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STRENGTHENING OF PESTICIDE DEVELOPMENT CENTRE

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INDIA

Technical report: Findings and recommendations*

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

Based on the work of Th. F. Tadros,
consultant in R&D formulation

Backstopping Officer: B. Sugavanam, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

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* This document has not been edited.

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REPORT ON THE VISIT TO DELHI ORGANISED BY UNIDO

10 - 18 DECEMBER 1993

GENERAL INTRODUCTION

I arrived in Delhi on Friday 10, 1993 and left on Saturday 18 December 1993. During that period, I attended the conference on Microemulsions (organized by Delhi University and Sponsored by several organizations including the Institute of Pesticide Formulation Technology, Gurgoen) on Friday and Saturday 10 and 11, 1993. During the conference I delivered a lecture on "Microemulsions in Agrochemicals". I have met at the Conference Dr. Dhua from UNIDO India and Dr. Patenjali from the Institute of Pesticide Formulation Technology. I held various discussions with several scientists and students on various topics of formulations of agrochemicals. I also took part in a panel discussion on the future application of microemulsions in agrochemicals. I spent Monday till Friday at the Institute of Pesticide Formulation Research, where I had several discussions on the work they are carrying out in the field of agrochemical formulations (see below). I also gave a seminar on "Spray Formulations" and had an opportunity to visit Indian Oil Institute, where I also delivered a seminar on "Emulsions". Since my main mission was to consult for the Institute of Pesticide Formulation Technology, I will give a summary on the discussions I had with the Personnel of that Institute and make some recommendations for the future.

DISCUSSIONS AT THE INSTITUTE OF PESTICIDE FORMULATION TECHNOLOGY

I have visited the institute in 1989 and I can give a general impression of the progress the Institute made during the last four years. Since my last visit Dr. Kawal Dhari has been appointed National Project Coordinator for the Institute. I was met on arrival by Dr. Dhari who explained to me his role and the organisation of the institute. I was pleased to find that Dr.

Dhari was aware of the work and objectives of the Institute and the new role they are seeking in training various groups at the Institute. He explained to me the plan for a new conference building and the possibility of offering training and education in the field of Pesticide Formulation Technology. Indeed, during my visit, the Institute was engaged in a training course for the Indian Institute of Standards. I have had the opportunity to interact with some of the delegates, who were very pleased with the organization and training. I was very pleased to see considerable progress in various areas of formulation technology in the institute and these are summarised below.

WETTABLE POWDERS

A great deal of research was carried out to identify the most suitable fillers and dispersing agents for wettable powders (WP). A specific example of 50% WP Malathion was under investigation using Perlite and silica as fillers and lignosulphonates and Dispersol PS (from ICI) as dispersants. Some problems were encountered in this formulation, whereby the Malathion was not adequately retained. This was thought to be due to the batch variation of the ingredients. A research programme carried out by Dr Ramdas and Dr Khattar established the problem and some solutions could be found by adjustment of the filler level and composition as well as the dispersing agents.

SUSPENSION CONCENTRATES (SC's)

This area of formulations started during my last visit and considerable progress was made. The group is now able to formulate suspension concentrates (SC's) in a professional manner. They have acquired a Dyno mill, a particle size analyzer (Malvern Master sizer) and a rheometer (Haake-Rotovisco). During my last visit, I explained to the group the fundamentals of preparation of stable SC's and the methods that could be used for their evaluation. This was followed and a great understanding of the principles was observed. In addition, the technical staff

acquired the necessary skills for preparation of the SC. They were able to use the Dyno mill under optimum milling conditions. The resulting SC was assessed using the Master sizer and the Haake-Rotovisco. Several SS's were developed and below some examples are given.

A 50% Endosulfan SC was formulated using Atlox 4896 as dispersing agent and Rhodopol 23 as the antisettling agent. During my stay, Dr Ramdas and Mr Sarin prepared such SC and showed me how they approach the evaluation of the resulting formulation. I was impressed by their competence which now match the skills of formulation chemists in International companies. Various other SC's were also developed such as Isoproturon 50 SC, Sulphur 52 SC and Lindane 57 SC. Dr Ramdas showed me the collaboration with various companies on these projects, who made significant financial contributions to the Institute.

