WORKSHOP ON PRODUCTION OF USER AND ENVIRONMENT FRIENDLY PESTICIDE FORMULATIONS, QUALITY ASSURANCE AND INSTRUMENTAL METHODS OF ANALYSIS, DELHI, INDIA, MARCH 2-9, 2009

REGIONAL NETWORK ON PESTICIDES FOR ASIA & THE PACIFIC
REGионаl Network on PesticidE for Asia and PacifIc

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friendly pesticide formulations, quality assurance and instrumental
methods of analysis, Delhi, India, March 2-9, 2009

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Based on the work of Mrs. Bella Fe Carmona the Chairperson and Mrs.
Bhekiwe Hlope of Swaziland as the Rapporteur

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Annexure I
I. INTRODUCTION

Contribution of agro-chemicals towards increasing agricultural production is well established, however, it causes damage to the environment; the ecosystem including the mankind. Pesticides are known to control insect pests, weeds, diseases, rodents and pests in the storage. Though the pesticide industry in the developed world has made good progress in the field of development and production of low risk/low volume user and environment friendly pesticides formulation, pesticides in the developing countries still now are mainly available in conventional formulations such as dust, wettable powder, emulsifiable concentrates, solutions, etc. Such conventional formulations pose problems relating to environmental protection, leaving residues in the ecosystem, food, finished products, etc. Hence, there is a growing demand towards switching over of the conventional pesticide formulations using petroleum and organic solvent based constituents to user and environment friendly water based formulations. These formulations are targeted only to replace toxic, non-degradable ingredients of the formulations but also increase the efficacy of the products through proper control on the size reduction of the toxic active ingredients.

RENPAP has been assisting and advising its 16 member countries of the Asia and Pacific Region in achieving self-sufficiency in the production of user and environmentally friendly formulations. In this context, the RENPAP has successfully organized a series of workshops on the subject at its Technical Coordinator Unit (TCU) at the Institute of Pesticide Formulation Technology (IPFT) in India and trained experts from the member countries including experts from the African region. Since the advances in this field of formulation development are taking place at a relatively greater pace,
there is a strong need to update the expertise based on the latest developments. This is indeed very important in the light of the various international conventions viz. Stockholm Convention on Persistent Organic Pollutants, Basal Convention, Rotterdam Convention, Montreal Protocol seeking safer technologies for the protection of the ecosystem and the mankind.

As per the recommendations of the last TPR/PMC meeting of the RENPAP held in Bali, Indonesia during May 26-28, 2008 and the approved workplan of the RENPAP, the Government of India has once again generously offered to host this Workshop on Production of User and Environment Friendly Pesticide Formulations, Quality Assurance and Instrumental Methods of Analysis in Delhi, India from March 2-9, 2009 for the benefit of the member countries at the Institute of Pesticide Formulation Technology (IPFT), which is serving as the Technical Coordinator Unit of RENPAP on the subject.

II. Objectives of the Workshop

The main objective of the workshop is to assist the member countries of the network in strengthening their capabilities in the field of pesticide formulation development and quality assurance. The workshop would cover:

advances made in the field of pesticide formulation development and application including biopesticides and botanical pesticides for the environment protection and safety to workers/operators/farmers,

- “hands on” training in the production of pesticide formulations with special emphasis on new generation formulations in the laboratory and in the pilot plant,

- quality assurance of pesticides formulations
- “hands on” training on preparation of water based pesticide formulation and instrumental methods of analysis,
- progress made by the member countries, especially the industries in the field of promotion of environment friendly formulations development and production,
- steps being taken up by the member countries with regard to the compliance of the requirements of the Stockholm Convention obligations.

III. PARTICIPANTS

The workshop was attended by the expert nominees from the member Governments of the Network including the African countries. Besides the Government nominees, there were participants from the Indian Pesticide Industry A list of the participants is placed at Annexure I of the report.

IV. OPENING OF THE MEETING

Dr. Vairamani, Director, Institute of Pesticide Formulation Technology (IPFT) welcomed the dignitaries and the delegates from the member countries and the Indian pesticide industry. He said that the facilities of the IPFT, which is serving as the Technical coordinator Unit of the RENPAP on Pesticide Formulation Technology, are of international standard. He said that facilities and the expertise available with IPFT is opened to the member countries of the RENPAP for sharing knowledge and imparting training on formulation technology.

Dr. Dhua, Regional Coordinator RENPAP extended a very warm welcome to Mr. Bijoy Chatterjee, Secretary, Ministry of Chemicals & Fertilizers, Government of India, other dignitaries from Government of India, UNIDO
and introducing the participants from the member countries and African Countries and from the Indian Pesticide industry individually.

Dr Dhua expressed his deep gratitude to the member countries of the RENPAP who have generously contributed both in cash and the kind to make it possible to continue and strengthen the RENPAP activities in its current phase. He welcomed Mr. Chen Yinghui of People’s Republic of China, Ms. Eva Dasmita of the Government of Indonesia, Ms. Thipphavanh SILIPANYO of Government of Lao PDR, Mr. Sahadev Prasad Humagain of the Government of Nepal, Ms. Bella Fe Camona of the Government of the Philippines, Ms. Duangrat Wilasinee of the Department of Agriculture, Government of Thailand, Mrs. Elizeth Luzola Cost Godinho Goncalves, POPs Focal Point of the Government of Angola, Mrs. Albertina Benza Canda of the Government of Angola, Ms. Bhekiwe Hlope, POPs Focal Point of Swaziland and Mr. D. Khumalo of the Government of Swaziland. He also welcomed participants from the Indian pesticide industry to the Workshop.

