

**NATIONAL CENTRE FOR CATALYSIS RESEARCH  
INDIAN INSTITUTE OF TECHNOLOGY MADRAS  
CHENNAI 600036**



**REPORT ON THE ACTIVITIES OF NCCR DURING 2008**

**(Document submitted to the Director IITM)**

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**A. Education, Capacity Building and Human Resource Development**

1. The following six research scholars of NCCR completed their Ph.D. thesis work during this year and have been awarded the degree by IITM:

**Mr. S. Navaladian**

**Ms. C.M. Janet**

**Mr. Ch. Venkateswara Rao**

**Mr. L. Himakumar,**

**Mr. P. S. Kishore and**

**Ms. J. Rajeswari**

2. The following students have joined NCCR for research work and some of them have since been registered for their Ph.D. degree:

Mr. Anil Kumar

Mr Ramanamurthy

Mr. Mahendran

Mr.P.R.Venkatesan

Ms.Anandhakirupa

**New Research Associates** who have joined the centre during this year include:

1. Dr P P George
2. Dr Thirunavukarasu
3. Dr Anuradha
4. Dr Navaladian

Presently, the total number of research scholars and project associates at NCCR is **18** and Research associates (PDF) is **six**.

3. Detailed syllabus for an M.Tech course at IITM in Catalysis and Technology has been drawn and submitted to our administration for necessary action to enable us to offer this course from the next academic year.
4. The 9<sup>th</sup> Orientation program on catalysis for the research scholars in the country was conducted during 17<sup>th</sup> November – 8<sup>th</sup> December 2008 (21 days) in which 35 students from different institutions participated.
5. One of our NCCR faculty (Dr. S. Sivasanker) taught a regular course on industrial catalysis for the students of M.Sc. Applied Chemistry of Anna University (I

- semester), as a part of an academic cooperation between NCCR and Anna University.
6. A similar academic cooperation with Departments of Chemistry and Energy of Tezpur University has been established with an MOU. Prof. B.Viswanathan conducted a course on catalysis for the M.Sc. students of Tezpur University, as a part of their curriculum. He also delivered some special lectures on spectro-electro chemistry. (Dates: 10<sup>th</sup> September to 22<sup>nd</sup> September 2008)
  7. For the students of M.Sc. Inorganic chemistry (3<sup>rd</sup> Semester) of Pune University, Dr. A.V. Ramaswamy gave a series of 12 lectures on homogeneous catalysis as a part of their course on organometallics (22<sup>nd</sup> to 27<sup>th</sup> September 2008).
  8. A special one day course on catalysis, zeolites and characterization technique, with particular reference to deNO<sub>x</sub> systems was offered to a group of employees of General Motors, Bangalore on 9<sup>th</sup> September 2008 by NCCR faculty (Prof. B. Viswanathan, Dr. A.V. Ramaswamy and Dr. S. Sivasanker) under a research grant given by GM India Ltd., to NCCR.
  9. The Annual Day of NCCR was observed on 2<sup>nd</sup> August 2008 with the participation of research scholars from Anna University, with four presentations on recent research work of the scholars and a special lecture by Prof. K. Shanthi of Anna University. For improving the general quality of research work, such joint programs will be conducted once in 6 months.
  10. NCCR took the initiative to conduct a pre-workshop school (Tutorial) for selected research scholars, prior to the National Workshop on Catalysis held at IMMT, Bhubaneswar (15-16 February 2008). The subject was “Thermal Methods in Catalysis” and conducted very successfully by Prof. B. Viswanathan, Dr. A.V. Ramaswamy and Dr. C.V.V. Satyanarayana (NCL, Pune). The annual meetings of the Catalysis Society of India (a symposium and a workshop alternatively), henceforth, will include such 2-day intensive tutorials (schools) for in-depth training of research scholars on a particular subject or technique in catalysis.
  11. As a part of course work for research scholars in catalysis of National Chemical Laboratory, Pune, Dr. A.V. Ramaswamy gave a series of lectures at NCL, Pune during 24<sup>th</sup> to 28<sup>th</sup> November 2008.
  12. Steps have been taken to enter into an MOU with some international institutions, including the Centre of Catalysis of the Technische Universität München, Germany.
  13. A book entitled “Heterogeneous Catalysis” authored by Prof. D.K. Chakrabarty and Prof. B. Viswanathan has come out as an international edition, published by New Age Science Limited Kent TN1 1YS, UK.