CONCENTRATED EMULSIONS (EW's)

A 50% EW of Butachlor has been developed on a laboratory scale and the formulation is ready for scale up. The group has acquired the required skills for formulation of EW's and they have fundamental understanding of the factors responsible for the preparation of stable EW formulations. In addition, they are able to assess the stability using the Master sizer by following the droplet size distribution as a function of time and temperature. The EW formulation could be used as replacement for the EC's in the future. Being water based, they are safer for the environment and they also are probably cheaper to formulate. Various emulsifiers were investigated by the group and they are able to optimise the system in a systematic way.

MICROEMULSIONS (μE)

This work is carried out by Dr Patanjali who has a great skill in this field of research. Besides carrying out his Ph.D. with Prof. Maitra at Delhi University on microemulsions, he also spent some months with Prof. Shah at Florida who is a world expert on

microemulsions. Dr. Patanjali developed a 10% Butachlor microemulsions and he presented his work at the International Symposium on Microemulsions, organized by Prof. Maitra. The work was well received and the audience showed great deal of interest in this kind of formulations. Apart form its thermodynamic stability (thus having an almost indefinite shelf life), the formulation could offer beneficial effect in biological efficacy. I certainly encouraged the group to continue in this research area and collaborate with some Indian Industries. The area of microemulsions has attracted considerable attention in recent years for formulating agrochemicals and it was pleasing that the Institute is aware of the importance of this area of research. Dr. Patanjali is certainly competent to pursue this field and he could expand his work for other products besides Butachlor.

WATER DISPERSIBLE GRANULES (WG's)

The group has recently acquired a fluid spray granulator which they used to produce a 75 WG Isoproturon. I have discussed the work with the person in charge of the large scale laboratory and he showed me the fluid bed granulator. The formulation produced is of high quality and it disperses very well on dilution. The Institute intends to continue this work of formulating WG's using other chemicals and various Industries are interested in using the granulator. There is sufficient interest from various companies to formulate some of their products as WG's. Clearly, this has to be evaluated carefully since production of WG's requires high capital cost and they may not offer great advantage over the cheaper formulations of SC's and EW's. However, WG's are finding considerable interest world wide, since it may be possible to contain them in water soluble bags and this remove the problem of disposal of the empty container after using the formulation. The latter problem is certainly an issue in Western Countries, but it may also become important for India. Thus, research in this area is certainly justified.

SUMMARY AND RECOMMENDATIONS

Having spent one week at the Institute and holding various discussions with the formulation chemists, I came to the conclusion that the Institute has served its objectives in the most successful way. Since my last visit, four years ago, the staff made significant progress and acquired the most modern techniques for evaluation of the formulations. The following recommendations are made:

(1) The Institute should continue its research programme and strengthen their collaboration with Industry.

(2) Careful thought should be given to application methods which are important for the Indian farmer. At present, the techniques applied may not be the most suitable for the Indian agriculture practices. This would require recruitment of two or three people who should become dedicated for this research. Some training abroad may be required.

(3) The Institute should act as a centre for training for Asian as well as African Countries. This could be done through courses practical training and help in formulation development.

(4) UNIDO should continue the support for the Institute for a period of five years. This is extremely essential to keep the Institute as a centre of excellence in India. It will also enable the institute to attract funds from the Industry, both from India and abroad.

(5) The staff should be encouraged and supported to spend some periods abroad to follow the progress in formulation technology and research. Funding should be made available through UNIDO. In addition, consultants from abroad should be invited at regular periods to evaluate the progress made and help in establishing the research and technology.

(6) An annual technical report should be produced highlighting the technical progress and any difficulties encountered. This report should be widely distributed to the Companies involved and the Consultants from abroad who could make comments and offer advise to strengthen the research and development work.

UNIDO TRAINING PROGRAMME AT IMPERIAL COLLEGE (LONDON) - MARCH 28 - APRIL 29, 1994

This programme, sponsored by UNIDO, is aimed at training 15 Indian fromulation Chemists and Technologists from various Industries and The Institute of Pesticide Formulation Technology as well as 4 formulation Chemists and Technologists from China. The application forms for the various delegates were sent to the British Council and copies were sent to Prof. Th.F. Tadros (Senior Research Associate at ZENECA AGROCHEMICALS and Visiting Professor at Imperial College). After various consultations, a programme was set up by Prof. Tadros and Dr. P.F. Luckham (Reader at Imperial College) who may be considered to be the official Organizers. We are aware of the diversity of Interest of the various delegates and hence a programme was set up to benefit all attending the training programme. There may be a need for some of the delgates to concentrate on certain aspects of the programme and have additional visits in their own interest. This matter will be discussed with the delegates at the opening day of the training programme. Unfortunately, the backstopping officer who engineered this training programme (together with Dr. Dhua (from UNIDO, India) cannot be available on the first day to open the training course. He will, however, be available during the training period and possibly at the closing day.