He stated that crop protection chemicals have played crucial role in assisting the farming community to feed the growing population of the Asia Pacific region. The RENPAP has been pursuing a three-pronged strategy to promote safety to the farming community and to the environment. One of this is to produce and use neem based botanical pesticides, the second to promote Bt based bio-pesticides and the third to produce and use water based pesticide formulations. This Workshop, he said, would appropriately focus on the technologies developed for the production and use of water based pesticide formulations which are farmer friendly and fairly benign to the environment as such formulation would help reducing use of petroleum based solvents and organic solvents essentially required in the conventional formulations.
He expressed his gratitude to the Government of India to provide all support necessary to enable organization of this very workshop, the Institute of Pesticide Formulation Technology to provide the hosting facilities for the workshop and the member Governments for so generously contributing to sponsor expert delegates to participate in the workshop.

He traced the history of the Pesticide development Programme in India (PDPI)/ Pesticide development centre (PDC) funded by the UNDP and executed by UNIDO. He mentioned that according to his assessment this institute is amongst the best in terms of equipment and trained manpower in the field of pesticide formulation development and quality assurance and is well placed to host training programmes of the type being organized.

Mr. Bhujabal, Director, Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers Government of India in his address said that the present workshop is another one of RENPAP’s endeavors at mitigating the adverse fall out of pesticides on environment.

He said that pesticides, mainly comprised of plant protection products (PPP) and biocidal products, are designed to influence fundamental processes in living organisms. These pesticides may have the potential to kill or control harmful organisms such as pests, but can also cause unwanted adverse effects on non-target organisms, human health and the environment.

He stated that the possible risks associated with the use of pesticides are accepted to a certain extent because of the direct benefits that it generates (in particular for farmers). Toxic pesticides are applied on a large scale and generally considered as essential in modern cropping systems since they contribute to ensuring reliable supplies of affordable and healthy agricultural products of high quality. Undesirable amounts of
certain pesticides can however still be found in environmental media (in particular soil and water) and residues exceeding regulatory limits still occur in agricultural produce. The risks to human health and the environment from pesticide use are therefore being closely evaluated. He emphasized that exposure to pesticides should be minimized or, where possible, eliminated. Research and development of less harmful, including non-chemical, alternatives should be further encouraged. Whereas pesticide industry in the developed world has made good progress in the field of development and production of low risk/low volume user and environment friendly pesticides formulation, pesticides in the developing countries still now are mainly available in conventional formulations such as dust, wettable powder, emulsifiable concentrates, solutions, etc.

He said that RENPAP Network has been working for promotion of user and environment friendly pesticides formulation and quality assurance. Hence, RENPAP is shouldering a global responsibility in ensuring a more responsible and better environment. He said that this workshop would be a major step forward to hand over a more friendly living to our future generations.

Mr. Philippe Scholtes, UNIDO Representative and Head, Regional Office for South Asia, New Delhi welcomed the participants and expressed his sincere gratitude to the Department of Chemicals and Petrochemicals, Government of India, the Regional Network on Pesticide for Asia and the Pacific (RENPAP), and the Institute of Pesticide Formulation Technology for organizing this important event.

He said that the chemical industry provides important inputs for the development of other industrial sectors. It also provides many valuable
inputs to agriculture in the form of agro-chemicals such as pesticides and fertilizers. He mentioned that UNIDO has been designated as an ‘Executing Agency with Expanded Opportunities’ for implementing the Global Environmental Facility’s (GEF’s) mandate in respect of the Stockholm Convention on POPs. This reflects the growing concern of the international community such as UNIDO towards the scientific handling and disposal of such toxic chemicals. He said that RENPAP has been the precursor to the Stockholm Convention on Persistent Organic Pollutants.

In the Asia-Pacific region, through its RENPAP Network, UNIDO has been facilitating South-South Cooperation. He said that UNIDO has been particularly active in establishment of a technical base of necessary skills and manpower for safe and environmentally sustainable production, application and disposal of toxic chemical pesticides. He was also happy to note that with the assistance and technical guidance of RENPAP, Enabling Activities projects on POPs have been initiated with GEF funding in many of the member countries of the Network, including India.

Finally, he thanked the Department of Chemicals and Petrochemicals, Government of India, for its continued support to UNIDO’s programmes and for its strong support and guidance in strengthening RENPAP’s activities in the region and UNIDO would look forward to receiving this continued and vital support in the future as well. Once again, he extended an earnest welcome to all the participants, and wishes this Workshop all success.

Mr. Rajju Shroff, Chairman & Managing Director of United Phosphorus Limited in his address highlighted the role of pesticide industry in the developing and promoting safer environmentally pesticide formulations. He lauded the role of RENPAP and the IPFT in bringing the Indian pesticide
industry at the international standard. He said that such meetings of international participants bring in rich experiences of the member countries to share with the counterpart Indian experts. He wished successful deliberations in the workshop.

Mr. Harikumar, Chairman & Managing Director of Hindustan Insecticides Limited said that though pesticides are harmful to the human being and environment but the value judgment of a chemical vary from one place to another. A product found to be persistent and toxic in colder climate is not behaving in the same fashion in tropical country like India. Developing nations should not just follow the developed world, we should have our judgment, otherwise under IPR developing nations would be forced to buy costlier products from developed nations.

