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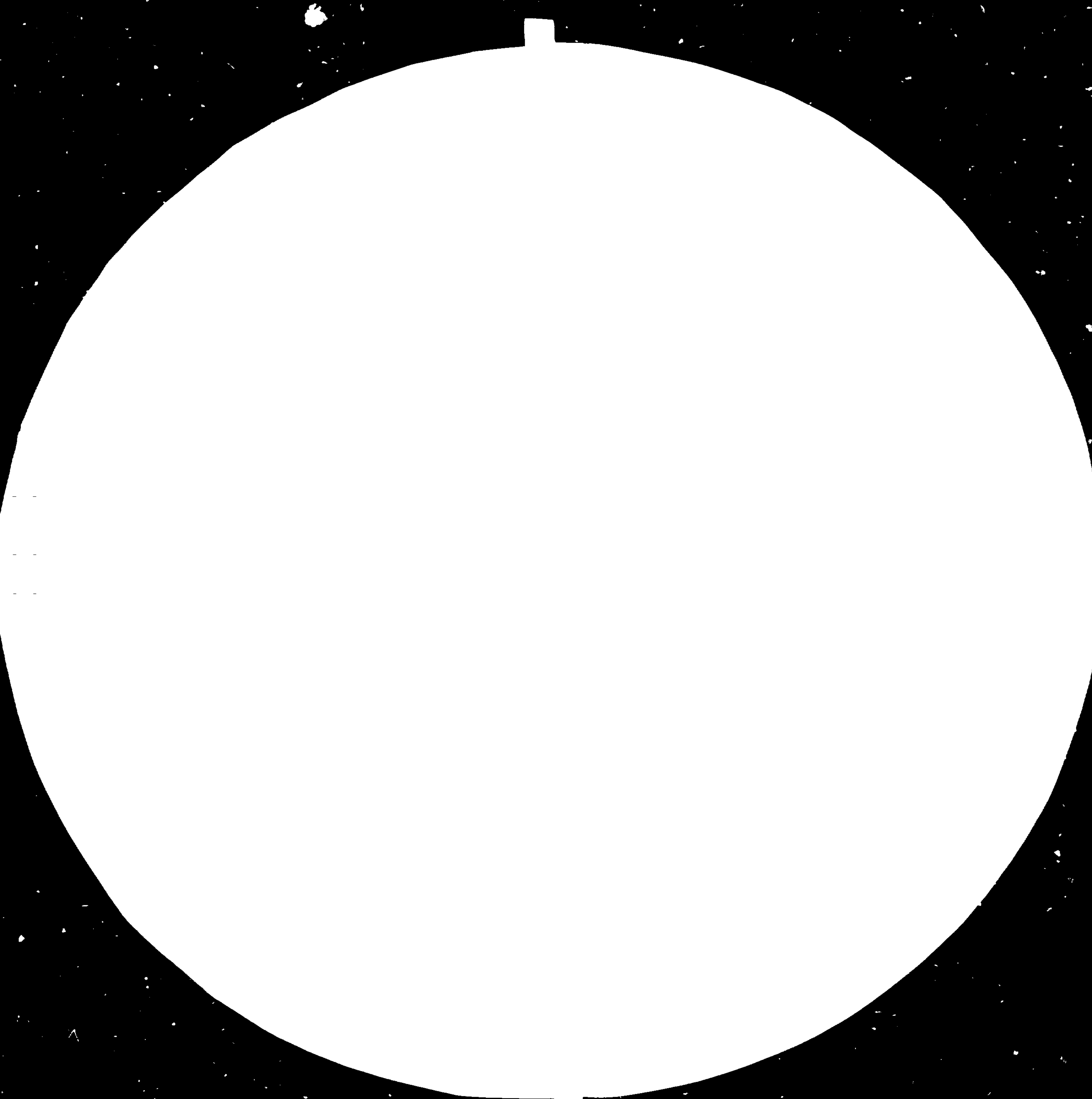
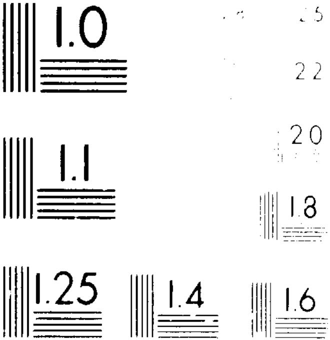
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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BIOSCIENCE AND ENGINEERING

DP/IND/80/003

INDIA.