The enclosed programme will hopefuly be followed as planned, but some modifications may be made once we meet with the delegates. We would welcome any comments and/or additions for those receiving a copy of the programme. All enquiries should be sent to :

Prof. Th.F. Tadros
ZENECA AGROCHEMICALS
Jealott's Hill Research Station
Bracknell, Berkshire RG12 6EY, U.K.
Fax 44-734-55629

Monday 28, 1994

9.00 - 10.30	**Prof. Th.F. Tadros** - Welcome Each delegate will introduce himself/heself indicating his/her main interest and what he/she wants to get out of the training programme.
10.30 - 11.00	Coffee break
11.00 - 12.00	**Prof. Th.F. Tadros** - Objectives of the training programme
12.00 - 14.00	Lunch break
14.00 - 15.00	**Prof. Th.F. Tadros** - Introduction on the Basic Fundamentals of Agrochemical Formulations
15.00 - 15.30	Tea break
15.30 - 16.30	**Dr. P.F. Luckham** - Basics of Colloid and Interface Science
18.30 - 20.30	**Dinner at Imperial College**

Tuesday 29th, 1994

9.30 - 10.30	**Dr. B. Costello** - Particle size measurements, Principles
10.30 - 11.00	Coffee break
11.00 - 12.00	**Dr. B. Costello** - Particle size measurements, Experimental methods
12.00 - 14.00	Lunch break
14.00 - 16.30	**Dr. B. Costello + Ph.D. Students** - Tutorials and demontsrations on particle size analysis methods

Wednesday 30, 1994

9.30 - 10.30	**Dr. P.F. Luckham** - Surfactants and their selection
10.30 - 11.00	Coffee break
11.00 - 12.00	**Prof. Th.F. Tadros** - wetting spreading and adhesion, importance in applications
12.00 - 14.00	Lunch break
14.00 - 16.30	**Dr. P.F. Luckham and Ph.D. Students** Tutorials and demonstrtions of Surfactant Phase diagrams

Thursday 31st, 1994

9.30 - 10.30	**Dr. R. Aveyard** - Surface and Interfacial Tension and their measurement
10.30 - 11.00	Coffee break
11.00 - 12.00	**Dr. R. Aveyard** - Adsorption from solutions to liquid surfaces, aggregation and solubilisation
12.00 - 14.00	Lunch break
14.00 - 16.30	**Dr. R. Aveyard and Ph.D. Students** - tutorial sessions and demonstration of surface and interfacial tension measurements

Friday 1st April - Monday 4th April

Bank Holidays and week end - delegates may like to visit other parts in the U.K. Organizers can advise, but they should take care of themselves and cover their own cost.

Tuesday 5th April

9.30 - 10.30	**Prof. Th.F. Tadros** - Fundamentals of Suspension Concentrates in Agrochemicals
10.30 - 11.00	Coffee break
11.00 - 12.00	**Prof. Th.F. Tadros** - Fundamentals of Emulsion Concentrates in Agrochemicals
12.00 - 14.00	**Lunch break**
14.00 - 16.30	**Prof. Th.F. Tadros and Ph.D. Students** Tutorials and demonstrations on Suspension Concentrates and Emulsion Concentrates.

Wensday 6th April 1994

9.30 - 10.30	**Prof. B. Briscoe** - Powder Characterisation
10.30 - 11.00	Coffee break
11.00 - 12.00	**Prof. B. Briscoe** - Powder compaction and agglomeration
12.00 - 14.00	Lunch break
14.30 - 16.30	**Prof B. Briscoe and Ph.D. Students** - Tutorials and demonstrations on Poweder characterization, comapction and agglomeration

Thursday 7th April

8.00 - 10.30	Coach from Imperial College to Bristol University
10.30 - 11.00	Coffee break
11.00 - 12.00	Dr. J. Goodwin - Basic Principles of Rheology
12.00 - 13.00	Dr. J. Goodwin - Measurement techniques of Rheology
13.00 - 14.00	Buffet Lunch
14.00 - 16.00	Dr. J. Goodwin and Post Doctoral Fellows - Tour of the Labs and demonstration of rheological equipments.
16.00 - 18.30	Coach to Imperial College.