Mr. Bijoy Chatterjee, Secretary, Department of Chemicals and Petrochemicals, Ministry of Chemicals & Fertilizers, Government of India inaugurated the Workshop on Production of User and Environment Friendly Pesticide Formulations, Quality Assurance and Instrumental Methods of Analysis organized by the Regional Network on Pesticides for Asia and the Pacific and extended a warm welcome to all the participants.

In his inaugural address he said that pesticides are an important segment of the chemical industry and play a crucial role in boosting national agricultural production. Agrochemicals have been acknowledged to have made a significant contribution in ushering in the Green Revolution. If we are self sufficient in foodgrains today, the role of agrochemicals in making this possible cannot be underestimated, he stated.
He said that though the pesticide industry in the developed world has made good progress in the field of development and production of low risk/low volume user and environment friendly pesticides formulation, pesticides in the developing countries still now are mainly available in conventional formulations such as dust, wettable powder, emulsifiable concentrates, solutions, etc. Such conventional formulations pose problems relating to environmental protection, leaving residues in the ecosystem, food, finished products, etc. Hence, there is a growing demand towards switching over of the conventional pesticide formulations using petroleum and organic solvent based constituents to user and environment friendly water based formulations. These formulations are targeted only to replace toxic, non-degradable ingredients of the formulations but also increase the efficacy of the products through proper control on the size reduction of the toxic active ingredients.

He was happy to note that RENPAP programme is reaching out to nearly 16 countries that are all very active and willing to work together for promotion of user and environment friendly pesticides formulation and quality assurance. This clearly demonstrates that the RENPAP network is reacting to the fast development in agro-chemical technology and to the genuine concern of the environmentalists and public over the use of agro-chemicals, especially pesticides. It has also been purposefully working towards establishment of risk reduction programmes, facilitating information exchange on toxic chemicals, assisting in the assessment of chemical risks at the international level, and strengthening national capabilities, particularly through establishment of eight specialized
Technical Coordinator Units in the member countries. The Institute of Pesticide Formulation (IPFT) Technology in India has been functioning as one such Technical Coordinator Unit.

He said that IPFT was created through a project of UNDP/UNIDO and the Government of India, and has been assisting the Indian pesticide industry in development and production of user and environment friendly formulations. The Institute has been registered under the Societies Act and is working under the administrative control of the Department. This process has enabled the pesticide industry to participate in the management of the Institute for deriving maximum benefits. The main objective behind setting up of IPFT was to provide state of the art facilities and technology for developing user and environmental friendly pesticide formulations to the pesticide industry.

He mentioned that the important aspect facing the agro-industry for the country today is the issue of pesticide residues in food products meant for export. With the EU and USA making minimum residue standards more and more stringent, there is need for a review of the pesticides being used in the production of various products being tea, coffee, spices, groundnut and other products on the ground that they contained higher than the acceptable levels of various pesticides. There is the need for not only switching over to more eco-friendly pesticides but also for educating the farmers on the need for their proper application. Since India is a signatory to various international conventions including the Stockholm Convention on Persistent Organic Pollutants (POPs), there is a greater need for developing pesticide formulations using active ingredients which are not likely to be included in the POPs list in the near future. In this context, he mentioned that the Department of Chemicals and Petrochemicals, Government of India, has supported a programme for promotion of eco-friendly Neem based pesticides in India with the assistance of
UNDP/UNIDO. Neem based pesticides have acquired increased significance, especially in case of exportable agricultural crops and commodities, owing to the stringent maximum pesticide residue limit standards imposed on imports by USA and the European Union. After reviewing the success of this low cost neem based product, the Department has launched the phase II of the Neem programme to cover larger crop areas including plantation crops viz. tea, coffee and spices. This programme would provide Neem as a viable alternative to replace the toxic, persistent non-biodegradable POPs pesticides.

He was happy to note that UNIDO through its RENPAP Network, has been facilitating South-South Cooperation and with the assistance and technical guidance of RENPAP, Enabling Activities projects on Persistent Organic Pollutants (POPs) under the Stockholm Convention have been initiated with GEF funding in many of the member countries of the RENPAP Network, namely Nepal, Lao PDR, Indonesia, P.R. China, Mongolia and India. Also, RENPAP has been able to develop proposals for Post-NIP projects for many member countries including India on “Environmentally Sound Management and Final Disposal of PCBs in India” and “Environmentally Sound Management of Medical Wastes in India”, etc.

He said that the Government of India is aware of the need for the state of the art laboratory and research facilities in the area of pesticide formulation development. It is in recognition of this need that the Department of Chemicals & Petrochemicals has provided necessary budgetary support to IPFT for the construction of the new laboratory building and installation of necessary equipment for achieving ISO 9000.

He said that it is a matter of pride for the Institute that it is hosting the International Workshop on Production of User and Environment Friendly Pesticide Formulations, Quality Assurance and Instrumental Methods of
Analysis organized jointly by the Government of India and UNIDO. He once again extended a very hearty welcome to all participants and the Workshop would benefit immensely from the rich experience of various countries and deliberations would result in very positive results of benefit to the farming community at large in all member countries of the RENPAP.

Dr. Ramdev, Assistant Regional Coordinator, RENPAP extended the Vote of Thanks.

V. ADOPTION OF AGENDA
The agenda as presented was adopted unanimously and is placed at Annexure -II.

VI. ELECTION OF OFFICE BEARERS
Ms. Bella Fe Carmona of Philippines was elected as the Chairperson and Ms.Bhekiwe Hlophe of Swaziland as the Rapporteur.

