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UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANISATION



INTERNATIONAL CENTRE FOR
SCIENCE AND HIGH TECHNOLOGY



CHEMISTRY DEPARTMENT
UNIVERSITY OF CAPE TOWN

FINAL REPORT

Workshop on

“Cleaner Technologies for Sustainable Chemistry”

Cape Town, South Africa, 9-11 December 2002

**UNIDO PROJECT TF/GLO/00/105
CONTRACT No. : 2002/249**

OBJECTIVES

Despite the increase of restrictions on the use of toxic/hazardous chemicals and on the disposal of wastes, polluting manufacturing processes are still widely used in the chemical industry. The introduction of cleaner technologies would be to the advantage of the economy, the environment and the quality of life of inhabitants. Analogous benefits would result from the valorization, for chemical and fuel production, of the natural products produced locally. The considerations above are even more important if one remembers that many African countries may have great reservoirs of natural resources that are presently under-exploited.

The main objectives of the workshop were as follows:

- To identify the current environmental problems of chemical industry with respect to polluting processes and the applicability of cleaner processes.
- To examine available cleaner technologies for the production of fine chemicals and petrochemicals
- To identify recent developments in cleaner catalytic technologies.
- To examine technologies available for remediation of polluted areas.
- To facilitate transfer of information and knowledge in the fields of clean chemistry and catalysis from experts in industry and academic institutions.
- To evaluate priorities in the countries from the region and formulate possible cooperative research projects.

ORGANIZATION

The workshop was organized jointly by the International Center for Science and High Technology (ICS), United Nations Industrial Development Organization and Chemistry Department of the University of Cape Town, South Africa.

The local organizing committee consisted of Dr Susan Bourne (chair), Professor Luigi Nassimbeni and Dr Eugene Sickle, with secretarial assistance from Ms Karin Badenhorst. Dr Paolo Fornasiero (ICS) provided advice on the selection of invited speakers and organization of the programme.

DATES AND VENUE

The workshop was held on 9-11 December 2002 at the Graduate School of Business (GSB) on the Breakwater campus of the University of Cape Town, Cape Town, South Africa. The GSB has excellent multi-media facilities as well as a strong conference organizational infrastructure.

FUNDING

UNIDO approved expenditure of US\$ 18 000 for this workshop. US\$ 14 400 was received in November 2002, with a further tranche of US\$ 3 600 to be received on acceptance of the final report. The University of Cape Town Research Committee provided ZAR 29 550 to cover organizational expenses not supported by UNIDO.

The Organizing committee paid for airtickets for several international participants and for some South African participants living outside Cape Town. Hotel bookings and reasonable

living expenses were covered. A summary of the final budget is given in Appendix 1. There are some discrepancies in the budget owing to the enormous fluctuation of the South African currency in the past 4 months - when we initially prepared the budget, the exchange rate was ZAR10 = US\$1. During the next few months it changed to as much as ZAR10.50 = US\$1 and is currently ZAR8.50 = US\$1. This, combined with an inflation rate of between 10 and 15% (also fluctuating every month), made forecasting budget figures extremely difficult.

SCIENTIFIC PROGRAM

Seven keynote one-hour lectures, nine invited lectures and ten 20-minute country reports were presented. The detailed programme is given in Appendix 2.

The topics covered during the workshop were:

- A. Alternative / renewable sources of energy and fuels
- B. Current catalytic methods
- C. Clean catalytic technologies
- D. Alternative routes in the synthesis of fine chemicals
- E. Cleaner technologies in industry
- F. Technologies for the remediation of polluted soils, water and air
- G. The WSSD in Joburg 2002
- H. Environmentally benign technologies
- I. Life Cycle Analysis of technologies
- J. Country Reports

PARTICIPATION

Lecturers

A total of 16 lecturers, selected for their expertise in aspects of the workshop themes, participated in the scientific programme. Lecturers came from a variety of countries and institutions and are listed in Table 1. Their affiliations included universities (75%), R & D institutes (12.5%) and industry (12.5%). A copy of the lecture notes has been included (on CD-ROM) as Appendix 4.

