

DEPARTMENT OF CHEMICAL ENGINEERING

RESEARCH REPORT 2004

(Including Bioprocess Engineering Research Unit, Catalysis Research Unit, Mineral Processing Research Unit, Bioprocess Engineering Research Unit, and C*Change – DST-NRF Centre of Excellence in Catalysis)

Head of Department: Professor E. van Steen

Departmental Profile

The Department of Chemical Engineering has a proud national and international reputation both for the quality of its graduates at the BSc and postgraduate levels and for its research programs, thriving on the dynamic created by a synergy between research, industry and education. The undergraduate program enjoys accreditation with the Engineering Council of South Africa. The postgraduate program forms the largest academic research activity in Chemical Engineering on the continent, and is focused on mineral processing, catalysis, bioprocess engineering, environmental and process systems analysis as well as precipitation and crystallization. Based on close contacts with the chemical, petrochemical, biotechnological and mining industries, the research programs in the Department, although fundamental in nature, have a strong industrial flavor. The Department of Chemical Engineering is the host of the national DST-NRF centre of excellence in Catalysis, C*Change. At the end of 2003 the department took occupation of a new building on the upper campus. This building, funded largely by industrial donors, provides cutting-edge facilities for both research and education. The new building is a living laboratory, which has facilities to show students the working of a building. Furthermore, the Department of Chemical Engineering envisages to have integrated mini-plants showing students the linkage between the various unit operations in a (bio-) chemical and minerals processing plant.

Departmental Statistics

Permanent and Long-term Contract Staff

Professors	3
Associate Professors	5
Senior Lecturers	5
Research Staff (contract)	11
Technical Support Staff (permanent)	8
Technical Support Staff (contract)	20
Administrative and Clerical Staff (permanent)	3
Administrative and Clerical Staff (contract)	14
Total	69

Honorary Staff

Honorary Professors	1
Honorary Associate Professors	3
Honorary Senior Lecturers	4
Adjunct Professors	2
Total	10

Students

Doctoral	44
Masters	77
BSc(Eng)	294
Total	415

Research Fields and Staff

Professor Geoff Hansford

Bioprocess Engineering Research Unit - bioleaching; bioprocess treatment of acid mine drainage

Professor Sue Harrison

Director of the Bioprocess Engineering Research Unit - interaction of micro-organisms with the biochemical, thermal and hydrodynamic environment; bioprocess kinetics; and bioproduct formation; alkane biotechnology; microbial cell damage and disruption; high temperature (~75°C) bioleaching; biological sulphate reduction and sulphide oxidation processes; solid-liquid separation in biological processes

Professor Cyril O'Connor

Dean of Engineering and the Built Environment Faculty. Director of the Mineral Processing Research Unit; flotation; reagent evaluation; cell design. Catalysis Research Unit: heterogeneous catalyst and catalytic processes; zeolites; supported metal catalysts and metal oxide catalysts

Professor Eric van Steen

Head of Department, Catalysis Research Unit; Fischer-Tropsch synthesis; catalysis by gold; nano-materials; molecular modeling of heterogeneous catalytic systems; reaction kinetics

Associate Professor Stephanie Burton

Director of Postgraduate Studies, Bioprocess Engineering Research Unit - biocatalysis, using oxidative enzymes and membrane bioreactors; biotransformation of phenolics; amino acid synthesis; accessing enzymes from South Africa's microbial biodiversity

Associate Professor Jack Fletcher

Director of the Catalysis Research Unit; catalysis by gold; zeolite catalysed conversion of hetero-aromatic components; shape selectivity in zeolites and molecular sieves

Associate Professor Duncan Fraser

Process synthesis; heat and mass exchange networks; education development

Associate Professor Alison Lewis

Precipitation and crystallization, particularly relating to the minerals industry; environmental engineering; modelling and simulation; waste reprocessing

Associate Professor Klaus Möller

Catalysis Research Unit; separations; diffusion; adsorption; kinetics; reactor modelling; chemical vapour deposition; zeolites; reactions; selectivity; alkylation; post synthesis modifications

Dr Aninda Chakraborty
Environmental and Process Systems Engineering; Process system analysis; process optimization; waste minimization