VII. COUNTRY REPORTS
The Country reports presented by the delegates are summarized below:

Angola
Mrs. Elizeth Luzola Costa Godinho Goncalves, the nominee of the Government of Angola presented the country report. She said that Angola is a tropical African country with very fertile soil. Angola ratified the Stockholm Convention on 23 October 2006 which obliges the country to comply with its commitments.

The country has an arid coastal strip, a wet interior plateau, a dry savannah in the interior South and South-East, and tropical forest in the North and in Cabinda. The Zambezi River and several tributaries of the Congo River have their sources in Angola.
Angolan government has signed several agreements and partnerships in many socio-economic and environmental areas, including a wide range of conventions related to the chemical products. There would be number of new projects that may focus directly or indirectly in matters related to pesticides (e.g. forestry processing industry). The National Implementation Plan (NIP) would prioritize and generate other projects including on POP pesticides.

In the country over 50% of the population is engaged in agriculture and pesticide industry plays a relevant role. There is greater demand in the business of importing and marketing of pesticides. The country offers promising conditions for agriculture and beyond, leading to a greater demand for almost all categories of pesticides to combat the various pests and plant diseases from insecticides, herbicides, fungicides, acaricides, ticks etc.

The Ministry of Agriculture is responsible for the management of pesticides in the country. These responsibilities focused from the product registration to its entry into the country. The ministry requires compliance with current regulation and standards and international codes. Before the ratification of the Stockholm Convention, the government instructed the Ministry of Agriculture to take up the task of disposal of obsolete pesticides.

Pesticide Formulation industry takes a back seat as there is lack of support and technical skill in the field. There is need to build infrastructure and capacity in the country to import and use quality products in the country. Low level of education of the target group is somehow a barrier to reception of new information and a bigger constraint to its application. However, the government has already introduced some ideas about this reality which will take time to be effective.

People's Republic of China
Ms. Cao Xinmei of People's Republic of China presented the country report. She made her presentation in five parts viz. Status of the Pesticide Industry in China, New policy for development and promotion of newer types pesticide formulations, Technology and facilities situation of new pesticide formulation in China, Status of the Persistent Organic Pollutants (POPs) and the Level of acceptance of new pesticide technology and products.

Part 1: Status of the Pesticide Industry in P.R. China
She said that China is one of the largest agricultural countries in the world and large quantities of pesticides are produced and used in agriculture against a variety of pests including insects, fungi, weeds and other pests. She said that during the year 2007 the total production of pesticides (a.i) in China was more than 1,731,000 tons of over 600 varieties of compounds and over 18,000 formulated products which showed a steady increase in production of pesticides for the last over five years. It has increased from 863,000 tons in 2003 to 1,731,000 tons in 2007; out of these 600,000 tons (34.7%) were insecticides, 137,000 tons (7.9%) fungicides, 562,000 tons (32.5%) herbicides.

She said that China exported pesticides worth USD$1350 million during the year 2007. She stated that China mainly exports to the United States of America, Thailand, Argentina, Vietnam and Indonesia.

In respect of pesticide formulations, she mentioned that a large variety of formulations are manufactured in the country including the environment friendly formulations and during the year 2007 the following types of pesticide formulations were manufactured:

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Quantity</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulsifiable Concentrate (EC)</td>
<td>1040</td>
<td>48.8</td>
</tr>
<tr>
<td>Wettable Powder(WP)</td>
<td>445</td>
<td>20.9</td>
</tr>
<tr>
<td>Powders</td>
<td>7</td>
<td>0.3</td>
</tr>
<tr>
<td>Other (SC,SL,WG,EW, etc.)</td>
<td>640</td>
<td>30</td>
</tr>
<tr>
<td>Environmentally Friendly</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part 2.: New Policy for Development and Promotion of New Type Pesticide Formulations

She said that in the era of globalization of world economy and China’s entrance to WTO, the Chinese Government is taking various steps for the promotion of environmentally safer formulation and these include:

i. Internationalization of pesticide registration
ii. Promoting pesticide industry for increased international trade.
iii. Raising Administrative abilities
iv. Improving application technology

Part 3.: Technology and Facilities situation of new pesticide formulation in China

She stated that several regulations and measures have been taken to reduce the production and use of highly toxic pesticides. She discussed the various user and eco-friendly formulations developed and commercialized in the country especially at the Nantong Pesticide Formulation Center (NPFC). She said that more and more production facilities are being redesigned to suit the production of environment friendly water based formulations. In this context, she said that the NPFC has entered into joint venture with many pesticide industries to produce variety of pesticide formulations in the country for the overall benefit of the farming community.

Part 4: The Status of Persistent Organic Pollutants (POPs)

She said that China joined the Stockholm Convention on POPs in May 2001 and on April 14, 2007, the State Council had passed the National Implementation Plan of the country. She said that the manufacture, use and import-export of POP pesticides such as DDT, Chlordane and mirex will be prohibited in 2009.
Part 5: Level of acceptance of new pesticide technology and products

She said that acceptance of new technology is undertaken through:

i. propagation
ii. support for R&D
iii. popularization
iv. tests and demonstrations of new formulations.