Friday 8th April

9.30 - 10.30	Dr. P.F. Luckham - Rheology of Suspension Concentrates
10.30 - 11.00	Coffee break
11.00 - 12.00	Dr. P.F. Luckham - Sedimentation of Suspensions and its prediction using rheology
12.00 - 14.00	Dr. P.F. Luckham and Ph.D. Students - Tutorials and demonstrations of rheology and sedimentation of suspension concentrates

Saturday 9 and 10 th April 1994

Week end - Delegates who wish to visit other places in the U.K. may seek advise from the organizers.

Monday 11 April, 1994

9.30 - 10.30	**Mr. D.A. Knowles** - Formulation Objectives, Review of Formulation Types, International Codes
10.30 - 11.00	Coffee break
11.00 - 12.00	**Mr. D.A. Knowles** - Solution concentrates, wettable powders, Emulsifiable concentrates, Suspension Concentrates
12.00 - 14.00	Lunch break
14.00 - 16.30	**Mr. D.A. Knowles and Ph.D. Students** - Tutorials and practical demonstrations relating to morning session

Tuesday 12 April

9.30 - 10.30	**Mr. D.A. Knowles** - Emulsions, Suspensions
10.30 - 11.00	Coffee break
11.00 - 12.00	**Mr. D.A. Knowles** - Controlled release, Seed treatment
12.00 - 14.00	Lunch break
14.00 - 16.30	**Mr D.A. Knowles and Ph.D. Students** - Tutorials and demonstrations relating to Morning session

Wednesday 13 April

9.30 - 10.30	**Mr D.A. Knowles** - WG Formulations
10.30 - 11.00	Coffee break
11.00 - 12.00	**Mr D.A. Knowles** - WG Processes
12.00 - 14.00	Lunch break
14.00 - 16.30	**Discussions and Seminar on "Spray Drying and Fluid Bed Granualation by Nitro-Aeromatic"**

Thursday 14 April

9.30 - 10.30	Mr. D.A. Knowles - Formulation Adjuvants
10.30 - 11.00	Coffee break
11.00 - 12.00	Mr. D.A. Knowles - Recent Formulation Trends
12.00 - 14.00	Lunch break
14.00 - 16.30	Discussions and Seminar on "Surfactants for Agrochemical Formulations" by ICI Surfactants

Friday 15 April

8.30 - 10.30 ZENECA	Coach to Visit Formulation Department, Agrochemicals, Yalding - Delegates will be accomapnied by Mr D.A. Knowles
16.00 - 18.30	Coach from Yalding to Imperial College

Saturday 16 and Sunday 17 April

Weekend - Delegates who wish to visit other parts in the U.K. may seek advise from the Organisers.

Monday 18th April

9.30 - 10.30	Mr Keith S Johnson - Effluent Treatment, Principles of Treatment Technology, Treatment Plant Design and Operation
10.30 - 11.00	Coffee break
11.00 - 12.00	Mr. Keith S Johnson - Quality Aspects and Control of Treated Effluents and Industrial water Prior to Disposal
12.00 - 14.00	Lunch break
14.00 - 16.30	Mr Keith S. Johnson - Discussions on topics of Morning session and Practical Demonstrations

Tuesday 19 April

8.30	Coach for Site visits to Operational Effluent Treatment Plants - Agrochemical Formulation Factory - Horticultral Research Institute Field Station - Delegates Accompanied by Mr. Keith S. Johnson
16.00	Coach to Imperial College

Wednsday 20 April

9.30 - 10.30	Mr Keith S. Johnson - Waste Management and Disposal, Principles of Waste minimisation, On-site Waste Management and Storage, Methods of Waste Handling and Preparation for Disposal
10.30 - 11.00	Coffee break
11.00 - 12.00	Mr. Keith S. Johnson - Disposal Options for Wastes arising from the fromulation of Agrochemicals, Chemical Treatment and Fixation, Controlled Landfill, Incineration (high Temperature)
12.00 - 14.00	Lunch break
14.00 - 16.00	Mr Keith S Johnson - Discussions and Practical demonstrations

Thursday 21 April

8.30	Coach for Site Visits to Large Waste Treatment Centre and Controlled Licensed Landfill - Delegates Accompanied by Mr Keith S Johnson
16.00	Coach Return to Imperial College

