

**Name and Designation** : **DR. SHRI CHAND**  
*Professor*

**Date of Birth & Age** : 1<sup>st</sup> January, 1951 ; 53 years

**Institution** : IIT Roorkee

**Department** : Chemical Engineering

**Field of Specialisation** : Catalysis, Petroleum Refining & Petrochemicals,  
 Industrial Pollution Abatement, Mass transfer

**Date of Superannuation** : January, 2013

**Academic (B.Sc./B.E. degree onwards) & Professional Qualifications :**

Sl. No.	Degree	University/ Institution	Year	Specialisation
1.	B.Sc. Chem. Engg.	B.H.U., Varanasi	1972	Chemical Engg.
2.	M.Sc. Chem. Engg.	-do-	1974	-do-
3.	Ph.D. Chem. Engg.	-do-	1980	Mass Transfer

**Employment** :

Institution/ University	Post Held	From	To	Duration
IIT, Kharagpur	Lecturer	1.9.80	21.1.87	6 yrs 4 mts
University of Warwick, U.K	Senior Research Fellow	22.1.87	25.10.89	2 yrs 9 mts
University of Roorkee IIT Roorkee (w.e.f. 21 <sup>st</sup> Sept. 01)	Lecturer Asstt.Professor Associate Professor Professor	21.2.90 9.4.96 25.6.01 31.10.03	8.4.96 25.6.01 30.10.03 contd	6 yrs 2 mts 5 yrs 2 mts 2 yrs 4 mts ..contd..

**Industrial Experience, if any (in 100 words)** : NIL

**Award/Prize/Certificate etc. won** :

The Sir Ganga Ram Memorial Prize 1993-94 for the best research paper awarded  
 by the Institution of Engineers (India).

**Publications** :

1. Number of Research Papers Published in : 32 (International – 12)  
 National/International Journals
2. Number of Research Papers Published/ : 18 (International – 5)  
 Presented in National/International Conference/

Conference Proceedings

3. Number of Reports Published : NIL

### **LIST OF Ph.D. THESES SUPERVISED**

**(TOTAL No. - 9)**

**(Completed = 7, In Progress = 2)**

#### **[A] DEGREE AWARDED - (4)**

1. 'Some Studies on Disproportionation of Toluene'  
by M.K.Barooah at I.I.T. Kharagpur in **1987**.
2. 'Vehicular Emission Control- Studies on Non-Noble Metal Based Catalysts for CO and Propylene Oxidation'  
by Anil Kumar Sharma at University of Roorkee in **1999**.
3. 'Selective Disproportionation of Toluene to Produce Benzene and p-Xylene'  
by Abdal Kareem M.A., at IIT Roorkee in **April 2001**.
4. 'Synthesis and Activity Test of Polymer Anchored Metal Complexes'  
by Hamad K. Abdul Kadir at IIT Roorkee, **2003**

#### **[B] SUBMITTED – (1)**

5. 'Synthesis and Activity Test of Metal Encapsulated Zeolites'  
by Salam J.Jibraeel, Started **July 1999**, **SUBMITTED on 26 August 2003**  
**Reports not yet received**  
(Co-supervisor- Dr..M. R. Maurya, Dept. of Chemistry)

#### **[C] COMPLETED – (2) (Likely to be submitted by Dec 2003)**

6. 'Removal of Toxic Organic Chemicals from Waste Water using Catalytic Wet Air Oxidation' by Anurag Garg, Started **January 2000**.
7. 'Studies on the Catalytic Behaviour of Some Simple and Immobilized Transition Metal Complexes' by Ms.Hanna Sabeih Abbo registered at Gurukul Kangri University, Hardwar on **December 8, 2001**. (Co-supervisor- Dr Randhir Singh,

Dept of Chemistry, G.K.U.).

**[D] IN PROGRESS - (2)**

8. 'Treatment of Distillery Wastewater' by Parmesh Kumar Chaudhary, Started **September 3, 2001** (Co-supervisor- Dr. I.M.Mishra).
9. 'Removal of carboxylic acids from waste water' by Pradeep Kumar, Started **January 2003** (Co-supervisor- Dr. B. Prasad).