India

Dr. Basu presented the country paper for India. The paper described the production of the technical grade as well as the consumption in the country. It was mentioned that currently 217 pesticides are registered in the country and about 25 pesticides are banned and 12 are under restricted use. The paper also gave the market scenario of India pesticide vis-à-vis global. The paper briefly outlined the scenario of bio-pesticides in the country.

Indonesia

The country paper of Indonesia was presented by Ms. Eva Dasmita, Ministry of Industry, Government of Indonesia. She said that agriculture sector is the backbone for Indonesia’s national development. Agro-chemicals (fertilizer & pesticides), as agro-inputs, are absolutely required for the agricultural production process. Around 13 pesticide companies are operating in the country producing technical grade pesticides and about 341 companies are formulating pesticides as finished products. The pesticide management in the country is operated through inter-ministerial coordination involving different ministries such as Ministry of Agriculture, Ministry of Marine and Fishery, Ministry of Forestry, Ministry of Health, Ministry of Environment, Ministry of Trade, Ministry of Industry. She also presented an overview of the different Laws and regulations framed by the Government to regulate pesticides. She described in detail the
pesticide licensing procedure and explained three kinds of pesticide licenses in vogue viz. Experimental License, Temporary License and Permanent License.

**Lao PDR**

Mr. Thavone Vongphosy representing the Government of Lao PDR presented the country paper. He said that the Lao’s People Democratic Republic is located in Indochina, between latitude 14-23 degrees North and longitude 100-108 degrees East. It has common borders with China (505km), Lao PDR(435km), and Vietnam (2,069km). He said that agriculture is the mainstay of the economy of Lao PDR and engages 80% of the population and contributes 48% to the GDP. There has been increasing trend in the use of pesticides for increasing agricultural production. He said that Laos’s pesticides requirement is met through import only. However, Lao PDR does not yet have any specific law or regulation for the management of pesticide and no pesticide industry, formulation plant is in process of establishment. The Lao PDR has signed the Stockholm convention on POPs which required development of National Implementation Plan (NIP) under the convention. Presently, the Environmental Research Institute, Water Resources and Environment Administration, under Prime Minister’s Office serving as the POPs National Focal point is implementing the project on enabling activities to facilitate early action on the implementation of the Stockholm Convention on Persistent organic pollutant (POPs) in Lao PDR.

**Nepal**

The country paper for Nepal was presented by Mr. Sahadev Prasad Humagain of the Department of Agriculture, Government of Nepal. He said that the agriculture sector contributes 38% to the National GDP in Nepal. Loss estimation in pre to post-harvest due to insect, disease, weed,
rodents and birds is about 20-35%. Synthetic pesticides are used by the farmers to control these pests, diseases and weeds. He mentioned that the average consumption of pesticides in Nepal is 142gm/ha. The Government has been emphasizing on the safe and judicious use of pesticides with low mammalian toxicity and pesticide specific to the target pests. He said that there is no pesticide industry and formulation plant at present registered legally in Nepal; pesticides are imported from other countries including India in the form of different formulations like emulsifiable concentrate (EC), wettable powder (WP), dust (DP), granule (GR) which are more in use. The new formulations of pesticides that are relatively safe and environmental friendly like grain bait, encapsulated granule (CG), powder of dry seed treatment (DS), suspension concentrate (SC), suspension liquid (SL) and soluble powder are also available in market. The total import/consumption of the pesticide in 2006 was 131284.5 kg a.i. with the grass sale valued at US$ 1.7 million. He stated that these pesticides are being imported from 7 different countries with the major import from India.

Plant Protection Directorate (PPD) became the focal point of the National Plant Protection Organization after Nepal became the signatory country to IPPC on 8th May 2006. Pesticide Registration and Management Division (PRMD) under the Plant Protection Directorate of Department of Agriculture (DOA) is the organization responsible for pesticide registration and management under the Pesticide Act 1991 and Pesticide Rules 1993. The pesticide, to be registered, needs to be submitted with evidence of foreign registration certificate, original labels of pesticide to be registered, authorized dealership, efficacy data, residue analysis report, ecotoxicological data, summary of intended use in the country, and labels and leaflets in Nepali language, she said. After scrutinizing and taking care for ensuring protection of the environment, human health, animal
and birds, the Certificate is issued for a period of five years on payment of prescribed fee.

He said that Nepal government has endorsed IPM as the main strategy of plant protection which has also been ratified by the long term Agriculture Perspective Plan (APP). Government has formulated policies, different Acts and Rules including Pesticide Act 1990 and Rule 1993 and has adherence to different International Conventions like Stockholm Convention on Persistent Organic Pollutants (POP), Rotterdam Convention on Prior Informed Consent (PIC) and Basal Convention which addresses the management of pesticide in the country. The policies are directed towards promoting the relatively safe less toxic pesticides and also bio-pesticides.

Laboratories with needed facilities have been developed in some public and private institution but a designed laboratory which could analyse and test for pesticide residue and quality control is lacking in the governmental set up. Hence these services are being taken from private organizations like Nepal Environmental and Scientific Services (NESS).

He also presented the status of date expired pesticides. With the introduction of IPM, farmers have started using local herbs and bio-pesticides (microbial and local plant products). Technicians as well as the farmers are exploring the indigenous and traditional technologies and testing them on vegetables, coffee etc which are also grown organically. But their standards vary and yet to follow the standards to be developed by the Ministry of Agriculture and Co-operates with the certification process.