14. Our annual program for Children's Club on "Synthetic Strategies in Chemistry" has been placed as an e-book in our Centre's web site. Our E-prints server has crossed over a 1000 documents this year in the area of catalysis.

### B. Basic Research/Outcome

1. NCCR's focus on basic research has been in four areas, viz., catalysis in energy conversion, new materials and environmental catalysis, surface science and theoretical studies and modeling of catalysts and surfaces. The pursuit of research by the Ph.D. scholars and post-doctoral fellows in these areas and the research output are reflected in the research publications, presentations at national and international conferences, reviews and status documents of NCCR faculty and the research scholars. During 2008, we have published more than 30 research papers (list to be appended), 20 or more of papers presented at conferences (list to be appended) and special lectures delivered by the faculty.

Name	Title of the presentation	Details of presentation conference with date
A.V. Ramaswamy	Designing Functional Ceria Materials by Nano-architecture	Plenary lecture at International Catalysis Conference, Tehran, Iran, 28-30 April, 2008
A.V. Ramaswamy	Chemical States and Redox properties of Mn/CeO <sub>2</sub> -TiO <sub>2</sub> Nano composites	Lecture at Institute of Isotopes, Budapest, Hungary, 4 November, 2008
	<b>Others details are given at the end of this document under presentations 2008</b>	

2. We have submitted a patent application for a novel membrane material based on composite polymers for filing in India.

### C. Industry supported projects/Industry-Academy interactions

1. The following projects sponsored by Chennai Petroleum Corporation Limited, Chennai have been completed and final reports have been submitted:
- Adsorptive desulphurization of diesel fraction and
  - End point reduction of diesel fuel.
2. The following projects are under progress:
- Deposition of ceramic oxides on SS surfaces (under Shell Fellowship)**
  - IOC (Preparation of alumina support)**
  - NMITLI, CSIR (Glycerol to value added products)**
  - P&G (Oxidation at terminal position in alkanes)**
  - GM Research Grant for studies on deNO<sub>x</sub> reactions**

3. With General Motors India Ltd., Bangalore, a project proposal on the mechanistic aspects of SCR of NO<sub>x</sub> has been filed and is under consideration for funding.
4. Following the interactions with BASF, USA personnel and their visit to NCCR earlier, an agreement for sponsoring of projects by BASF at NCCR is being signed.
5. We had two interactive sessions with researchers of Nissan Motors for possible areas of collaboration and research projects to be undertaken at NCCR.
6. A research proposal for MNRE, as per their request in Hydrogen energy program, with multiple institutional involvement has been submitted.
7. The following new proposals are under consideration:
  - a) Consultancy work for Sri Ram Fibers Ltd.,
  - b) Consultancy work for Tamil Nadu Petro-products Ltd.,

#### **D. International Collaboration**

1. Under the Indo-Hungarian joint research project on metal clusters and surface Studies, exchange visits and discussions had taken place. Three of the Hungarian Scientists visited NCCR, and reciprocal visits by two professors from NCCR to Budapest and a long term (3 months' visit) of one of the research scholars from NCCR to Institute of Isotopes, Budapest for working on the project have been completed. The details are given below:

<b>Name</b>	<b>Organization</b>	<b>Details of the visit and dates</b>
Prof. Laszlo Guzzi and Dr. Zoltan Schay	February 2008	12-24, February 2008 Also participated and gave lectures at the National Workshop on Catalysis, IMMT, Bhubaneswar
Dr. Zoltan Paszti	April 16 to 30 <sup>th</sup> 2008 for two weeks	To work on Centre's XPS machine
Mr. G. Magesh	Research Scholar, NCCR, IITM	April to July 2008 to carry out research
Prof. B. Viswanathan and Dr. A.V. Ramaswamy	Faculty, NCCR, IITM	31 October to 8 November 2008

2. Indo-Taiwan (Project on development of fuel cells and membranes)
3. Indo-Australian (Carbohydrates to chemicals)

#### **D. Activities related to Catalysis Society of India:**

1. NCCR brought out four issues of the Bulletin of the Catalysis Society of India in time during this year. The other activities of CSI are coordinated from the Centre.