Friday 22 April

9.30 - 10.30	Mr Keith S Johnson - Envirmentally Related Aspects of Work-place Hygeine and Safety
10.30 - 11.00	Coffee break
11.00 - 12.00	Mr Keith S Johnson - Enviromentally Related Aspects of Work-place Hygeine and safety (Cont.)
12.00 - 14.00	Lunch break
14.00 - 16.30	Mr Keith S Johnson - Review of Course Activities and Discussion

Saturday 23 and Sunday 24 April

Week end - delegates who want to visit other parts in the UK may seek advise from the Organisers

Monday 25 April

9.30 - 11.00	**Prof. G.A. Matthews** - Introduction to Pesticide Application. The Physics of Droplet Formation, Types of Hydraulic Nozzles
11.00 - 11.30	Coffee break
11.30 - 12.30	**Prof. G.A. Matthews** - Environmental Factors and Spray Coverage
12.30 - 13.00	**Dr. E.W. Thornhill** - The Product Label
13.00 - 14.00	Lunch break
14.00 - 15.30	**Dr. E.W. Thornhill** - Nozzle Selection - Flow Rate and Patterns of Hydraulic Nozzles - Practical and Demonstration
15.30 - 16.00	Tea break
16.00 - 17.00	**Prof. G.A. Matthews and Dr E.W. Thornhill** Assessment of Spray Coverage by the use of Artificial Targets - Field Practical

Tuesday 26 April

9.30 - 11.00	**Dr E.W. Thornhill** - Hydraulic Energy Sprayers - Compression Sprayers - Diaphragm and Piston Pump Knapsack Sprayers
11.00 - 11.30	Coffee break
11.30 - 13.00	**Dr E W Thornhill** - Calibration and Application to Field Plot by Knapsack Sprayers (group Activity)
13.00 - 14.00	Lunch break
14.00 - 15.00	**Ms Elizabeth Chadd** - Extension Training for Farmers in Pesticide Application
15.30	**Depart by Coach to Attend the Inaugural Lecture by Prof. G.A. Matthews at Imperial College**
18.00	**Return by Coach to Accomodation**

Wednesday 27 April

9.30 - 11.00	Dr. E.W. Thornhill - Safety Aspects - Pesticide Application and Operator Protection
11.00 - 11.30	Coffee break
11.30 - 13.00	Prof. G.A. Mattews - Rotary Atomisation and Control droplet Application - Electrostatics
13.00 - 14.00	Lunch break
14.00 - 15.00	Prof. G.A. Mattews - Very low volume Application by Controlled Droplet Application to Assess Spray Coverage by Ultra Violet Tracer
15.00 - 16.00	Dr E.W. Thornhill - Tractor Spraying Lecture and Field demonstration
16.00 - 17.00	Prof. G.A. Matthews - Discussion of Application Problems and Review

Thursday 28 April

9.30 - 11.00	Prof. G.A. Matthews - Air Assisted and Gaseous Energy Sprayers
11.00 - 11.30	Coffee break
11.30 - 13.00	Dr. E.W. Thornhill - Aerosol Generators and Space Treatments and Demonstration
13.00 - 14.00	Lunch break
14.00 - 15.30	Dr. E.W. Thornhill - Motorised Mistblowers
15.30 - 16.00	Tea break
16.00 - 17.00	Prof. G.A. Mattews - Dry Powder and Granule Application

Friday 29 April 1994

9.00	Coach to ZENECA - Jealott's Hill Research Station - Prof. Th.F. Tadros to Organise a tour through the laboratories
12.30 - 14.00	Lunch break - Lecturers are also invited
14.00 - 1600	Discussions and Close of the Training Course - All Lecturers are welcome to attend and contribute to the discussions

UNIDO Comments

The report of the consultant gives a brief review of different projects carried out in the Institute of Pesticide Formulation Technology. It also provides the pressed made so far in the area of Research and Development R&D) projects and interactions with the industries. The author's recommendations to translate R&D results into commercial success is vital for sustainability of the Institute to promote safe development of pesticides. UNDP/UNIDO's continued support, recommended by the consultant, would be a major topic to be discussed during the next tripartite review meeting.

The consultant is involved in a training course to be organized in collaboration with the Imperial College, London. Success of such a workshop would provide greater interaction between the developing countries and the industrialized countries in learning the new developments and in following international norms.