**Philippines**

Ms. Bella Fe Carmona, the nominee of the Government of Philippines, presented the country report. She said that the Fertilizer and Pesticide
Authority (FPA) was created under Presidential Decree as a regulatory agency for pesticides, fertilizers and other agricultural chemicals. The FPA has been established to ensure the availability of vital agricultural inputs such as fertilizers and pesticides and also to regulate their production, distribution, and use for the protection of human health and the environment.

She discussed the FPA regulatory programs including Institutionalized Pesticide Registration and Licensing Procedures, registration of Biorationals, Fast-tracking of Registration of Less Hazardous Products, Licensing Requirements, Import & Export Control, Quality Control of Pesticide Formulations for ensuring quality products to the farming community.

She said that FPA implements quality control programs at various levels viz. Pre-registration, Post-registration Quality Control, Quality Control at the Production Sites, Quality Control on Imported Technical/Finished Products, Quality Control Monitoring at the Dealers' Level:

The FPA, in coordination with other government agencies and private sectors, managed to set-up quite a good quality control program to ensure compliance with set quality control standards. A number of laboratories are now available with capabilities to assist the authority in this endeavor.

She said that there is need of a global effort to take the decisive political action toward environmentally sound management of chemicals to ensure both sustainable human progress and survival due to various disastrous accidents involving pesticides. Following the country commitments in this endeavour, she stated that FPA strongly supported the international initiatives (Prior Informed Consent and The Stockholm Convention on POPs) towards regulating pesticides for health and environmental regions.
Swaziland

Mr. Khumalo presented the country report for Swaziland. He said that Swaziland is a landlocked country with an area of about 17163 square kilometers and has a total population of about 1,141,000 people. The major source of income in Swaziland is agriculture since 80% of the Swazis practice farming. Major crops are maize (a staple food), sugarcane, citrus, cotton, sorghum and groundnut.

With regard to plant protection situation in the country, he said that through a FAO funded project, a pest list has been prepared which would be shared with neighbouring SADC countries namely South Africa, Mozambique, Zambia, Lesotho, Botswana, Zimbabwe, Namibia and Malawi. The Pesticides Management Bill is presently under discussion at the stakeholder level.

He stated that Swaziland has a number of legislation that support agriculture production and safe use of pesticides in an effort to enhance environmental protection. Swaziland is party to a number of international conventions including the Stockholm, Basel and the country is on the process of ratifying the Rotterdam convention. The Rotterdam convention is presently waiting for the approval by parliament. Other legislations include the Plant Control Act of 1981, the Animal Health Act No. 5 of 1969, Swaziland Environmental Act of 1992 with waste regulation of 2000, the Ozone Depleting Substances Regulation, 2003 and the Flora Protection Act No. 10 of 2001 to mention but a few. There is hope that the present parliament will pass the pesticide management bill.

He said that Swaziland does not manufacture any pesticides. All pesticides are imported from the Republic of South Africa. The total annual pesticides import was 23 metric tones in 2005. Because Swaziland
does not manufacture pesticides, there is presently no registration of pesticides in the country. Current practice of the retailers is to obtain trading license and an import permit from the ministry of Enterprise and Department of Veterinary Services respectively. Presently there is no tax on all pesticides imports to Swaziland and there is no regulation of quality, quantity and user of the product as agricultural inputs are exempted from tax. Pesticides, listed in the POPs list under the Stockholm Convention on Persistent Organic Pollutants are still in use in Swaziland and not regulated.

As a small country Swaziland operates three main retailer shops namely Farm Chemical, Swaziland Agricultural Suppliers (SAS) and Khuba Traders. Farm Chemicals is based in Malkems and operates two branches in BigBend and Manzini. Swaziland Agricultural suppliers is one of the oldest pesticides supplier in the country, it is based in Manzini and has a branch in Matata. Lastly, Khubna Traders operates two branches in Manzini and Mbabane. Similar to all countries there are numerous quantities of pesticides that are found on non pesticides retailing shops. There have been formulations brought in through informal import routes whose chemical composition is unknown and usually labeled as broad base pesticide. These also lack toxicological studies. They come labeled in informal packages and the target market being the low income Swazi users. The present national inventory on POPs intends to identify these and their profiles to facilitate their management.

The agro-industry is being revived in the country and there would be an increase in the import and use of pesticides. Bio pesticides are slowly filtrating into the country’s markets with the introduction of organic farming especially in cotton. A Number of organic pesticides are now available on local market outlets. Production these days is market driven, and organic products are in high demand.
He said that Swaziland is presently compiling an inventory of all pesticides and POPs. It is anticipated that there will be addition to the existing obsolete stockpile which were collected in 1998-2000 inventories by DANIDA, presently housed at Ka-Langa Rural Development Area. Swaziland had participated in the African Stock Pile programme to get rid itself of the 88 tones of pesticides currently listed as obsolete. Swaziland is gearing up to the enactment of the Pesticides Management Bill which will enhance the countries capacity in regulating of import, export, use and disposal of pesticides in the country. It has also been proposed, through the bill, the need to establish an office to register pesticides and monitor their use within the country.

Thailand

Ms. Duangrat Wilasinee presented the country paper of Thailand. She said that Thailand is an agricultural based country mainly due to its richness in natural resources and fertile land. Pesticides have been given the status of essential input in increasing agricultural production.