#### **E. Other Events and Activities:**

1. New analytical instruments installed this year include, HPLC (With a number of detectors) (Shimadzu, Japan) and XRF (wave-length dispersive) (Rigaku, Japan).
2. The annual MAC meeting was held on 7<sup>th</sup> July 2008, chaired by Prof. M.M. Sharma and attended by among other members, Dr. T. Ramasamy, Secretary, DST, New Delhi.
3. We have established NCCR Academic Trust to encourage students and provide incentives and awards to deserving researchers. We need to build this trust with generous contributions from everyone.
4. Our centre finds a place in the documents prepared by the British High Commission for Fuel opportunities in India and for Fuel Cell today. These two documents refer to our efforts in the research on fuel cells.
5. Ms. M. Helen (research scholar) won the best poster award at the recent International Conference on Functional Materials, held at IITM during November 2008.
6. The PAC meeting of the Physical Chemistry of DST was organized by the Centre on March 2008 to include an interactive session with PIs of new proposal for quality improvement of their project proposals.
7. Our Centre was formally declared open by Mr. Kabil Sibal, the Minister of Science and Technology, Government of India on in a glittering ceremony to mark the golden Jubilee of IITM and the Indo-German cooperation.

#### **List of Publications (2008)**

1. Veda Ramaswamy, Pallavi Shah, Karoly Lazar and A.V. Ramaswamy, Synthesis, Characterization and Catalytic activity of Sn-SBA-15 Mesoporous Molecular sieves, Catal. Surv. Asia, 12 (2008) 283.
2. B. Murugan and A.V. Ramaswamy, Chemical States and Redox Properties of Mn/CeO<sub>2</sub>-TiO<sub>2</sub> Nanocomposites prepared by Solution Combustion route, J.Phys.Chem.C, (on web, in press)(2008)
3. B. Viswanathan, and A V Ramaswamy, Selection of solid heterogeneous catalysts for transesterification reaction, Chemistry Industry Digest Pp 91-99 August 2008.

4. D. Titu, and A. Chadha , Preparation of Optically Pure Alkyl 3-(Hetero-2-yl)-3-Hydroxypropanoates by *Candida parapsilosis* ATCC 7330 Mediated Deracemisation, *Journal of Molecular Catalysis B: Enzymatic* (2007), doi:10.1016/j.molcatb.2007.11.006.
5. T. Vaijayanthi and Anju Chadha, Asymmetric reduction of aryl imines using *Candida parapsilosis* ATCC 7330 *Tetrahedron: Asymmetry*, Volume 19, Issue 1, 30 January 2008, Pages 93-96.
6. B.Viswanathan, Challenges in the development of Fuel cells Photo/electrochemistry and photobiology for Energy fuel and environment, *Research Signpost*, 2008 to appear.
7. Ch. Subrahmanyam, S. Shanmugam, B. Viswanathan and T.K. Varadarajan Synthesis and Characterization of Thermally Stable Mesoporous Titania, *Eurasian Chemico-Technological Journal* Volume 10 No 2 10(2008)1-31.
8. V.Chidambaram and B.Viswanathan “Single step liquid phase synthesis of methyl isobutyl ketone (MIBK) from acetone, *Eurasian Chemico-Technological Journal* Volume 10 No2 2008 to appear.
9. **P. Selvam** and S. Rajasekar “Synthesis, characterization and catalytic properties of Microporous cobalt aluminosilicate (CoLTL) molecular sieves, *Eurasian Chemico-Technological Journal* Volume 10 No1 2008 to appear.”
10. R.Mahalskshmy, P.Indraneel and B.Viswanathan “Functionality of carbon surfaces in Indian Journal of Chemistry section A Communicated.
11. R. Ulaganathan, R. Mahalakshmy and B. Viswanathan “Identification of Active Phase of Sn-Sb-Mixed Oxide Partial Oxidation System A Combined MM/DFT Study, *Bulletin of the Catalysis Society of India*, 7, 50-55 (2008).
12. S.Sabiah and B. Viswanathan “Mo-aminoacid Complexes as Analogs for Mo-based Enzymes: A DFT Approach submitted (2008).
13. V.Venkatasubramanian, M Sankaran B. Viswanathan and V R Subramanian, Tungsten carbide as possible support for Pt in electrochemical Reactions, *Bulletin of the Catalysis Society of India* submitted 7,146-152(2008).
14. B. Viswanathan, and M Sankaran, “Hetero-atoms as activation centers for hydrogen absorption in carbon nanotubes, *Diamond and Related Materials*, submitted (2008).
15. S.Arunachalam and B. Viswanathan, “South-South cooperation: The case of indo-Chinese collaboration in scientific research, *Current Science*, 95,311 (2008).
16. S.Arunachalam and B. Viswanathan “A historiographic analysis of fuel-cell research in Asia – China racing ahead, *Current Science*, 95, (2008) 36-49.
17. P. Sangeetha, K. Shanthi, K.S. Rama Rao, B. Viswanathan, **P. Selvam** “Hydrogenation of nitrobenzene over palladium-supported catalysts-Effect of support, *Applied catalysis, Available online 6 November 2008*).
18. Anil Kumar, M P Maiya, S Srinivamurthy, and B.Viswanathan, Structural hydrogen storage and thermodynamic properties of some misch metal nickel alloys with partial substitutions for nickel in *Journal of alloys and compounds Available online 6 November 20 08*.
19. Jothiramalingam, Wang and B.Viswanathan Heterogeneous catalysts for Transesterification reaction, *Photo/electrochemistry and photobiology for Energy fuel and environment, Research Signpost*, 2008 to appear.