Dr Dave Deglon
Mineral Processing Research Unit; modelling of mechanical mineral flotation cells; computational fluid dynamics; hydrodynamics; gas dispersion; solids suspension

Dr Jenni Case
Education Development Officer; engineering education; student learning; women in engineering

Dr Paul Musonge
Environmental and Process Systems Engineering; computational fluid dynamics, filtration, engineering education

Dr Harro von Blottnitz
Director of Undergraduate Studies, Environmental and Process Systems Engineering; environmental systems analysis using LCA; waste management; renewable energies and fuels processing

Honorary Professors, Adjunct Professors, Associate Professors, Senior Lecturers

Professor Mark Dry
Catalysis Research Unit; Fischer Tropsch (FT) catalytic processes; production of synthesis gas

Adjunct Professor Peter Gaylard
Mineral Processing Research Unit; metallurgical research; development of undergraduate courses in mineral processing and related fields

Adjunct Professor Peter Harris
Mineral Processing Research Unit; froth flotation

Associate Professor Jim Petrie
University of Sydney; environmental performance; technology development; life cycle assessment and management systems; waste management; site remediation and recovery from waste

Associate Professor John Raimondo
African Environmental Solutions; environmental impact assessment; environmental management systems

Dr Dee Bradshaw
Mineral Processing Research Unit; reagent development; collectors for sulphide mineral flotation; froth visualisation

Dr Michael Claeys
Catalysis Research Unit; Fischer Tropsch synthesis; nano-materials

Dr Kim Clark
Bioprocess Engineering Research Unit; interaction of micro-organisms with the biochemical, thermal and hydrodynamic environment; bioprocess kinetics alkane biotechnology

Mr. Martin Harris
Mineral Processing Research Unit; flotation; modelling; simulation

Dr Malcolm Powell
Mineral Processing Research Unit; comminution; modeling; simulation

Postdoctoral Fellows

Dr Gillian Balfour
University of Cape Town; SASOL fuel laboratory

Dr Lauren Basson
University of Sydney; environmental process system analysis

Dr Nicolette Coram
University of Stellenbosch; bioprocess engineering

Dr Bulent Içgen
bioprocess engineering

Dr Gunther Klatt
molecular modelling

Dr Shehnaaz Moosa
University of Cape Town; bioprocess engineering

Dr Silke Sauerbeck
University of Kaiserlautern; catalysis; zeolite synthesis

Dr Christian Taty Costodes
University of Paris; precipitation and crystallization

Dr Rob van Hille
Rhodes University; precipitation and crystallization/ bioprocessing

Dr Yifei Zhang
University of Shanghai; precipitation and crystallization

Distinguished Visitors

Professor Frances Arnold
CALTECH, Biotransformations

Professor J.P. Franzidis
JKMRC, University of Queensland; Mineral Processing

Professor J. Laskowski
University British Columbia, Canada; Mineral Processing

Professor Cedric Linder
University of Uppsala, engineering educations

Dr Emmy Manlapig
JKMRC, University of Queensland; Mineral Processing

Professor Tim Napier-Munn,
JKMRC, University of Queensland; Mineral Processing

Professor Mike Nicol
Murdoch University, Perth Australia; Mineral Processing

Professor Frank Roessner
University of Oldenberg, Germany; Catalysis

Professor Steven Simukanga
University of Zambia; Mineral Processing

Professor Gerda van Rosmalen
Technical University Delft; Crystallization

Research Output

(Including Bioprocess Engineering Research Unit, Catalysis Research Unit, Mineral Processing Research Unit, Bioprocess Engineering Research Unit, and c*change – DST-NRF Centre of Excellence in Catalysis)

ARTICLES IN PEER-REVIEWED JOURNALS

Botes, F.G. and Böhringer, W.F.W. 2004. The addition of HZSM-5 to the Fischer-Tropsch process for improved gasoline production. *Applied Catalysis A-General*, 267(1-2): 217-225.

Burton, S.G. 2003. Oxidative biotransformations using microbial oxidases. *Trends in Biotechnology*, 21: 543-549.

Burton, S.G. and Dorrington, R.A. 2004. Hydantoin-hydrolysing enzymes for the enantioselective production of amino acids: New insights and applications. *Tetrahedron: Asymmetry*, 15: 2737-2741.