She mentioned that DOA is the responsible government agency for the control of plant protection products and has a policy covering the proper quality of import/or local formulated pesticides, application and disposal of pesticides. The Office of Agricultural Regulation is responsible for Hazardous Substance Act B.E.2535 (1992) to control and regulate import, export and sale of pesticides throughout the country. She explained the three phases of registration system namely Trial clearance, Provisional clearance and Full Registration in the country. Most of pesticides used in Thailand are either formulated from the imported technical grade materials or repacked from imported finish products. At present there are around 439 types of pesticides with more than 25,000 trade pesticides are
registered in the country. Herbicide and insecticides together constitute over 80% of the total consumption in the country.

She said that Government of Thailand has been taking steps to meet the obligations under the Stockholm Convention on POPs which includes the followings besides others:

1. Restricting or limiting use of persistent organic pollutants POPs
2. Monitoring the residue problems of POPs
3. Increasing and restricting the use of POPs that have been used due to the agreement.
4. Management and monitoring POPs originated from industrial system

She said that botanical and biopesticides are pursued both as homemade recipes as well as readymade commercial products. The later is comparable expensive and only higher market want to use them. There are many bio-pesticides in market such as Bt (Bacillus thuringiensis), which is now produced in the Department of Agriculture in Bangkok, Chiangmai and also from private companies. There are two types of Bt in the market, Bt insa releaders and Bt kurstarki.

She mentioned that the environment friendly formulations such as water dispersible granules (WDG), suspension concentrates (SC), are being actively campaigned for increased use in the country.

VIII. TECHNICAL SESSION

The Technical session comprised a series of lectures followed by practical sessions in the laboratories and in the pilot plant. Summary of the various lectures delivered by the experts are presented here.
Pesticide Formulations – An overview

The presentation gave an overview of the pesticide formulations. It compared the conventional formulations vis-a-vis new generation user and environmentally friendly formulations.

Slide 1

PESTICIDE FORMULATIONS
“AN OVERVIEW”

Slide 2

WHAT IS PESTICIDE?

• Any chemical used to directly control pest populations or to prevent or reduce pest damage.

• Pesticides also include plant growth regulators, defoliants, or desiccants.
WHY THEY ARE NEEDED?

- India produced 231 million ton (Rs. 7 trillion worth) of food grains in 2007-08.
- Our food requirement is about 284 million ton by 2020.
- 20% (Rs 1.4 trillion) of its potential food crop is lost every year due to pests and diseases.
- Timely control of pests by pesticides can raise the crop yield by 30%.

PESTICIDE VS FORMULATION

- **Pesticide = Active Ingredient or a.i.**
  - controls the target pest

- **Pesticide Formulations**
  - active ingredient + inert ingredients

WHY FORMULATIONS?

Formulations make an active ingredient -

- more convenient to handle
- safer to applicator
- more accurate to apply and
- more attractive to the pest.
Slide 6

WHAT IS FORMULATION?

Formulation is a physical mixture of pesticide with inert ingredients which can be suitably stored, transported and applied by practical means to achieve effective, safe and economic control of pests.

Slide 7

CHOICE OF FORMULATION

Factors to be considered (from industry’s point of view) –

• Biological effectiveness
• Manufacturing
• Convenient application methods
• Cost

Slide 8

FORMULATION TYPES

• Conventional Formulations
• New Generation Formulations
CONVENTIONAL FORMULATIONS

Formulations which are successfully being used in agricultural and public health sector for long time.

- Dustable Powder (DP)
- Wettable Powder (WP)
- Emulsifiable Concentrate (EC)
- Soluble Concentrate (SL)
- Granular Formulation (GR) (Coated & Impregnated)
- Aerosols Formulation
- Baits Formulation

DUSTABLE POWDERS

Ingredients: Pesticide, Carrier/ Diluents

Advantages
- Economic
- Good stability

Disadvantages
- Inhalation of dust
- Drift downwind
- Application inconvenience

Sulphur 80 WP

WETTABLE POWDER

Ingredient: Pesticide, Diluents/ Carrier, Wetting and Dispersing agents

Advantages
- Economic (production & packaging)
- Easy to handle
- Tolerant to low temperature

Disadvantages
- Product dusty; difficult to measure and mix.
- Active ingredient degradation by inert
- Application inconvenience (sedimentation, low wetting)
- Dust inhalation risk
Slide 12

**EMULSIFIABLE CONCENTRATE**

**Ingredient:** Pesticide, Solvents, Emulsifiers, Stabilizers

**Advantages**
- Easy to produce
- Easy to handle and mix
- High efficacy

**Disadvantages**
- Contain organic solvent
- Expensive to pack and transport
- Sensitive to freezing
- Can cause phytotoxicity
- May be corrosive to metal and plastic
- May be sensitive to water hardness

Cypermethrin 25 EC

Slide 13

**SOLUBLE CONCENTRATE**

**Ingredients:** Pesticide, Water miscible solvent

**Advantages**
- Cheap and easy to produce
- Low volatility
- Low phytotoxicity
- Easy to mix

**Disadvantages**
- Expensive to pack and transport
- Frost sensitive
- Can not contain high active ingredient
- Poor rain fastness
- Poor spreading

Imidacloprid 17.8 SL

Slide 14

**GRANULES (COATED/IMPREGNATED)**

**Ingredient:** Pesticide, carriers
- (river sand/marble hips), Coating agent

**Advantages**
- Easy to handle and pack
- Low drift
- Long residual activity
- Low phytophagous

**Disadvantages**
- May be consumed by non-target organism (especially birds)
- No spray application

Phorate 10 GR
Slide 15

**AEROSOL**

Composition: Pesticide, Propellant, Inhibitors, Fragrances

**Advantages**
- Package is safe and convenient for the user
- Long shelf life under normal condition
- No direct contact with the pesticide
- Few seconds needed for spraying

**Disadvantages**
- Expensive

Slide 16

**BAIT**

Composition: Pesticide, Diluents

**Advantages**
- Entire area need not be covered.
- Control pests that move in and out of an area.

**Disadvantages**
- Can be hazardous to children, pets, domestic animals, and non-target wildlife.
- Pest may prefer the crop or other food to the bait.
- Dead pests may cause odor problems.