**LIST OF M.E.THESES SUPERVISED (TOTAL NO. = 25)**

1. Studies on control of Biological waste treatment processes by Kaushlendra Kumar (1992)
2. Removal of chromium from waste water using adsorbents by Pawan Kumar (1993)
3. Recovery of acetic acid from waste water by solvent extraction by Sudesh Kumar Jain (1994)
4. Removal of carboxylic acid from waste water using adsorbents by Vivek Kumar (1994)
5. Catalytic hydrogenation of carbon-di-oxide by Hemant Kumar Upadhyay (1995)
6. Vehicular pollution control- Reduction of carbon-monoxide by Vishal Kumar Sharma (1996)
7. Performance evaluation of a cyclone using CFD model by Rupam Niranjana (1998)
8. Vehicular pollution control- Removal of carbon-monoxide by Anurag Garg (1999)
9. Selective disproportionation of toluene to produce benzene and xylene by Parmesh Kumar Chaudhary (2000).
10. Removal of toxic organics from pulp and paper mill effluent using catalytic wet air oxidation by VVVSS Narayan (2002)
11. Single step catalytic conversion of methane to methanol and formaldehyde by Dhananjay Singh (2002)
12. Removal of Phenolic Compounds from Waste Water by Catalytic Wet Air Oxidation

by Pradeep Kumar (2002)

13. Catalytic Wet Air Oxidation of Black Liquor by Neeraj Sharma (2003)

14. Aromatization of n-heptane by Shaik Feroz Ahmad (2003)

15. Removal of Carboxylic Acids by Wet Air Oxidation by P V K Raghavendra (contd)

+ **8 M.E. THESES** supervised when I was lecturer at **I.I.T. KHARAGPUR**

during 1980-1987 on the topics related to hydrodesulfurization , hydrodenitrogenation, hydrocracking of petroleum stocks and disproportionation & alkylation of toluene

+ **2 M.Phil** (Physics) Theses supervised in the field of Instrumentation in Waste-water Analysis.

**TOTAL 25**

## **RESEARCH AREAS**

### **(A) Catalysis**

- Hydrodesulfurization , Hydrodenitrogenation and Hydrocracking of petroleum stocks
- Disproportionation and Alkylation of toluene (to produce p-xylene)
- Automotive Exhaust Emission Control (Non-Noble metal based catalysts)
- Oxidative Coupling of Methane (Natural Gas Utilisation)
- Hydrogenation of Carbon-dioxide (to produce gasoline range hydrocarbons)
- Waste Water Treatment (Removal of Cr(VI) and carboxylic acid using low cost adsorbents)
- Wet Air Oxidation of Toxic and Non-biodegradable Organics from Waste Water
- Polymer Anchored Metal Complexes
- Metal Encapsulated Zeolites

### **(B) Mass Transfer with Chemical Reaction**

- Gas absorption with and without chemical reaction in turbulent liquid films
- Simultaneous absorption of two gases in a reacting liquid

### **SPONSORED/ CONSULTANCY PROJECTS HANDLED**

1. Environmental Impact Assessment of Bongaigaon Refineries Ltd., Bongaigaon, Assam. Project cost Rs. 22 Lakh. Completed 1998.
2. Safety Audit and Hazop Analysis of Pasupati Acrylons, Kasipur, U.P. Project cost Rs. 5 Lakh. Completed 1994.
3. Stack Monitoring and Water Quality Monitoring of **several** sugar mills

### **SHORT TERM COURSE/SPECIALIST COURSES**

Delivered more than **25 specialist lectures** to Practicing Engineers and Faculty Members from other Institutions under Continuing Education / QIP Programme on various topics related to Industrial Pollution Abatement, Catalysis, Corrosion and other allied subjects.

### **REVIEW ARTICLES**

- i) 'Removal/Recovery of Acetic Acid from Waste-waters - A Review' by Shri Chand and S.K.Jain, Indian J.Environmental Protection, 13(10) 761-764 (1993)
- ii) 'Selective Disproportionation of Toluene to Produce Benzene and p-Xylene - A Review' by Shri Chand, Abdal Kareem M.A. and I. M. Mishra J. of Scientific and Ind. Research 60, 319-327 (2001)

### **VISITS ABROAD**

United Kingdom – Senior Research Fellow (Jan. 1987- Oct 1989) - **3 Years**  
at Department of Engineering, **University of Warwick**, Coventry  
**Group Leader** of a joint research work on '**Automotive Exhaust Emission Control** Through Catalytic Converters' for Austin Rover Motor Company, U.K.