Case, J.M. and Jawitz, J.P. 2004. Using situated cognition theory in researching student experience of the workplace. *Journal of Research in Science Teaching*, 41(5): 415-431.

Case, J.M. and Marshall, D. 2004. Between deep and surface: Procedural approaches to learning in engineering education contexts. *Studies in Higher Education*, 29(5): 605-615.

Chakraborty, A., Malcolm, A., Colberg, R.D. and Linninger, A. 2004. Optimal waste reduction and investment planning under uncertainty. *Computers and Chemical Engineering*, 28: 1145-1156.

Chakraborty, A., Purkarthofer, K.A. and Linninger, A. 2004. Conceptual design of metallurgical processes based on thermodynamic and economic insights. *Chemical Engineering and Processing*, 43: 635-640.

- Cowan, D.A., Arslanoglu, A., Burton, S.G., Baker, G.C., Cameron, R.A., Smith, J.J. and Meyer, Q. 2004. Metagenomics, gene discovery and the ideal biocatalyst. *Biochemical Society Transactions*, 32(2): 298-302.
- Dixon, D.G. and Petersen, J. 2003. Comprehensive modeling study of chalcocite column and heap bioleaching. *Copper 2003 - Volume VI: Hydrometallurgy of Copper (book 2)*, VI: 493-526.
- Dry, M.E. 2004. Present and future applications of the Fischer-Tropsch process. *Applied Catalysis A-General*, 276: 1-3.
- French, S.A., Sokol, A.A., To, J., Catlow, C.R.A., Phala, N.S., Klatt, G. and Van Steen, E.W.J. 2004. Active sites for heterogeneous catalysis by functionalisation of internal and external surfaces. *Catalysis Today*, 93-95: 535-540.
- Gopal, H., Kleinsmidt, J.N., Case, J.M. and Musonge, P. 2004. An investigation of tertiary students' understanding of evaporation, condensation and vapour pressure. *International Journal of Science Education*, 26(13): 1597-1620.
- Hedlund, J., Ohrman, O., Msimang, V.Z., Van Steen, E.W.J., Böhringer, W. and Moller, K.P. 2004. The synthesis and testing of thin film ZSM-5 catalysts. *Chemical Engineering Science*, 59: 2647-2657.
- Heitling, E., Roessner, F. and Van Steen, E.W.J. 2004. Origin of catalyst deactivation in Fries rearrangement of phenyl acetate over zeolite H-Beta. *Journal of Molecular Catalysis, A: Chemical* 216: 61-65.
- Mainza, A.N., Powell, M. and Knopjes, H.G. 2004. Differential classification of dense material in a three-product cyclone. *Minerals Engineering*, 17: 573-579.
- Malysiak, V., Shackleton, N.J. and O'Connor, C.T. 2004. An investigation into the floatability of a pentlandite-pyroxene system. *International Journal of Mineral Processing*, 74(1-4): 251-262.
- Matcher, G.F., Burton, S.G. and Dorrington, R.A. 2004. Mutational analysis of the hydantoin hydrolysis pathway in *Pseudomonas putida* RU-KM3s. *Applied Microbiology and Biotechnology*, 65: 391-400.
- Moller, K.P., Hedlund, J., Ohrman, O. and Msimang, V.Z. 2004. The catalytic evaluation of structured zeolite catalysts. *International Journal of Chemical Reactor Engineering*, 2: 1-14.
- Moon, G.C., Böhringer, W.F.W. and O'Connor, C.T. 2004. An investigation into factors which influence the formation of p-cresol in the methanol alkylation of phenol over MCM-22 and ZSM-5. *Catalysis Today*, 97(4): 291-295.
- Nerinckx, W., Broberg, A., Duus, J., Ntarima, P., Parolis, L.A.S., Parolis, H. and Claeysens, M. 2004. Hydrolysis of Nothogenia Erinacea Xylan by Xylanases from Families 10 and 11. *Carbohydrate Research*, 339(February): 1047-1060.
- O'Connor, C.T., Malysiak, V. and Shackleton, N.J. 2004. An investigation into the absorption of cationic species, especially copper, onto Pyroxene and Feldspar and their subsequent flotation behaviour. *The Journal of Ore Dressing*, 6(11): 55-60.
- Phala, N.S., Van Steen, E.W.J. and Klatt, G. 2004. A DFT study of hydrogen and carbon monoxide chemisorption onto small gold clusters. *Chemical Physics Letters*, 395: 33-37.