In addition, country reports were solicited from among participants selected to attend the workshop. Each presented an outline of the industries and natural resources in their country, the major industrial pollutants and an indication of the presence or availability of less polluting technologies. The presenters are listed in Table 2 and country reports are included in Appendix 4.

Table 1. Lecturers

KEYNOTE LECTURER	INSTITUTION	COUNTRY
J. L. Scott	Monash University	Australia
C. Ukwe	UNIDO	Austria
P. Fornasiero	ICS / University of Trieste	Italy
M. G. Clerici	Eni Technologie	Italy
H. van Bekkum	Delft University of Technology	Netherlands
J. R. Moss	University of Cape Town	South Africa
C. Buckley	University of Natal	South Africa
J. Broadhurst	University of Cape Town	South Africa
K. Slatter	Anglo Platinum	South Africa
P. Steyn	IUPAC President	South Africa
E. Breet	Potchefstroom University	South Africa
C. Imrie	University of Port Elizabeth	South Africa
H. von Blottnitz	University of Cape Town	South Africa
D. van Vuuren	CSIR	South Africa
M. Zimmer	Connecticut College	USA
J. Zvimba	Midlands State University	Zimbabwe

Table 2. Presenters of Country Reports

SPEAKER	INSTITUTION	COUNTRY
N. Torto	University of Botswana	Botswana
M.H. Abu Bieh	National Research Centre	Egypt
C. Z. Moturi	Kenya Industrial Research & Development Institute	Kenya
K. Habib	KSIR	Kuwait
M. C. Matoetoe	National University of Lesotho	Lesotho
H. M. Kwaambwa	University of Namibia	Namibia
S. Bourne	University of Cape Town	South Africa
R. Machunda	Tropical Pesticides Research Institute	Tanzania
S. Ssebegala	Uganda Cleaner Production Centre	Uganda
W. Mutatu	Midlands State University	Zimbabwe

Participants

The organizers solicited applications by means of flyers posted and emailed to institutions throughout Africa. In addition the workshop was advertised on the Internet. Table 3 details the geographical and institutional origin of the participants. Participants' affiliations included universities (65%), R & D institutes (25%) and industry (10%). Participants not resident in Cape Town were sponsored (partial airfare, full living expenses and accommodation). Participants resident in Cape Town were sponsored for all social activities and meals relating to the workshop. Full details of all participants are listed in Appendix 3.

Table 3. Participants according to countries

COUNTRY	NUMBER OF PARTICIPANTS
Botswana	1
Egypt	1
Lesotho	4
Kenya	1
Kuwait	1
Namibia	1
South Africa	5
Tanzania	1
Uganda	1
Zimbabwe	3

WORKSHOP MATERIALS

Each participant and lecturer was provided with a workshop bag containing the following:

- Abstracts of presentations
- A CD-ROM containing files of the lectures
- Detailed workshop program
- List of participants with their mailing addresses
- Pen and notebook
- Identification badge

OPENING CEREMONY

The workshop was officially opened by the President of the South African Chemical Society (Prof G E Jackson) and the representative of ICS-UNIDO (Dr P Fornasiero).

SOCIAL EVENTS

Teas and lunches were provided for all participants of the workshop. A welcome reception was held at the Breakwater Lodge on the evening of the 8 December 2002. A conference dinner was held at the Africa Café on the final evening of the workshop. Lecturers were invited to dinner at local restaurants on Monday 9 and Tuesday 10 December. All other participants were given ZAR100 subsistence to cover their dinner expenses.

ASSESSMENT

The workshop was assessed by the participants by means of an anonymous and optional questionnaire. The questionnaire is attached in Appendix 5 and an analysis of the responses is presented in Appendix 6. Participants evaluated the workshop organization as being very good to excellent. Most respondents felt that the duration of the course was "just right" though some felt that the days were too long.

The general sense among participants was that the lecturer presentations were very good. All except one respondent stated that they would recommend attending a workshop of this type to members of their institution.