Hong Kong - A short visit of 10 days (August 2002)

## **EXTRA-CURRICULAR ACTIVITIES**

**Warden** of a Bhawan (Hostel) – Jan.1998- April 2001

**Chief Warden** Rajendra Bhawan – Jan. 2004 onwards

## **RESEARCH PROJECTS**

1. **UGC Major Research Project** entitled “Treatment of Pulp and Paper Mill Effluent through Catalytic Wet Air Oxidation” started June I, 2001 (Project Cost – Rs. 5.14 Lakh)
2. UGC Minor Research Project (1998-2000) – 2 years
3. UGC Research Assistance by UOR (1991-1998) – 7 years in continuation

## **DETAILS OF RESEARCH PUBLICATIONS**

### **PAPERS PUBLISHED IN JOURNALS**

1. Z.Qadir, Shri Chand and B.K.B. Rao  
Scheme for Utilization of Bombay High Naphtha  
Urja, August, 933-934 (1995)
2. A.K. Bhattacharya, J.A. Breach and S. Chand et al.  
Selective Oxidation of Methane to Carbonmonoxide on Supported Palladium Catalyst  
**APPLIED CATALYSIS A: GENERAL 80, L1-L5 (1992)**
3. AK. Bhattacharya, S. Chand, K.K. Mallick and R.S. Talayan  
Catalytic Oxidative Coupling of Methane on Metal Oxides I. Effect of Oxidation State of Bismuth and Reversibility of Lattice Oxygen on Activity in Ba-La-Bi Oxides  
**APPLIED CATALYSIS A : GENERAL 85, 135-145 (1992)**
4. Shri Chand and S.K. Jain  
Removal/Recovery of Acetic Acid from Waste Water - A Review  
**Indian J. of Environmental Protection** 13(10), 761-764 (1993)
5. K. Kumar, Desh Deepak, S.D. Bhattacharya and Shri Chand  
Studies on Control of Activated Sludge Processes  
**Institution of Engineers (India) J-CH 74, 13-18 (1993).**
6. Shri Chand, V.K. Agarwal and Pawan Kumar

- Removal of Hexavalent Chromium from Waste-water by Adsorption  
**Indian J. Environ. Health** 36(3), 151-158 (1994)
7. Shri Chand  
Effect of Nitrogen Concentration on Hydrodesulfurization  
**Research and Industry** 39(9), 194-197 (1994)
  8. Shri Chand, Desh Deepak and S.K. Jain  
Removal and Recovery of Acetic Acid from Waste-water by Solvent Extraction-  
an Economic Approach  
**Research and Industry** 39(12), 261-266 (1994)
  9. Shri Chand and S.K. Jain  
Recovery of Acetic Acid from Waste-water by Solvent Extraction  
**Indian J. Environ. Health** 37(1) 11-18 (1995)
  10. Anil Sharma, Shri Chand and I.M. Mishra  
Vehicular Air Pollution and its Control  
**Engineering Advances** 7(11), 72-76 (1995)
  11. Sudesh Kumar Jain and Shri Chand  
Removal/Recovery of Carboxylic Acids from Waste Water  
**Chemical Engineering World** 30(10), 55-61 (1995)
  12. S.K. Jain and Shri Chand  
Selection of Particulate Control System  
**Engineering Advances** 7(12), 51-53 (1995)
  13. Shri Chand, Preeti Sharma and J. Rai  
Ultraviolet Spectrophotometric Calibration Charts for Waste-water Analysis  
**Engineering Advances** 9(6), 67-69 (1997)
  14. Shri Chand and Preeti Sharma and J. Rai  
U.V. Spectrophotometric Calibration charts for Waste-water Analysis  
**Engineering Advances** 9(9), 75-78 (1997)
  15. Shri Chand, Rupam Niranjana and B. Mohanty  
Dust Gas Separation using Cyclones  
**Engineering Advances** 10(8), 67-70 (1998)
  16. Shri Chand, Vivek Kumar and C.B.Majumder  
Recovery of Acetic Acid from Waste-water by Adsorption on Bagasse and  
Coconut Jute Carbon  
**Indian J. of Environmental Health** 41(3), 170-175 (1999)