Seewoo, S., Lewis, A.E. and Van Hille, R. 2004. Aspects of gypsum precipitation in scaling waters. *Hydrometallurgy*, 75(1-4): 135-146.

Sissing, A. and Harrison S.T.L. 2003. Thermophilic mineral bioleaching performance: A compromise between maximising mineral loading and maximising microbial growth and activity. *SAIMM Journal* (March): 1-4.

Wilkenhoner, U., Duncan, W.L., Moller, K.P. and Van Steen, E.W.J. 2004. Intracrystalline diffusivity of hydroxybenzenes in TS-1 and Al-free Ti-beta. *Microporous and Mesoporous Materials*, 69: 181-186.

BOOK

Hansford, G.S., Harrison, S.T.L., Lewis, A.E. and Moosa, S.E. 2004. The mechanisms and kinetics of biological treatment of metal-containing effluent: 1-160. South Africa: Water Research Commission.

CHAPTERS IN BOOKS

Case, J.M. 2004. A critical look at innovative practice from the student perspective. In C. Baillie and I. Moore (Eds.), *Effective learning and teaching in engineering*: 139-155. London and New York: Routledge Falmer.

Claeys, M.C. and Van Steen, E.W.J. 2004. Basic Studies. In A.P. Steynberg and M.E. Dry (Eds.), *Studies in surface science and catalysis 152: Fischer-Tropsch Technology*: 601-674. Netherlands: Elsevier.

Dry, M.E. 2004. Chemical Concepts used for engineering purposes. In A.P. Steynberg and M.E. Dry (Eds.), *Studies in surface science and catalysis 152: Fischer-Tropsch Technology*: 196-254. Netherlands: Elsevier.

Dry, M.E. 2004. FT Catalysts. In A.P. Steynberg and M.E. Dry (Eds.), *Studies in surface science and catalysis 152: Fischer-Tropsch Technology*: 533-593. Netherlands: Elsevier.

Dry, M.E. and Steynberg, A.P. 2004. Commercial FT process application. In A.P. Steynberg and M.E. Dry (Eds.), *Studies in surface science and catalysis 152: Fischer-Tropsch Technology*: 406-477. Netherlands: Elsevier.

Petrie, J.G., Basson, L., Notten, P.J. and Stewart, M. 2004. Multi-criteria decision analysis: The case of power generation in South Africa. In A. Azpagic, S. Perdan and R. Clift (Eds.), *Sustainable development in practice: Case studies for engineers and scientists*: 367-396. Chichester, England: John Wiley and Sons.

Steynberg, A.P. and Dry, M.E. 2004. Fischer-Tropsch reactors. In A.P. Steynberg and M.E. Dry (Eds.), *Studies in surface science and catalysis 152: Fischer-Tropsch Technology*: 64-183. Netherlands: Elsevier.

PEER-REVIEWED PUBLISHED CONFERENCE PROCEEDINGS

Basson, L. and Petrie, J.G. 2004. An integrated approach for the management of uncertainty in decision making supported by LCA-based environmental performance information. Proceedings of Complexity and Integrated Resources Management, Transactions of the 2nd Biennial Meeting of the International Environmental Modelling and Software Society, Manno, Switzerland, 313-318.

Böhringer, W., Moon, G., Fletcher, J.C.Q., O'Connor, C.T. 2004. Zeolite H-MCM-22, catalyst of choice for mass transfer controlled phenol methylation? In W. Reschetilowski and T. Heine (Eds.), Tagungshandbuch, 16. Deutsche Zeolith-Tagung, Dresden, Germany, 3-5 March 2004, RR10.

Callanan, L.H., Burton, R., Wilkenhoner, U. and Van Steen, E.W.J. 2004. Phenol hydroxylation of over aluminium-free titanium-beta using water as a solvent. Proceedings of the 14th International Zeolite Conference, Cape Town, 2596-2602.