POSSIBLE FOLLOW-UP

The workshop was considered a success amongst participants. It was noted that the workshop provided a highly informative 'snapshot' of the problems faced in Africa and of initiatives already underway aimed at introducing chemical technologies for sustainable development. There is now a greater awareness of state-of-the-art catalytic technologies and the design aspects of green chemistry. The establishment of Cleaner Production Centres in a number of African countries is expected to facilitate communication between academic and industrial institutions in this important area.

During the concluding session, a general discussion based on country reports was held. The following conclusions were drawn:

- A project will be proposed to UNIDO in order to develop technologies for extracting low volume, high value products from plant and animal matter. Critical to the success of such a project will be the recognition and use of indigenous knowledge systems to identify compounds of high commercial value. The possibility of using biomass generated by this project to generate energy in under-resourced areas should also be explored.
- There was extensive interest in the development of curriculum material and training courses/material for Green Chemistry, in particular at teaching institutions. The feasibility of funding a scheme whereby staff at academic institutions may be relieved, in part, of their teaching duties in order that they may develop new curricula focused on Green Chemistry should be explored. Furthermore, a mechanism should be set up whereby course materials could be exchanged between institutions allowing for a coherent approach to teaching across a region.
- There was general agreement that the workshop had been valuable in fostering discussion of pollution problems and cleaner technologies between academic and industrial sectors and between neighbouring and regional countries. Several participants felt that an annual or bi-annual workshop of this nature would be beneficial. Further discussion should be engaged with ICS-UNIDO on the nature of such workshops as there was consensus that smaller, more focused "expert group meetings" dealing with just one or two closely related themes would be of more value.
- A summary of the workshop, including key lectures and country reports will be written up and submitted to the journal Green Chemistry, with the intention of having this published in the "News and Views" section of the journal.

APPENDICES:

Appendix 1:

Summary of budget and expenditure

Appendix 2:

Detailed programme of the workshop

Appendix 3:

List of lecturers and participants (with full addresses)

Appendix 4 (On CD-ROM):

Copies of key lectures presented in the workshop

Appendix 5:

Evaluation Questionnaire

Appendix 6: Summary analysis of evaluation questionnaire (%)

Workshop on Cleaner Technologies for Sustainable Chemistry
Cape Town, South Africa, 9-11 December 2002
EDPs (1.2)

TOTAL FUNDS FROM UNIDO US\$18,000

DESCRIPTION	Budget In US\$	Disbursement US\$	Disbursement l.c.	Difference US\$
Travels				
J. L. Scott		1,963	17662.89	
H. van Bekkum		1,082	9734	
M. Clerici		1,136	10223	
<i>Total travel for international lecturers</i>	4,200	4,181	37,620	20
N. Torto		331	2980	
L. Mpholle		108	968	
M.A. Qholsokoane		278	2500	
M.C. Matoeloe		278	2500	
H. W. Alemu		278	2500	
H.M. Kwaambwa		326	2935	
D. Musingarabwi		511	4598	
W. Mutatu		511	4598	
P. Shoko		500	4500	
S.D. Sithole		483	4347	
J. Zvimba		511	4598	
M. H. AbuBieh		333	3000	
R. Machunda		333	3000	
C. Z. Moturi		333	3000	
S. Ssebegala		333	3000	
E. Breet		161	1450	
C. Buckley		340	3064	
C. Imrie		260	2340.9	
<i>Total travel for invited international participants</i>	9,250	6,208	55,879	3,041
<i>accommodation and meals for international lecturers and participants</i>	2,406	3,764	33,877	(1,358)
<i>Accommodation and meals for participants from the country</i>	1,284	1,892	16,939	(698)
<i>Transport</i>	860	400	3500	460
<i>Conference bags</i>		362	3260	
GRAND TOTAL	18,000	16,797	147,915	1,203

18,000
14,400
2,397

TOTAL BUDGET FROM UNIDO
ALREADY TRANSFERRED AMOUNT (80%)
REMAINING FUNDS TO BE TRANSFERRED
(after actual disbursement)