17. Abdal Kareem M.A., Shri Chand and I.M.Mishra  
Ion exchanged ZSM-5 Zeolites as Catalysts for Toluene Disproportionation Reaction.  
**J. of Scientific & Ind. Res.** 59, 591-595 (2000)
18. Shri Chand, A.K.Sharma, Anurag Garg and I.M.Mishra  
Supported Perovskites as Catalysts for CO Oxidation  
**J. of Scientific & Ind. Res.** 59, 944-948 (2000)
19. Anurag Garg and Shri Chand  
Vehicular Pollution Control – Removal of Carbon Monoxide Through Catalytic Converters  
**Indian J. of Chemical Technology** 8, 219-222 (2001)
20. Abdal Kareem M.A., Shri Chand and I.M.Mishra  
Disproportionation of toluene to produce benzene and p-xylene – A review  
**J. of Scientific & Ind. Res.** 60, 319-327 (2001)
21. M R Maurya, S J J Titinchi , Shri Chand, I.M.Mishra  
Zeolite-encapsulated Cr(III), Fe(III), Ni(II), Zn(II) and Bi(III) salpn Complexes as Catalysts for the Decomposition of H<sub>2</sub>O<sub>2</sub> and Oxidation of Phenol  
**J. OF MOLECULAR CATALYSIS A: CHEMICAL** 180, 201-209 (2002)
22. M R Maurya, S J J Titinchi and Shri Chand  
Spectroscopic and Catalytic Activity Study of N,N'-bis(salicylidene)propane-1,3-diamine copper(II) Encapsulated in Zeolite-Y  
**APPLIED CATALYSIS A: GENERAL**, 228(1-2), 177-187 (2002)
23. Parmesh K. Chaudhary, Pradeep Saini and Shri Chand  
Comparative Performance of Ion-exchanged ZSM-5 and Y-Zeolite Catalysts for Toluene Disproportionation Reaction  
**J. of Scientific & Ind. Res.** 61, 810-816 (2002)
24. Kareem M.A.A., Shri Chand and I.M.Mishra  
Toluene Disproportionation Over Modified ZSM-5 Zeolite Catalysts  
**IE(I) Journal-CH**, 83, 6-8 (2002)
25. Gupta K C, Abdulkadir H K, Chand S  
Polymer supported N,N'-bis(salicylidene) hydrazine Co(II) schiff base complex and its catalytic activity  
**J. OF MACROMOLECULAR SCIENCE, PURE AND APPLIED CHEMISTRY**, A39(12) (2002) 1451-1474



26. Mannar R Maurya, Salam J J Titinchi, Shri Chand  
Oxidation of Phenol with H<sub>2</sub>O<sub>2</sub> catalysed by Cr(III), Fe(III) or Bi(III) N,N'-bis-(salicylidene)diethylenetriamine(H<sub>2</sub>saldien) complexes encapsulated in Y-zeolite  
**J. OF MOLECULAR CATALYSIS A: CHEMICAL** 193 (2003) 165-176
27. Mannar R Maurya, Salam J J Titinchi, Shri Chand  
Oxidation of phenol with H<sub>2</sub>O<sub>2</sub> catalysed by Cu(II), Ni(II) and Zn(II) complexes of N,N'-bis-(salicylidene)diethylenetriamine(H<sub>2</sub>saldien) encapsulated in Y-zeolite  
**J. OF MOLECULAR CATALYSIS A: CHEMICAL** 201 (2003) 119-130
28. Gupta K C, Abdulkadir H K, Chand S  
Synthesis of styrene-allylchloride copolymer supported cobalt(II) schiff base complex and its catalytic activity  
**J. OF MACROMOLECULAR SCIENCE, PURE AND APPLIED CHEMISTRY**, A40(5) (2003) 475-500
29. Mannar R Maurya, Maneesh Kumar, Salam J J Titinchi, Hanna S. Abbo, and Shri Chand  
Oxovanadium(IV) Schiff base complexes encapsulated in zeolite-Y as catalysts for the liquid-phase hydroxylation of phenol  
**CATALYSIS LETTERS**, 86 (2003) 97-105
30. Gupta K C, Abdulkadir H K, Chand S  
Synthesis of polymer anchored N,N'-bis(3-allyl salicylidene)-o-phenylenediamine cobalt(II) Schiff base complex and its catalytic activity for decomposition of hydrogen peroxide  
**J. OF MOLECULAR CATALYSIS A: CHEMICAL** 202 (2003) 253-268
31. Anurag Garg, Somen Saha, Vinayak Rastogi & Shri Chand  
Catalytic wet air oxidation of pulp and paper mill effluent  
**Indian J. of Chemical Technology** 10 (2003) 305-310
32. Gupta K C, Abdulkadir H K, Chand S  
Polymer immobilized N,N'-bis(actylacetone\_ethylenediamine cobalt(II) Schiff base complex and its catalytic activity in comparison to its homogeneous analogue  
**J. APPLIED POLYMER SCIENCE** 90 (2003) 1398-1411
33. M.R. Maurya, S.J.J. Titinchi and S. Chand  
Liquid phase catalytic hydroxylation of phenol using Cu(II), Ni(II) and Zn(II) complexes of amidate ligand encapsulated in zeolite-Y as catalysts  
**CATALYSIS LETTERS**, 89 (2003) 219-227
34. Gupta K C, Abdulkadir H K, Chand S  
Synthesis, characerization and catalytic activity of N,N'-bis(3-allyl salicylidene)