Chakraborty, A., Malcolm, A. and Linninger, A. 2004. Pharmaceuticals product-only design. Proceedings of FOCAPD 2004 Foundations of Computer-Aided Process Design, Princeton, New Jersey, 347-351.

Fraser, D. 2004. Measuring engineering student success. Proceedings of the 2nd African Regional Conference on Engineering Education, ARCEE2004, Lagos, Nigeria, 112-122.

Fraser, D. and Case, J.M. 2004. Student understanding of ratio and proportion. Proceedings of Improving Cooperation Among Researchers, Policy Formulators and Implementors of Policy in Mathematics, Science and Technology Education, University of Swaziland, 426-431.

Heitling, E., Van Steen, E.W.J. and Roessner, F. 2004. A new approach describing solvent effects on zeolite catalysed Fries rearrangement of phenyl acetate. Proceedings of the 14th International Zeolite Conference, Cape Town, 2809-2814.

Martinovic, J., Bradshaw, D.J. and Harris, P.J. 2004. Investigation of surface properties of gangue minerals in platinum bearing ores. Proceedings of the International Platinum Conference, Platinum Adding Value, SAIMM 2004, South Africa, 151-157.

Moon, G.C., Böhringer, W.F.W. and O'Connor, C.T. 2004. Pressure induced enhancement of shape selective phenol methylation. Proceedings of the 14th International Zeolite Conference, Cape Town, 2255-2260.

Musonge, P. 2004. Sustainability and internationalisation of engineering in Africa. Proceedings of the 2nd African Regional Conference on Engineering Education, ARCEE 2004, Lagos, Nigeria, 123-128.

Notten, P.J. and Petrie, J.G. 2004. Enhanced presentation and analysis of uncertain LCA results with principal component analysis. Proceedings of Complexity and Integrated Resources Management, Transactions of the 2nd Biennial Meeting of the International Environmental Modelling and Software Society, Manno, Switzerland, 326-331.

O'Connor, C.T. and Malysiak, V. 2004. An investigation into the adsorption of cationic species, especially copper, onto pyroxene and feldspar and their subsequent flotation behaviour. Proceedings of the 10th International Mineral Processing Symposium: Challenges and Opportunities in Minerals Processing, Cesme, Turkey, 415-425.

Ohrman, O., Hedlund, J., Msimang, V.Z., Moller, K.P. and Sterte, J. 2004. ZSM-5 Structured catalysts coated with silicalite-1. Proceedings of the 14th International Zeolite Conference, Cape Town, 677-684.

Reed, B. and Case, J. 2004. Learners' conceptions of technology: A phenomenographic perspective. Proceedings of the 12th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education, Cape Town, 836-842.

NON PEER-REVIEWED PUBLISHED CONFERENCE PROCEEDINGS

Böhringer, W.F.W., Kotsiopoulos, A. and Fletcher, J.C.Q. 2004. Selective Fischer-Tropsch wax hydrocracking: Opportunity for improvement of overall gas-to-liquids processing. Proceedings of the International Research and Development Forum on Oil, Gas and Petrochemicals (IRDF), Kuala Lumpur, Published on CD-Rom.

Botha, T.J. and Von Blottnitz, H. 2003. Green electricity or fuel ethanol? A comparative life cycle assessment of two energy products from sugarcane bagasse. Proceedings of the SAChE National Conference, Sun City, 3-5.

Lewis, A.E. 2004. Aggregation of nickel carbonate in a fluidised bed reactor. Proceedings of Mineral Processing 2004, Cape Town RSA, 75.

Lewis, A.E. 2004. Real world complications in the measurement of particle size. Proceedings of Mineral Processing 2004, Cape Town, 93.

Lewis, A.E. and Hounslow, M. 2004. Understanding factors influencing nickel morphology. Proceedings of Mineral Processing 2004, Cape Town, 76.

Lewis, A.E. and Pillay, V. 2004. The system $MgSO_4-H_2O$ at eutectic conditions: Thermodynamic solubility products of $MgSO_4 \cdot 12H_2O$ and $MgSO_4 \cdot 7H_2O$. Proceedings of Mineral Processing 2004, Cape Town, 77.