Programme

Sunday 8 December			
17.00 - 18.00	Registration : Breakwater Lodge foyer		
18.00 - 19.30	Welcome function: Private Dining Room, Breakwater Lodge		
Monday 9 December			
8.30 - 9.00	Registration		
9.00 - 9.20	Session 1: Opening and Welcome (Chair: S. Bourne) Welcome (10 mins)		G.E. Jackson, SACI President P. Fornasiero, ICS S. Miertus / P. Fornasiero
9.20-9.40	Introduction to ICS Activities in the area of catalysis and sustainable chemistry Alternative / renewable sources of energy and fuels		
9.40 - 10.40	Carbohydrates : A Renewable Feedstock		H. van Bekkum
10.40 - 11.00	Tea		
11.00 - 11.30	Session 2: Current catalytic methods (Chair: S. Bourne) Catalysts & Catalytic technology in South Africa		J.R. Moss C. Ukwe
11.30 - 12.00	Application of Zeolite Catalysts for Cleaner Production in the Petroleum Refining and Petrochemical Industry in Nigeria		
12.30 - 14.00	Lunch		
14.00 - 15.00	Session 3: Clean catalytic technologies (Chair: D. Gammon) Acid and redox zeolites in fine chemicals synthesis		M. Clerici M. Zimmer
15.00 - 15.30	Nitrile hydratase: An example of an industrially used environmentally benign catalyst.		
15.30 - 15.45	Tea		
15.45 - 16.05	Session 4: Country reports (Chair: D. Gammon) Botswana		N. Torto
16.05 - 16.25	Kuwait		K. Habib
16.25 - 16.45	Namibia		H. M. Kwaambwa
16.45 - 17.05	Kenya		C.Z. Moturi
17.05 - 17.25	Tanzania		R. Machunda
17.25 - 17.45	Algeria		M. Hadjel

ICS-UNIDO Workshop: "Cleaner Technologies for Sustainable Chemistry"

Programme

Tuesday 10 December

9.00 - 10.00	Session 5: Alternative Routes in the synthesis of fine chemicals (Chair: L. Nassimbini) Green Chemistry: Benign by design	J.L. Scott
10.00 - 10.30	Tea (Workshop Photograph)	
10.30 - 11.30	Session 6: Cleaner technologies in industry (Chair: L. Nassimbini) Cleaner production demonstration projects in South Africa	C. Buckley
11.30 - 12.10	The role of cleaner technology in closure planning for the minerals extraction industry	J. Broadhurst
12.10 - 12.30	Cleaner Production Technology	J. Zvimba
12.30 - 14.00	Lunch	
14.00 - 14.50	Session 7: Technologies for the remediation of polluted soils, water and air (Chair: J.R. Moss) Catalytic technologies for control of air pollution from mobile sources	P. Fornasiero
14.50 - 15.30	Environmental Rehabilitation: Some of the Hidden Advantages	K. Slatter
15.30 - 15.45	Tea	
15.45 - 16.05	Session 8: Country reports (Chair: J.R. Moss)	M.C. Matoetoe
16.05 - 16.25	Lesotho	W. Mutatu
16.25 - 16.45	Zimbabwe	S. Bourne
16.45 - 17.05	South Africa	M. H-A. Abu Bleh
17.05 - 17.25	Egypt	S. Ssebaga
17.25 - 17.45	Uganda	M.H. Duku
	Ghana	

Wednesday 11 December

9.00 - 10.00	Session 9: The WSSD in Joburg 2002 (Chair: E. Sickle) The Role of Chemistry in Sustainable Development	P. Steyn, IUPAC President
10.00 - 10.30	Tea	
10.30 - 11.30	Session 10: Environmentally benign technologies (Chair: E. Sickle) Supercritical CO2 Extraction & Impregnation: Clean Process Technology for Sustainable Chemistry	E. Breet
11.30 - 12.30	Use of ionic liquids as non-volatile sustainable reaction solvents in simple organic transformations.	C. Imrie
12.30 - 14.00	Lunch	
14.00 - 14.50	Session 11: Life Cycle Analysis of technologies (Chair: P. Fornasiero) Biofuels in the African Context: Understanding their chemistry and their (contribution to) sustainability	H. von Blottnitz
14.50 - 15.40	A Life Cycle Analysis of New Klin Technology highlights a significant reduction in CO2 emissions	D. van Vuuren
15.40 - 16.00	Tea	
16.00 - 17.00	Session 12: Round-table discussion and recommendations (Chair: P. Fornasiero)	
19.30 - 22.00	Conference Dinner @ Africa cafe (bus leaves from hotel at 19.15)	