ethylenediamine cobalt(II) Schiff base complex anchored on new polymer support  
**CHINESE JOURNAL OF POLYMER SCIENCE** 22 (2004) 31-42

35. Mannar R Maurya, Himani Sakalani, Amit Kumar, and Shri Chand  
Dioxovanadium(V) complexes of dibasic tridentate ligands encapsulated in zeolite-Y for the liquid phase catalytic hydroxylation of phenol using H<sub>2</sub>O<sub>2</sub> as oxidant  
**CATALYSIS LETTERS**, 93 (2004) 121-127
36. Mannar R Maurya, Salam J J Titinchi, Shri Chand  
Catalytic activity of chromium(III), iron(III) and bismuth(III) complexes of 1,2-bis(2-hydroxybenzamido)ethane (H<sub>2</sub>hybe) encapsulated in zeolite-Y for liquid phase hydroxylation of phenol  
**J. OF MOLECULAR CATALYSIS A: CHEMICAL** 214 (2004) 257-264
37. Hanna S. abbo, Salam J.J. Titinchi, Shri Chand and Rajendra Prasad  
Investigation of [Ni{Me<sub>4</sub>Bzo<sub>2</sub>[14]aneN<sub>4</sub>}]Cl<sub>2</sub> catalyzed selective hydroxylation of phenol to catechol by H<sub>2</sub>O<sub>2</sub> in the homogeneous medium  
**J. OF MOLECULAR CATALYSIS A: CHEMICAL** (2004) Accepted- To appear in the coming issue.

**PAPERS PUBLISHED/ PRESENTED IN CONFERENCE/CONFERENCE  
PROCEEDINGS**

1. Shri Chand and G. Tripathi  
Gas Absorption in Turbulent Liquid Films  
Seminar on Transport Phenomena, B.H.U., Varanasi , May 8-10 (1978)
2. Shri Chand and G. Tripathi  
Gas Absorption with Fast, Irreversible Chemical Reaction in Turbulent Liquid Films  
Seminar on Transport Phenomena, B.H.U., Varanasi , May 8-10 (1978)
3. Shri Chand and B.K.B. Rao  
Pyrite Catalyzed Hydrodesulfurization of Liquid Fuels  
**Catalysis Society of India** in its Workshop/Seminar on Catalysis for Coal Conversion, Fertilizers and Allied Industries, Central Fuel Research Institute, Dhanbad (1984)
4. M.K. Barooah, Shri Chand and B.K.B. Rao  
Toluene Disproportionation Using Zeolite Molecular Sieve Catalysts  
VII National Symposium, Advances in Catalysis-Science & Technology, by the **Catalysis Society of India**, I.P.C.L. Baroda,365-374 (1985)

