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INSTITUTO VENEZOLANO DE INVESTIGACIONES CIENTIFICAS (IVIC)

**ICS-UNIDO Training Course
Catalytic Processes
for the Refining and Petrochemical Industries
27 November - 8 December 1995
Caracas, Venezuela**

**Final Report
IVIC-UNIDO Contract N° 95/217
Project N° US/GLO/105**

Caracas, March 1996

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Programa Iberoamericano de Ciencias y
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Escuela de Química y el Centro de Catalistas, UCV



International Training Course
"Catalytic Processes for the Refining and Petrochemical Industries"
Caracas, Venezuela
Nov. 27 to Dec. 8 1995



1. **Objective:** To transfer scientific and technological knowledge to young researchers and engineers from Latin American countries through high level intensive training in a scientifically advanced and industrially important subject.

2. **Place and date:** The course was held at the Eurobuilding Hotel in Caracas, Venezuela from 27 November to 8 December 1995.

3. **Organisation:** The Venezuelan Institute for Scientific Research (IVIC) assumed the responsibility as contracting institution. The Organising Committee was constituted as follows:

Dr. Paulino Andréu (CIED/CYTED), Chairman

Prof. Mauro Graziani (ICS/University of Trieste), Co-Chairman

Dr. Roberto Sánchez Delgado (IVIC)

Dr. Alfredo Morales (INTEVEP)

Dr. Francisco Machado (School of Chemistry, UCV)

Dr. Carlos Scott (Catalysis Center, UCV)

(CIED: International Center for Education and Development of PDVSA, the Venezuelan Petroleum Corporation, CYTED: Iberoamerican Program for Science and Technology for Development; ICS: International Center for Science and High Technology, UNIDO, Trieste; IVIC: Venezuelan Institute for Scientific Research, Caracas; INTEVEP: Petroleum Research and Development Center of PDVSA, the Venezuelan petroleum Corporation; UCV: Central University of Venezuela, Caracas)

Excellent organisational support was obtained from CLAB, the Latin American Center for Biology (UNESCO-IVIC), who provided experienced personell (Mrs. Miriam Ramos and her assistant Mrs. Belángela Tarazona); further support came from CIED, INTEVEP and UCV.

All technical sessions were held at the Eurobuilding Hotel, which is conveniently located in Caracas and provides excellent facilities. The cost of these facilities was kindly covered by CIED; in order to facilitate access, lecturers were also lodged at this hotel. Participants were accomodated in shared rooms at a nearby second-class hotel, and bus transportation to the Eurobuilding Hotel and back was provided daily.

4. Funding: Contributions were received from the sources detailed below

UNIDO	U.S. \$ 59.000
CONICIT	U.S. \$ 25.000
CIED	U.S. \$ 12.000
IVIC	U.S. \$ 5.000
INTEVEP	U.S. \$ 5 000
CYTED	U.S. \$ 5.000
TOTAL	U.S. \$ 111.000

This represents a distribution cost of 53.15% of cash funding by UNIDO and 46.85% by local sources.

Additional local financial support not included in the accounts was obtained from CIED, CYTED, IVIC, INTEVEP, and UCV, in the form of manpower plus computing and communication facilities and other services, including travelling for 18 people in a private plane of PDVSA to the Cardón refinery.

5. Lecturers: A group of 26 distinguished scientists, geographically distributed as described below, and specialised in various aspects of catalysis and engineering was gathered to act as Lecturers.

Additionally, Mr. Mohammed Derrough from UNIDO (Vienna) was present during the course as a special guest, and as a speaker at the two round tables held.

Country of origin	Number of lecturers
Argentina	1
France	1
Germany	1
Italy	4
Spain	3
United States	3
Venezuela	13

In view of the desired nature of the course, oriented towards the practical applications of catalytic processes, a large proportion of lecturers coming from industry was selected. A number of local academic and industrial institutions (UCV, INTEVEP, IVIC, PEQUIVEN, PROCTER & GAMBLE) contributed by providing an excellent group of experts as Lecturers. A complete list is presented as Annex 1.

6. Participants: Invitations were circulated to appropriate institutions in most countries in the region of Latin America and the Caribbean.

A selection process was conducted by the Organising Committee on the basis of several criteria. Priority was given mainly on the following basis:

Educational background: young people with training at least to the M.Sc. level in chemistry or chemical engineering.