20. P.S.Kishore, B.Viswanathan, and T K Varadarajan “Synthesis and characterization of metal nanoparticle embedded conducting polymer polyoxometalate composites, *Nanoscale Res.Lett.*, 3, 14, 2008.
21. P.S.Kishore, B.Viswanathan and T. K.Varadarajan, “Electrochemical oxygen reduction reaction by Pt nanoparticles supported on carbon support stabilized by polyoxometalates, *J Nanosci.Nanotech* (In press).
22. P.S.Kishore, B.Viswanathan and T.K.Varadarajan, “Silicotungstic acid based carbon supported noble metal electrodes for energy conversion and storage applications, *J.Phys.Chem* (Under revision).
23. P.S.Kishore, B.Viswanathan and T.K.Varadarajan, “ Preparation of tungsten carbide from conducting polymer polyoxometalate composite and its selective role as supports for Pt nanoparticles in fuel cell applications ( in preparation).
24. P.S.Kishore, B.Viswanathan and T.K.Varadarajan, “Exploitation of Pt/WC for the facile hydrogen evolution reaction (in preparation.)
25. S.Shanmugam, B.Viswanathan and T.K.Varadarajan, “ The preparation of metal oxygen molecular cluster embedded in organic inorganic nanocomposite and its rectifying behaviour, *Materials chemistry and Physics*, 112(2008) 863-868.
26. S. Navaladian, B. Viswanathan, T. K. Varadarajan and R.P. Viswanath, “A rapid synthesis of oriented palladium nanoparticles by UV irradiation *Nanoscale Research Letters*, **Published online:** 4 December 2008.
27. G.Vasu, A. Tangirala B. Viswanathan, K.S.Dhathatreyan, Continuous bubble humidification and control of relative humidity of H<sub>2</sub> for a PEMFC system *International Journal of Hydrogen Energy*, Volume 33, Issue 17, September 2008, Pages 4640-4648.
28. Ch.Subramanian, S.Shanmugam, B. Viswanathan, and T K Varadarajan, “ Synthesis and Characterization of thermally stable mesoporous titania, *Eurasian chem Tech Journal* 10(2008)1-31.
29. J Rajeswari, P S Kishore, B. Viswanathan, and T K Varadarajan, One dimensional MoO<sub>2</sub> nanorods for supercapacitor applications “ *Electrochemical communications* (in press).
30. J Rajeswari, P S Kishore, B. Viswanathan, and T K Varadarajan, One dimensional MoS<sub>2</sub> nanorods for HER, *Nanotechnology* (communicated).
31. G Magesh, B. Viswanathan, R.P.Viswanath and T K Varadarajan, Photo catalytic behavior of CeO<sub>2</sub>-TiO<sub>2</sub> system for the degradation of methylene blue, *Indian Journal of chemistry section A* communicated.
32. S. Navaladian, B. Viswanathan, T. K. Varadarajan and R.P. Viswanath, Microwave-assisted rapid synthesis of anisotropic Ag nanoparticles by solid state transformation, *Nanotechnology*, 19, 45603-45610 (2008).
33. K. Vidya, V.S. Kamble, N.M. Gupta, P. Selvam, Uranyl-anchored MCM-41 as a Highly Efficient Photocatalyst in the Oxidative Destruction of Short Chain Linear Alkanes: An in-situ FT-IR Study, *J. Phys. Chem. C* 112 (2008) 15832-15843.
34. N. Bhatt, P. Sharma, A. Patel, P. Selvam, Supported 12-tungstophosphoricacid: An efficient and selective solid acid catalyst for tert-butylation of phenol and cresols, *Catal. Commun.* 9 (2008) 1545-1550.