Technical Report*

Conversion of Cellulose to Glucose (CTG)

Prepared for the Government of India
by the United Nations Industrial Development Organization,
acting as executing agency for United Nations Development Programme

Based on the work of Karl Schügerl,
Consultant on biotechnology

United Nations Industrial Development Organization
Vienna

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Conversion of Cellulose to Glucose (CTG)

Brief report on the UNDP "Biotechnology of Cellulose Utilization" carried out at National Chemical Laboratory (NCL) Pune under the UNDP/UNIDO project DP/IND/80/003 and recommendations.

Ref.: DP/IND/80/003/11-52/32.1.H

Prepared by K. Schügerl
Consultant on Biotechnology

The report consists of three parts:

1) Short description of my programme in Pune,

2) Short description of the present state of the UNDP/UNIDO project,

3) Recommendations.

1. Short description of my programme in Pune

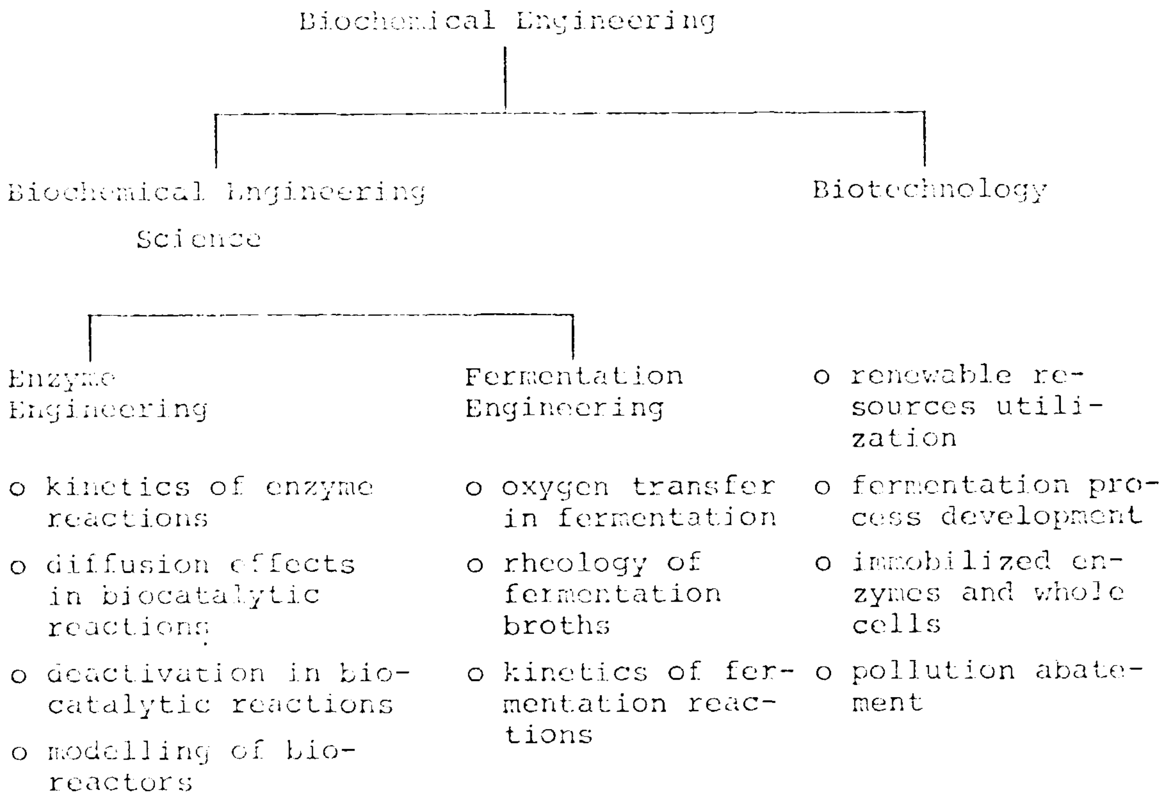
1-3-84	Arrival in Pune
1-4-84	Participation in IIChE 36th Annual Session at Tilak Smarah Mandir, Pune, on environmental engineering
1-5-84	- ditto -
1-6-94	Discussion with Biochemistry and Bioengng. Groups of NCL
1-9 to 1-11-84	Participation in ICREC