Professional situation: professionals either employed in an industrial research or production company, or holder of an academic position in a University or research institute. Additionally, graduate students with a favorable recommendation from their supervisor or department were also accepted. A balance was sought between participants from academia and from industry.

Financial contribution: participants coming from industry who could provide some financial contribution towards their own travel expenses. This criterion was not applied to university participants in view of the known financial restrictions for Latin American academic institutions.

Geographical distribution: a balance was sought to match the number of participants with the relative size and development of chemical science and industry in the various countries. This criterion was not applied to Venezuelan participants, particularly those from the Caracas area, since they caused minimal expenses.

The course was attended by 25 participants from 6 other Latin American countries as shown in the Table below, 38 from Venezuela (15 from outside the Caracas area), plus 1 young scientist of German citizenship coming from an Italian laboratory, who participated at his own expense.

A complete list of names and addresses of participants is contained in Annex 2.

Country of origin	Number of participants
Argentina	1
Brasil	4
Chile	5
Colombia	8
Mexico	4
Peru	3
Germany/Italy	1
Venezuela	38

7. Programme: An intensive programme of activities was covered during two weeks (full-time). This included 56 formal lectures with adequate time for extensive discussion, two Round Tables on "Technology trends" and "The needs for catalysis in Latin America", plus visits to industrial establishments: the Cardón Refinery (Maraven), and INTEVEP, or alternatively to IVIC, which houses the most complete science and technology library in Latin America.

Additionally, Prof. Mauro Graziani described the activities of ICS (Trieste) and the possibilities for interaction and training for developing countries, whilst Dr. Paulino Andréu presented the achievements and potential of the Catalysis Sub-programme of CYTED, the Iberoamerican Programme for Science and Technology for Development.

Emphasis was placed throughout the course on the applied aspects of catalysis to the refining, petrochemical and chemical industries, as well as on the utmost importance of the protection of the environment and the role of catalysis both in allowing cleaner processes and products, and in actually controlling or cleaning pollution. The topics covered ranged from the chemical fundamentals through reactor and engineering design to project management and technology transfer.

A complete programme is included as Annex 3.

8. Social events:

A couple of modest social gatherings were organised, which contributed greatly to a better integration of the group in an informal atmosphere. Also, in view of the heavy working load, the intermediate week-end was left free for participants to enjoy tourist attractions at

their own convenience. After a few days, groups spontaneously arrange for further meetings and outings.

9. **Results:** Firstly, a high level training was achieved, which undoubtedly accomplished the objective of updating or introducing participants in the subject area of the course. This knowledge can now be transmitted by these participants to other professionals in their countries of origin, which should produce the desired multiplying effect.

Secondly, this event served the purpose of establishing important links between scientists, engineers, and institutions or companies of the various countries represented, which should help to enhance individual capabilities and to promote joint actions.

10. **Comments and Conclusions:** Catalysis is a very important subject both for its commercial and scientific interest. It is a topic which is extensively researched and practised in the major industrialised countries and is one which contributes substantially to their economic well being.

A number of countries in Latin America have achieved a considerable development in their petroleum, petrochemical and chemical industries which are currently run in good part by local professionals with a high level training.

A key factor to enable the less developed countries to keep updated with the latest developments is the transfer of technology expertise to them. Much of this transfer is normally done at the senior management level, which has problems since senior managers are often set in their ways and the new knowledge does not always flow down to the practical production levels; also Universities and research institutes in Latin

America sometimes lag behind in including in their curricula the most recent state of the art in frontier areas of research and engineering. Therefore, offering high level training to young scientists and professionals has perhaps a greater potential for a real impact at both the academic and industrial environments in the region.

Traditionally a large number of Latin Americans have obtain their training in top schools of developed countries, notably the US; this has had a very positive impact, but also has caused a number of problems. For instance, scientists and engineers who have obtained a Ph.D. abroad tend to lose contact with local problems and the local "culture" in problem solving, or else on their return find the level of resources and funding in their own country inadequate. This then leads to frustration and dissatisfaction, and eventually emigration, with a consequent considerable loss to the home country. In recent times, this "brain drain" from Latin America to the more developed countries has become a problem of major concern.

A possible solution to this problem is to train fewer people abroad, and to do more in the developing nations, particularly in those areas where local expertise and strength are obvious. This has a number of clear advantages, eg.: (i) the locally available high level experts can be used as instructors in a "south to south" type of transfer of knowledge; (ii) the people receiving training will observe problem solving capabilities and attitudes in an environment not too different from their own; this is particularly true in courses of a regional nature such as this, since this offers a common cultural and technical background; (iii) the cost of running such a course in a Latin American country is probable lower than if the activity was conducted in North America or Europe.