35. P. Selvam, K. Vidya, A. Layek, Synthesis of vanadium oxide nanoclusters in confined environment via a template-exchange method, *Stud. Surf. Sci. Catal.* 165 (2008) 179-186.
36. S.K. Badamali and P. Selvam, Probing the Fe(III) sites in Mesoporous FeMCM-41, *Catal. Today* xxx (2008) in press; Available online 24 June 2008.
37. M. Pandey, S.K. Ray, and P. Selvam, The bonding configuration in a partially relaxed pseudomorphic epilayer of SiGe: evidence of the bc-8 phase of silicon, ***J. Phys.: Condens. Matter*, 20 (2008) xxx .**

### **Presentations for 2008**

1. B. Kuppan, B.Viswanathan and P. Selvam, Synthesis and Characterization of Ordered Mesoporous Carbon, National workshop on catalysis, IMMT, Bhubaneswar, Feb 18-20 (2008).
2. .K.Vidya, P.Selvam and B.Viswanathan, Synthesis, Characterization and Catalytic Properties of VSBA-15, National workshop on catalysis, IMMT, Bhubaneswar, Feb 18-20 (2008).
3. M.Bhaskar, A.Meenakshisundaram, B.Sairam, M.Banu and S.Sivasanker, Development of catalysts for end point reduction of straight run diesel fractions,” National workshop on catalysis, IMMT, Bhubaneswar, Feb 18-20 (2008).
4. B.Murugan and A.V.Ramaswamy, D.Srinivas, C.S.Gopinath and Veda Ramasamy, “The nature of manganese species in Mn/CeO<sub>2</sub>-TiO<sub>2</sub> solid solutions synthesized by solution combustion route,” National workshop on catalysis, IMMT, Bhubaneswar, Feb 18-20 (2008).
5. .B.Viswanathan, Appropriateness of Arrhenius equation for kinetic analysis of solid state reactions, National workshop on Thermal Analysis at IGCAR Feb 2008.
6. B.Viswanathan “Hydrogen production and storage for catalysis and future fuels,” Hydrocarbon conclave, II January 11, 2008 Goa (2008).
7. B.Viswanathan Conceptual reflections on hydrogen generation through PEC and its storage, 235 th ACS meeting in New Orleans, USA April 7, 2008,
8. B.Viswanathan Hydrogen storage options, Taiwan International conference on Carbon materials, May 2008.
9. P.S.Kishore, B.Viswanathan and T K Varadarajan “ Silicotungstic Acid (STA) based carbon supported noble metal electrodes for energy conversion and storage applications” 14th International congress on Catalysis.

10. B.Viswanathan “Some challenging avenues in the development of fuel cells” Hungarian academy of sciences on 5th November 2008 at 10 30 am in CRC.
11. B.Viswanathan “Photo electrochemical production of hydrogen a dream of Reality? Dr K Swaminathan Endowment Lecture at Loyola College on Wednesday December 10, 2008 at 11 am in the Lawrance Sundaram Hall. ”
12. B.Viswanathan, P.S.Kishore, J Rajeswari and T K Varadarajan, “Metal oxygen cluster compounds and their use in electrochemical devices to be presented in the Anna university course on nano materials in early 2009.”
13. B.Viswanathan, Hydrogen storage – Current Status, Tezpur University, Energy department 19<sup>th</sup> September 2008
14. B.Viswanathan, Fuel Cells and Spectro-Electro-Chemistry, University of Tezpur, Department of chemistry on 17<sup>th</sup> September, 2008.
15. B.Viswanathan, Development of membranes for fuel cell applications, Proceedings of the National workshop on Fuel cell Technology, SRM University, 22nd Feb 2008,
16. B.Viswanathan, Chemical analysis by Photo electron spectroscopy, National student’s symposium Horizon 08 NIT Trichi, 4th Oct 08,
17. B.Viswanathan, Photo-electrochemical methods - current status, Catalysis in Environmental Applications in IICT Hyderabad, 28th July 2008.
18. A.V.Ramasamy, Designing Functional Ceria Materials by Nano-architecture, plenary lecture at International Catalysis Conference, Tehran, Iran, 28-30 April, 2008
19. A.V.Ramasamy, Chemical States and Redox properties of Mn/CeO<sub>2</sub>-TiO<sub>2</sub> Nano composites, Lecture at Institute of Isotopes, Budapest, Hungary, 4 November, 2008.
20. G. Magesh, B. Viswanathan, T.K. Varadarajan, R.P. Viswanath, CeO<sub>2</sub>-TiO<sub>2</sub> system as visible light photo-catalyst for the degradation 4-chlorophenol, National workshop on catalysis, IMMT, Bhubaneswar, Feb 18-20 (2008).
21. M Helen, B.Viswanathan and S.Srinivasa Murthy, Nanocomposite Membranes for DMFC Applications, Conference on Functional materials, IITM, November, 27-29 2008 ( best poster award).
22. **P.Selvam** has made several presentations during his two visits abroad this year and also he has given a number of special presentations including the one at Holy