1-12-84 Lecture on upgrading cellulose. Discussion with Biochemistry and Bioengng. Groups of NCL. Participation in a meeting with the president of NCL, the group leader for Biochemistry and Bioengng. and other consultants of UNIDO

1-12-84 18:20 Departure from Pune

2. Short description of the present state of the UNDP/UNIDO project

The structure of bioengineering activities at NCL can be described by the following diagram:



Biochemical Engineering

Biochemical Engineering Science

Biotechnology

Enzyme Engineering

- o kinetics of enzyme reactions
- o diffusion effects in biocatalytic reactions
- o deactivation in biocatalytic reactions
- o modelling of bioreactors

Fermentation Engineering

- o oxygen transfer in fermentation
- o rheology of fermentation broths
- o kinetics of fermentation reactions

Biotechnology

- o renewable resources utilization
- o fermentation process development
- o immobilized enzymes and whole cells
- o pollution abatement

The UNDP is mainly concerned with renewable resources utilization but also covers several other activities mentioned in the above diagram, such as enzyme engineering for decomposition of cellulose/hemicellulose and fermentation engineering for production of these related enzymes and different aspects of biotechnology, such as fermentation process development involving immobilized enzymes and whole cells.

The main objective of the programme is to develop integrated and cost-effective processes for biomass (cellulose, hemicellulose and lignin) utilization.

In an extensive screening program two promising strains, a Penicillium funiculosum and a Sclerotium rolfsii were isolated; they grow rapidly on cellulose substrates with extracellular release of high endo-β-D-glucanase, exo-β-D-glucanase and β-D-glucosidase activities.

A Penicillium janthinellum strain was also obtained which grows rapidly on pretreated rice straw in the presence of ammonium sulphate and urea.

The great advantage of the strains P. funiculosum and S. rolfsii is their high β-glucosidase activities. A hypersecretive mutant was obtained from P. funiculosum which yields 30-36 IU ml^{-1} of β-D-glucosidase activity.

A UV mutant was obtained from S. rolfsii which produces high cellulase, β-D-glucosidase and xylanase activities.

P. janthinellum was used successfully to convert cellulose/hemicellulose into fungal cell mass.

Also simultaneous saccharification and fermentation of alkali treated cellulose powder and sugar cane bagasse was carried out with P. funiculosum.

Due to the high enzyme cost of the bioconversion of cellulose/hemicellulose the enzyme recovery can improve the economy of the process. With nonionic detergent 90 % of the enzyme recovery was possible from undigested residues of cellulosic materials.

For continuous ethanol production immobilized cells are used. Sweet sorghum juice was converted into ethanol with these cells at high conversion efficiency.

As this short report indicates the UNDP/UNIDO project shows satisfactory progress, especially in the field of screening of microorganism and enzyme engineering. A 100 l fermenter has been been purchased, process development can now also be accelerated.

In my opinion, process analysis and control should be further developed in the future in order to improve process efficiency.

3. Recommendations

The UNDP/UNIDO supported programme at NCL is hindered by the delay in commissioning of new equipment bought with UNDP assistance. For example, a nitrogen analyzer was delivered six months ago and has still not been fully installed by the company.

The spares and chemicals ordered through UNDP under the Field Purchase Order have not been obtained at all. Obviously, there is a communication gap in this regard between NCL/UNDP/UNIDO. This communication should be improved.

With regard to the programme I would recommend its extension to the production of acetone/butanol with immobilized cells.

Furthermore, inquiries ought to be made as to which solvents are needed in India. Biotechnological processes should be developed for other solvents as well.

Finally, I would like to acknowledge and thank the NCL for their help and hospitality.