One problem is that in any case to run these courses requires substantial funding both from UNIDO and from the host country. In this case, generous local funding was obtained as a result of a strong commitment of the Venezuelan Government (through CONICIT and IVIC), PDVSA, the Venezuelan Petroleum Corporation (through INTEVEP and CIED), and other sources (CYTED, UCV). Additionally, some other companies contributed with lecturers, for instance UOP, IFP, EXXON, which was particularly important for the success of the course. Also some of the participants were able to obtain some financial support in their home countries.

A good mix of lecturers from a wide range of countries was gathered for this activity. This included a good number of Venezuelan experts from academic and industrial origin, who took care of most of the fundamental topics which were covered in the first week, plus well established figures from North America, South America and Europe, who dealt with the more specialised topics during the second week. This was important since in spite of the fact that Venezuela possesses a high level of expertise in refining and petrochemicals, scientists from the more developed countries are needed to establish an appropriate level.

Teaching the course in Caracas required a substantial commitment for the Lecturers, but everyone was very willing to provide their time and effort generously, not only in the formal sessions, but also in informal meetings and discussions with the participants.

The idea of holding two round tables gave ample opportunity to discuss openly some topics and ideas of a more general nature than those presented in the lectures. These round tables were organised so as to include in the panel people from various countries and a good mix of

academic and industrial backgrounds. Although the conversations were lengthy and fruitful, perhaps the most important conclusions could be summarised as follows:

-The region of Latin America and the Caribbean has an immense potential for development of a modern refining, petrochemical and fine chemicals industry, in view of the available natural resources, geographical position, installed facilities and capabilities, and existing highly trained professionals.

-There is a strong need for further training such as the one provided by this course, on a regular basis, and the support of UNIDO and other international organisations should be actively sought for these purposes. It was considered that future courses or workshops should be more focussed on specific aspects of industrially important processes.

-Environmental considerations such as the ones presented in this course must be at the top of priorities concerning industrial development and future training.

-The exchange of knowledge and information should be further stimulated, both between the Latin American region and the developed nations, and between the various Latin American countries themselves. This could be done through academic and industrial training and exchanges, but also through joint projects and joint ventures. This could alleviate the differences at present existing in the level of scientific and technical development in different countries of the region. More extensive use of

programmes already existing should be made, for instance the possibilities offered by ICS (Trieste) and CYTED.

-The need for strong links between the industrial and the academic worlds was emphasised as an adequate means of utilising capabilities to their full potential.

The organisation and effort required to run this meeting in Caracas were very substantial indeed, and the group in charge and support personell worked with great enthousiasm and quality to achieve the goal.

11. Expenditures charged to the contribution of UNIDO:

Item	U.S. \$
Accommodation for Lecturers, plus lunch for Lecturers and participants at Eurobuilding Hotel	28,000
Daily subsistence allowance for Lecturers and participants (excluding those from Caracas)	10,000
Travelling for 24 participants (includes 7 Venezuelans from outside Caracas)	11,000
Accommodation for participants (24 persons x 15 days x ca. \$30/day)	10,000
Total	59,000

Annex 1

List of Lecturers

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Annex 2

List of Participants

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Annex 3

Programme of the Course

FINAL PROGRAM

PART 1. Introduction

- 1.1 *The refining industry (P. Andréu)*
- 1.2 *The petrochemical industry (J. Pachano)*
- 1.3 *The importance of catalysis for those industries (A. Morales)*

FUNDAMENTALS

PART 2. The catalytic Phenomenon

- 2.1 *Homogeneous Catalysis (R. Sánchez Delgado)*
- 2.2 *Heterogeneous Catalysis (A. Corma)*
- 2.3 *Biocatalysis (R. Rangel)*

PART 3. Heterogeneous Catalysis and Physical Adsorption

- 3.1 *Acid and Basic Catalysis (A. Corma)*
- 3.2 *Bifunctional Catalysis (G. Giannetto)*
- 3.3 *Physical Adsorption (F.R. Reinoso)*

PART 4. Homogeneous Catalysis

- 4.1 *Homogeneous Catalytic Processes in the Chemical Industry (L. A. Oro)*
- 4.2 *Homogeneous Catalytic Processes in the Petrochemical Industry (I. Horvath)*
- 4.3 *Relations between Homogeneous and Heterogeneous Catalysis (C. Bianchini)*