Marr, S.M., Mudondo, Z.E. and Von Blottnitz, H. 2004. Design for cleaner technology in the Southern African minerals processing industry. Proceedings of Waste Management, Emissions and Recycling in the Metallurgical & Chemical Process Industries, Randburg, South Africa, 1-10.

Ochieng, A. and Lewis, A.E. 2004. CFD simulation of mixing and power consumption at low impeller clearance. Proceedings of the 4th South African Conference on Applied Mechanics, Johannesburg, RSA, 1-9.

Von Blottnitz, H. 2004. Conversion of plant oils to methyl-ester fuels: Considerations for reactor design in commercial and small-scale production. Proceedings of the 16th International Congress of Chemical and Process Engineering: CHISA 2004, Prague, Published on CD-Rom.

PUBLISHED CONFERENCE ABSTRACTS

Marshall, D. and Case, J.M. 2003. Approaches to learning: A useful heuristic framework for higher education or a reified and elitist dichotomy? Southern African Academic Development Association (SAADA), Cape Town: 144.

Von Blottnitz, H. 2004. Life beyond the P&ID: Engagement of 4th year Chemical Engineering students with business, society and environment. *Engineering Education in Sustainable Development*, 1(1): 135.

THESES AND DISSERTATIONS PASSED FOR HIGHER DEGREES

Anand, H. 2004. The effect of pretreatment used in combination with mechanical methods on the extent of cell disruption and subsequent release of intracellular protein. MSc, University of Cape Town.

Balasundaram, B. 2004. A detailed investigation of microbial cell disruption by hydrodynamic cavitation for selective product release. PhD, University of Cape Town.

Biel, H.B. 2004. The effect of water partial pressure on low temperature iron Fischer-Tropsch reaction rate, selectivity and catalyst structure: 1-132. MSc, University of Cape Town.

Daramola, M.M. 2004. Effect of agitation on yeast quality. MSc, University of Cape Town.

Hangone, G.E. 2004. The role of collectors in the flotation of partially oxidised copper ores: 1-131. MSc, University of Cape Town.

Lombard, H.A. 2004. The influence of low levels of alumina on the attrition resistance and Fischer-Tropsch synthesis performance of a precipitated iron catalyst: 1-102. MSc (Applied Science), University of Cape Town.

Mailula, T.D. 2004. Factors affecting flotation of gangue minerals in PGM ores: 1-85. MSc, University of Cape Town.

Mphahlele, M.G. 2004. Evaluation of mass transfer in a catalytic distillation column using hydrogenation of 1-hexene as a test reaction: 1-130. MSc, University of Cape Town.

Phala, N.S. 2004. A theoretical investigation in heterogeneous gold catalysis: 1-186. PhD, University of Cape Town.

Pillay, V. 2004. The simulation of electrolyte systems: The system K-Na-Mg-Cl-SO₄-H₂O: 1-56. MSc, University of Cape Town.

Ting, M.B. 2004. Biotransformation of phenolic compounds found in grape MARC and related model compounds using laccases, to produce antioxidants: 1-154. MSc, University of Cape Town.

Zwane, S.T. 2004. Vanadia (V₂O₅) promoted Co/Al₂O₃ Fischer-Tropsch catalysts: 1-142. MSc, University of Cape Town.

EXTENSION AND DEVELOPMENT WORK

Lewis, A.E. 2004. Research-based Policy Report - March 2004: An investigation into the crystallisation behaviour of nickel through reduction with hydrogen - Phase 3. Impala Platinum.

Lewis, A.E. 2004. Research-based Policy Report - October 2004: An investigation into the crystallisation behaviour of nickel through reduction with hydrogen - Phase 3. Impala Platinum.

Lewis, A.E., Van Hille, R., Nathoo, J. and Seewoo, S. 2004. Interim Report: Prevention of calcium sulphate crystallisation in water desalination plants using slurry precipitation and recycle reverse osmosis (SPARRO). Water Research Commission.

CONSULTANCY AND OTHER ACTIVITIES BASED ON EXPERTISE DEVELOPED IN RESEARCH

Lewis, A.E. 2004. Analysis of AntiSolvent Crystallisation Process: Consultation to Somchem.

Departmental Contact Details

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