- Cross College, ( December 5, 2008) Trichirapalli and also another in Anna University, Chennai in October, 29, 2008.
23. B.Viswanathan, Techniques in Chemistry, at Stella Maris College on October 28, 2008.
  24. P. Selvam, Synthesis of Novel Nanoporous Carbon: NCCR-1, 9<sup>th</sup> Int. Conf. on Nanostructured Materials (NANO-2008), Rio de Janeiro, June, 1-6, 2008, pp.370.
  25. P.Selvam, Nanoporous Carbon Supported Platinum (Pt/NCCR-1): Electro-catalyst for Methanol Oxidation, XXI National Meeting of the Portuguese Chemical Society, Porto, June 11-13, 2008.
  26. P.Selvam, Green Chemistry and Catalysis, National Seminar on Green Chemistry, Mumbai, March 20-21, 2008.
  27. P.Selvam, Nanomaterials in confined environment, National Seminar-cum-Workshop on Nanotechnology and Nanobiology, Chennai, February, 14-16, 2008
  28. P.Selvam, Mesoporous Molecular Sieves and Their Applications in Catalysis, National Workshop on Catalysis–*Futuristic Materials as Catalysts & Adsorbents*, Bhubaneswar, February 19-20, 2008.
  29. P.Selvam, Application of Mesoporous Materials as Catalysts, Uiversite de Reims Champagne-Ardenne, Reims, FRANCE (June 9, 2008).
  30. P.Selvam, Nanoporous Molecular Sieves: Novel Inorganic Solids, Ecole Nationale Supérieure Montpellier, Montpellier, FRANCE (June 13, 2008).
  31. P.Selvam, Green Chemistry and Catalysis for Sustainability, Instituto Tecnologia Quimica, Valencia, SPAIN (June 20, 2008).

### **Books published or prepared during 2008**

1. B.Viswanathan, (Editor) Catalysis some selected Applications (Narosa publishing House and in Production) (2008).
2. B.Viswanathan, (Editor) Surface characterization techniques (Submitted to Narosa Publishing house and in consideration) (2008).
3. B.Viswanathan,(Editor) Nano materials (Narosa Publishing House and in Production) (2008)

4. .D.K.Chakrabarty and B.Viswanathan, Heterogeneous catalysis, International edition New Age Science Limited Kent TN1 1YS UK November 2008.
5. **ebook 4. Synthetic Strategies in Chemistry (Complete book is available) . (at the site <http://www.nccr.iitm.ac.in>)**

### **PATENTS-2008**

1. R P Viswanath and B.Viswanathan, water purification system (being submitted to the dean, 2007)
2. B.Viswanathan and M Helen, Membranes based on Heteropoly acid embedded polymer matrix, (submitted to the dean, November 2008).
3. S.P.Kishore and B.Viswanathan, Jointly with Malladi An improved process for the preparation of polylactic acid (Patent number216464 and the date of grant is 13-3-2008.)

### **Agreements signed:**

1. With the department of Chemistry, Anna University a cooperation agreement was signed in July 2008.
2. A cooperation agreement was signed with the Centre for Advanced Chemical Materials, Department of Chemistry, Kyungpook National University, Korea.
3. A cooperation agreement was signed with the New Chemistry Research Division, Korea Research Institute of Chemical Technology, (KRICT) Daejon , Korea.
4. The agreement with the centre for catalysis, Technical University, Munchen is in the process of development.