PART 5. Catalytic Materials and Adsorbents

- 5.1 *Molecular Sieves (A. Corma)*
- 5.2 *Activated Carbons (F. R. Reinoso)*
- 5.3 *Natural Materials (G. Deganello)*
- 5.4 *Natural Material (Clays) (M. Rosa-Brussin)*

PART 6. Catalysts Preparation

- 6.1 *Supports and Active Phases (R. Prada)*
- 6.2 *Industrial Production of Catalysts (R. Prada)*
- 6.3 *Textural and Structural Properties (N.P. Martínez)*

PART 7. Catalysts Characterization

- 7.1 *Fundamental Aspects (M. Rosa-Brussin)*
- 7.2 *Spectroscopic Characterization (H. Knoezinger)*

PART 8. Catalysts Evaluation

- 8.1 *Activity, Selectivity and Stability (F. Machado)*
- 8.2 *Theoretical Modelling (M. Ramírez de A.)*

PART 9. Catalytic Processes Scaling-up

- 9.1 *Types of Reactors (G. Dassori)*
- 9.2 *Bench and Pilot Testing (G. Dassori)*
- 9.3 *Reactors Design (Triphasic) (J. Krasuk)*

INDUSTRIAL APPLICATIONS

PART 10. Refining Catalytic Processes

- 10.1 *Introduction (R. Galiasso)*
- 10.2 *Catalytic Cracking (A. Koskas, IFP)*
- 10.3 *Hydrotreating: HDS y HDT (R. Galiasso)*
- 10.4 *Hydrocracking (R. Marinangly, UOP)*
- 10.5 *Reforming (A. Koskas, IFP)*
- 10.6 *Alkylation (D. Huskey, Intevep, SA)*
- 10.7 *Isomerization- Etherification (R. Marinangly, UOP)*

PART 11. Petrochemical Processes

- 11.1 *Production of Monomers (J. Pachano)*
- 11.2 *Polimerization (F. Chiardelli)*
- 11.3 *Production of Aromatics (BTX) (A. Koskas, IFP)*
- 11.4 *Alkylation of Aromatics (R. Marinangly, UOP)*
- 11.5 *Oxygenates Synthesis (R. Marinangly, UOP)*
- 11.6 *Fischer- Tröpsch Process (J. J. García)*

PART 12. Catalysis for the Improvement of the Environment and the Quality of Life

- 12.1 *Treatment of gaseous effluents (M. Rosa-Brussin)*
- 12.2 *Treatment of liquid effluents (J. Armour)*
- 12.3 *New Processes (J. Armour)*
- 12.4 *Emission Control (M. Graziani)*

TECHNOLOGY MANAGEMENT

PART 13. Management of Projects

- 13.1 *Modern Tools for Project Management and Development (R. Cunningham)*
- 13.2 *The effects of scale economics and investment costs (R. Cunningham)*
- 13.3 *Development of Projects and Processes (R. Cunningham)*
- 13.4 *The scenario for the next decade (R. Cunningham)*

PART 14. The Process of Technology Transfer

14.1 Integration of the overall Process (A. Morales)

14.2 Technology Protection (A. Morales)

14.3 Organization of the R&D Activity (A. Morales)

14.4 Model of Technology Management (N. P. Martínez)

ROUND TABLES

A) ROUND TABLE ON TECHNOLOGY TRENDS

(UOP, IFP, EXXON, PDVSA, INTEVEP S.A.)

B) ROUND TABLE ON LATIN-AMERICAN CATALYSIS NEEDS

(UNIDO-ICS, Participating Countries)

PARTICULAR AND GENERAL CONCLUSIONS



SOCIAL PROGRAM

The social program for the participants will be as follow:

Monday, November 27

Welcoming Reception Cocktail from 7:30 to 9:30 pm

Friday, December 1

* Tour 1: Visit to Cardón or Amuay Refineries of PDVSA. (Limited to 18 persons)

* Tour 2: Visit to El Palito and Morón Petrochemical Complex (unlimited)

Saturday 2 - Sunday 3 of December: (Optional)

Visit to the National Morrocoy Park located in the west zone of Venezuela. It is formed by mangroves, coral reefs and wonderful beaches. The transportation to the park will be done in sport boats. This visit is optional.

Thursday, December 5

Venezuelan Folklore Show

Friday, December 8

Closing Event Cocktail