Workshop on Cleaner Technologies for Sustainable Chemistry
Cape Town, South Africa, 9 – 11 December 2002



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ICS Workshop/Training Course: EVALUATION QUESTIONNAIRE

Course/Workshop: Workshop on Cleaner Technologies for Sustainable Chemistry, Cape Town, South Africa.
9 – 11 December 2002

A. Organization:

1. How did you obtain information about this workshop/course?

- | | Excellent | Very Good | Good | Fair |
|---|--------------------------|--------------------------|--------------------------|--------------------------|
| 2. The information process was | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. The announcement and pre-course material was
• Describe the content of the workshop/course: | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

- | | | | | |
|---|--------------------------------------|--|--------------------------|--------------------------|
| 4. I found the scientific programme | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.1. Applied Lecture/Workshop | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.2. Use of small working groups | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.3. Case Studies | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.4. The time spent by lecturers in class and after
class on specific questions/examples | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.5. Students scientific knowledge was | Balanced
<input type="checkbox"/> | Unbalanced
<input type="checkbox"/> | | |

B. Duration of programme:

- | | Just right | Too long | Too short |
|---------------------------|--------------------------|--------------------------|--------------------------|
| 1. Number of days | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Length of working days | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

C. Training facilities & Hotel:

	Excellent	Very Good	Good	Fair
1. Lecture/Training Rooms	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Breaks/refreshments	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Hotel accommodation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Meals at the hotel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If "Fair" please explain why: _____

D. Organizer's response to participants needs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Overall programme organization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

F. Would you recommend to others from your institution/
 country to attend a similar activity in the future?

Yes	Maybe	No
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1. Which part of the Activity did you find most useful?

2. Which part of the activity do you think should be expanded?

3. Which part of the activity do you think should be dropped?

4. Any other suggestions for future improvements to the programme?

5. Do you think that the topics/tools you studied during the course could be used by industries in your country? If so, how? If not, why not?

5. contd.

6. Can you suggest any programme and future activities which ICS could pursue in order to help with the technological and scientific advancement of your country?

7. Do you think you have benefited from participation in this course/workshop? If so, how? and your Institution?

8. How do you intend to disseminate the information you have acquired during the activity once back in your own country?

G. Evaluation of Lectures and Speakers

	Excellent	Very Good	Good	Fair
1. Course material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Resident Lecture presentation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. International Lecture presentation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Ability of lecturers to answer specific questions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Any comments:

Thank you for your collaboration.

Appendix 6: Summary analysis of evaluation questionnaire (%) based on 20 respondents.

A. Organization

Item	Excellent	Very good	Good	Fair
Information process	30	55	15	0
Announcement	5	65	25	0
Scientific program	30	35	10	0
Applied lecture/workshop	15	55	20	0
Small working groups	0	10	10	20
Case studies	5	40	30	5
Question time	5	25	20	5

Item	Balanced	Unbalanced
Students scientific knowledge	60	5

B. Duration of Program

Item	Just right	Too long	Too short
Number of days	65	0	35
Length of working days	60	35	0

C. Training facilities & hotel

Item	Excellent	Very good	Good	Fair
Lecture/Training rooms	40	45	10	0
Breaks/refreshments	45	45	10	0
Hotel accommodation	15	40	35	5
Meals at the hotel	30	45	20	0

D. Organizer's response

Excellent	Very good	Good	Fair
45	40	15	0

E. Overall program organization

Excellent	Very good	Good	Fair
30	65	5	0

F. Would you recommend to others to attend a similar activity in the future?

Yes	Maybe	No
90	5	0

G. Evaluation of lecturers and speakers

Item	Excellent	Very good	Good	Fair
Course Material	20	60	20	0
Resident lecture presentation	20	55	15	0
International lecture presentation	25	40	25	0
Ability of lecturers to answer specific questions	15	60	15	0