5. Shri Chand, M.H.M. Akhoond, B.K.B. Rao and T.S. Banerjee  
Zeolite-Based Catalysts for Hydrocracking  
Recent Advances in Catalysis and Catalytic Reaction Engineering, Proceedings of  
2<sup>nd</sup> **Indo-Soviet Seminar on Catalysis**, Hyderabad, (1986)
6. Z. Qadir, Shri Chand and B.K.B. Rao  
Studies on Disproportionation of Toluene to Benzene and Xylenes and the Effect of  
methanol on Disproportionation  
Recent Advances in Catalysis and Catalytic Reaction Engineering, Proceedings of  
2<sup>nd</sup> **Indo-Soviet Seminar on Catalysis**, Hyderabad, (1986)
7. Shri Chand and G. Tripathi  
Simultaneous Absorption of Two Gases in a Reacting Liquid  
**Indian Chemical Engineering Congress**, Madras (1991)
8. A.K. Sharma, Shri Chand and I.M. Mishra  
Catalytic Oxidation of Carbon-monoxide on Supported Ba and La Ferrite Catalyst  
**INTERNATIONAL CONFERENCE ON ENVIRONMENTAL STRATEGIES  
FOR 21<sup>ST</sup> CENTURY, SINGAPORE**, April 8-10 (1998)
9. Shri Chand, A.K.Sharma and I.M.Mishra  
Perovskite Based Oxide as Catalyst for Oxidation of CO and HC from Automotive  
Exhaust  
**Indian Chemical Engineering Congress**, Visakhapatnam, Dec.16-19 (1998)
10. Shri Chand, A.K.Sharma and I.M.Mishra  
CO Oxidation on Supported Lanthanum Cobaltate Catalyst  
**ASIA-PACIFIC CHEMICAL REACTION ENGINEERING SYMPOSIUM 99  
HELD AT THE HONG KONG UNIVERSITY OF SCIENCE AND  
TECHNOLOGY, HONG KONG** during June 13-17, 1999  
Proceedings p. 411-418
11. Abdal Kareem M.A., Shri Chand and I.M.Mishra  
Selective Disproportionation of Toluene over Ion exchanged ZSM-5 Catalysts  
**JORDAN INTERNATIONAL CHEMICAL ENGG. CONFERENCE III,  
AMMAN, JORDON** during 27-29 Sept. 1999  
Proceedings ,Vol. II, p. 895-910
12. A.K. Sharma, Shri Chand and I.M.Mishra  
Study on Non-Noble Metal Based Catalysts for CO Oxidation  
**52<sup>nd</sup> Annual Session of Indian Institute of Chemical Engrs., CHEMCON-99**  
Indian Chemical Engineering Congress 1999, Chandigarh during Dec. 20-23, 1999
13. Abdal Kareem M.A., Shri Chand and I.M.Mishra  
Toluene Disproportionation over Modified ZSM-5 Zeolite Catalysts

**Annual Convention of Chemical Engineers, Bhilai Feb. 8-10, 2000**

14. Anurag Garg, Shri Chand and I.M.Mishra  
Catalytic Wet Air Oxidation of Phenolic Wastewater  
**National Symposium on New Horizons in Heterogeneous Catalysis,**  
Banaras Hindu University, Varanasi, Feb 22-24, 2002
15. Parmesh Kumar Chaudhary, Pradeep Saini and Shri Chand  
Toluene Disproportionation over Ion-exchanged ZSM-5 and Y-Zeolite Catalysts  
**National Symposium on New Horizons in Heterogeneous Catalysis,**  
Banaras Hindu University, Varanasi, Feb 22-24, 2002
16. Anurag Garg, Shri Chand and I.M.Mishra  
Treatment of Phenolic Wastewater by Catalytic Wet Air Oxidation  
**17<sup>th</sup> International Symposium of Chemical Reaction Engineering: Challenges**  
**and Opportunities in a Global Environment, Hong Kong , August 25-28, 2002**
17. Anurag Garg and Shri Chand  
Wet Air Oxidation Of Phenolic Wastewater Over Promoted Ceria Catalyst  
**3rd Conference of the Indo-Pacific Catalysis Association & the 21st Taiwan**  
**Symposium on Catalysis and Reaction Engineering" Taipei, Taiwan 15-17June, 2003**
18. Shri Chand, Anurag Garg and I.M.Mishra  
Wet Air Oxidation of Paper Mill Effluent at Atmospheric Pressure Using CuSO<sub>4</sub> as Catalyst  
**Catalysis Forum, Europa Cat-VI, Innsbruck Austria, August 31- September 04, 2003**
19. Pradeep Kumar, Parmesh K. Chaudhary, and Shri Chand  
Thermal treatment of distillery waste water in presence of catalysts  
**Environmental Pollution: Perspective and Practices, IET Lucknow, 30 April, 2004**