous gratitude to my guide, Dr. Raksh Vir Jasra, for his invaluable supervision with the tenacity during the entire periods of my research work. The guidance from his astute knowledge of both the theoretical and practical aspects of the research problems endowed me to carry out my Ph.D. work with the high-pressure reactions like hydroformylation. His eternal ardour enthused me to accomplish my aspiration. Definitely, he wrought my stance toward research and developments. Indeed, I am privileged for being one of his students.

I am also earnestly indebted to Dr. Ram Sambhar Shukla, (Co-Guide) for his splendid guidance and supports in the form of successful completion of my Ph.D. His invariable inquisitiveness and fertile discussions from his profound knowledge reached me at the present position.

I wish to record my respectful regards to Dr. P. K. Ghosh, Director, CSMCRI, for his profound encouragements throughout the Ph.D. work.

I cannot fail to acknowledge my prodigious gratitude to Dr. Hari Chand Bajaj, Senior Scientist, for his constant encouragements and wholehearted interests in my Ph.D. work. His shrewd knowledge of operation and upholding of the autoclave reactors always helped me in the successful completion of my research work.

Dr. Sharad D. Bhatt, Senior Scientist, working in the high-pressure lab, deserves for my exceptional thanks. His profound knowledge for the handling and maintenance of the high-pressure reactor and gas cylinders always helped to carry out my Ph.D. work with safe and secure environment.

Also, I owe my sincere gratitude to my lab-mates, Mr. Dharmesh U. Parmar, Mr. Aliraza H. Lakhani, Mr. Sumeet K. Sharma, Mr. Kalpesh Sidhpuria and Mr. Munir D. Khokhar who have created a healthy, amusing and serene environment to carry out the research work.

I am also grateful to the scientific and technical staffs of Silicates & Catalysis Discipline, Dr. S.H.R. Abdi, Dr. (Mrs.) R.I. Kureshy, Dr. S. Kannan, Dr. R.S. Somani, Dr. N.H. Khan, Dr. H.M. Mody, Dr. Juggnu Bhatt, Dr. (Mrs.) Beena Tyagi, Dr. A.B. Boricha, Mr. Rajesh J. Tayde and scientists from other Disciplines, Dr. Amitava Das, Dr. S. Muthuswamy and Dr. Parimal Paul, Dr. D.B. Shukla for their co-operation, in various ways, whenever necessary, to complete my Ph.D. work.

I am extremely gratified to Dr. Vinod K. Shahi, Scientist, Reactive Polymers Discipline and his family who were always supported me in awful times during the Ph.D. work.

My sincere thanks also to, Mr. Mukesh K. Yadav (for FT-NMR analysis), Mr. Vinod P. Boricha (for FT-IR analysis), Mr. Shobhit Singh and Mr. Pradeep Parmar (for instrumentation in the autoclave reactor), Dr. (Mrs.) P. Bhatt (for P-XRD analysis) and Dr. E. Suresh (for Single-crystal X-ray analysis), Mr. Pramod N. Makwana and Sanjay N. Jani (from IT-cell) who have always been helpful and Baraiyabhai for providing Xerox service immediately.

I am also thankful to Mr. P. G. M. Pillai (Stenographer, Silicates & Catalysis), Mr. M.L. Bhatt, Mr. J.M. Parmar, Mr. B.B. Parmar, Mr. V.C. Zala, Mr. B.M. Waghela and Mr. C.D. Gohel (Technicians) who were also contributed in various ways to ensure the successful completion of my doctoral work.

I am also thankful to personnel from Workshop, Mr. S.N. Patel and Mr. J.H. Devmurari and Mr. J.N. Bhardia. They were always available for maintenance and rectification of the minute and major problems of the autoclave reactor without which it was difficult to carry out Ph.D. work in hydroformylation reactions in appropriate time-period. I am also thankful to personnel from Administration section Mr. Ram Babu and Mr. Yagnesh R. Trivedi for their kind co-operation in many ways.

I am also thankful to my senior colleagues Dr. P.H. Pandya, Dr. Y.M. Badheka, Dr. C.D. Chudasama, Dr. A.D. Shukla, Dr. A. Babu, and Dr. A. Dubey who inspired me to carry my Ph.D. work from such a premier institute.

I am extremely grateful to my friends and hostel-mates, Jince Sebastian, Kishore Dasari, Krishna Kumar D., Amar Ballabh, Manish K. Mishra, M.S. Reddy, Surendra Singh, Sunil A.P., Irshad Ahmed and Amilon Jose with whom I enjoyed a lot during the stay to carry out Ph.D. work.

The acquaintances are also gratefully acknowledged, C. Gunanathan, J. Krishnamurty, Gyanapraksh, Srinivasan, Laxmi, Achyut, Kavita, Pragati, Hasmukh, Jignesh, Prashant, Dharmesh, Jagan, J. Krishna Mohan, Nagrale, Gohelbahi for their moral supports.

The financial assistance from the Department of Science and Technology (DST) and Council of Scientific and Industrial Research (CSIR), Govt. of India, in the form of a research fellowship, is gratefully acknowledged.

It will be gaffe if I overlook them who had shaped me in early-age to reach at the present position. Among them, at the outset, I am earnestly gratified to my maternal uncle Prof. Shailendra K. Srivastava, Reader, Dept. of Physics, M.G.P.G. College, Gorakhpur (University of Gorakhpur, Gorakhpur) who exposed me the world of science and scientific research in early-age. It was definitely his confidence and moral supports during

the willowy periods of early-age that brought me at the position to carry out Ph.D. in Chemistry. My well-wishers and colleagues from Pipraich and Gorakhpur deserves for my extraordinary gratitude for their invaluable faith and love.

It is almost impossible to verbalize my regards to my father, mother, bother and family members for their everlasting support, belief and sacrifices, which helped in the successful execution of my mission.

Last but not least, I thank the almighty who stood to my side through all the endeavours of the work by providing me mental and physical strength which paved a lot till the end.

(Vivek Kumar Srivastava)

CSIR-SRF,

CSMCRI, Bhavnagar.