Slide 17

**NEW GENERATION FORMULATIONS**

New generation formulations are effective, safer, easier to handle and environment friendly.

- Water Dispersible Granules (WG)
- Suspension Concentrate (SC)
- Concentrated Emulsion (CE)
- Microemulsion (ME)
- Controlled Release Formulation (CR)
- Suspo-emulsion Formulation (SE)
- Tablet Formulation (WT)
- Multiple Emulsion Formulation
Slide 18

**WATER DISPERSIBLE GRANULES**

**Composition:** Active ingredient
- Diluents/Carrier
- Wetting and Dispersing agent

**Advantages**
- Dust free
- Easy packaging
- Easy to handle and measure
- Long shelf-life
- Good dispersibility

**Disadvantages**
- Higher process cost

---

**Thiamethoxam 25 WG**

Slide 19

**SUSPENSION CONCENTRATE**

**Composition:** Active ingredient
- Absorbent/Diluents
- Wetting agent
- Dispersing agent
- Thickener, Antifreezing agent, Antifoaming, Preservatives, Water

**Advantages**
- No solvent
- High concentration of active ingredient
- Easy to mix and storage
- Good bioefficacy

**Disadvantages**
- Setting/Sedimentation on long term storage
- Sensitive to freezing

---

**Carbendazim 50 SC**

Slide 20

**CONCENTRATED EMULSION**

**Composition:** Active ingredient
- Emulsifier
- Solvent/Thickener
- Antifreezing agent
- Anti-foaming agent
- Preservative and Water

**Advantages**
- No skin and eye irritation
- Less or no solvent
- Minimal phytotoxicity
- No flammability

**Disadvantages**
- Time consuming development effort
- Little manufacturing flexibility

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**Butachlor 50EW**
**MICROEMULSION**

Composition: Active ingredient
- No or minimum solvent
- Emulsifier, Co-surfactant

**Advantages**
- Thermodynamically stable
- Good bio-efficacy
- Easy application
- Low flammability

**Disadvantages**
- High emulsifier level
- Lower loading of active

---

**CONTROLLED RELEASE FORMULATION**

Composition: Active ingredient
- Polymer, Surfactant

**Advantages**
- Extend the activity
- Reduce loss and degradation
- Reduce pesticide level in environment
- Reduce phytotoxicity
- Reduce formulation odour

**Disadvantages**
- Long development effort
- Expensive process / inert ingredients

---

**SUSPO-EMULSION**

Composition:
- Insoluble solid (a.i.) as dispersed particle.
- Insoluble liquid (a.i.) as oil droplets, Surfactants
- Water as bulk phase

**Advantages**
- Solid and liquid in a single formulation
- Water based – no organic solvent
- Ready mixed solution
- Possible reduction in skin and eye toxicity

**Disadvantages**
- Difficult and time consuming to develop
TABLET FORMULATION

Composition:
- Active ingredient
- Lubricants
- Binding agent
- Dispersing agent

Advantages
- Easy to use
- Correct dose
- Minimal packaging

Disadvantages
- Long development efforts
- Expensive production equipment
Role of Surfactants in Pesticide Formulations

The paper describes the role of surfactants in pesticide formulations. It describes characteristic features of surfactants. Various categories of surfactants such as anionic, cationic, non-ionic and amphoteric types are discussed in details. Recent advances in surfactant technology are also described.

Slide 1

SURFACTANTS IN AGROCHEMICALS

Slide 2

SURFACTANT

The term derived from SURFace ACTive AgeNT.

“A formulant which reduces the interfacial tension of two boundary surfaces, thereby increasing, spreading, dispersibility and/or wetting properties of liquids or solids.”
A surfactant’s structure has two moieties
- hydrophilic (water – soluble)
- hydrophobic (water – insoluble)
or lipophilic (oil – soluble)

- hydrophilic head

Due to characteristic structures
- surfactants are adsorbed at interphases to form oriented monolayers.
- surfactants in solution aggregate to form micelles.

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**WORKING OF SURFACTANT**

Reduces - Interfacial Tension
Increases -

(I) Wetting Properties
(II) Sticking
(III) Cuticular Penetration
(IV) Absorption by Plants

---

**Emulsification**
Slide 9

**EFFECTS OF SURFACTANT CONC. ON SURFACE TENSION**

Slide 10

**CLASSIFICATION OF SURFACTANTS**

- ANIONIC
- CATIONIC
- NON-IONIC
- AMPHOTERIC

Slide 11

**ANIONIC SURFACTANTS**

- They are by far the largest surfactant class.
- Generally not compatible with cationic (although there are some important exceptions).
- Sensitive to hard water: sensitivity decreases in the order: carboxilate > phosphate > sulphate > sulphonate.

Contd…
Slide 12

- A short polyoxyethylene chain between the anionic group and the hydrocarbon improves salt tolerance considerably.

- A short polyoxyethylene chain between the anionic group and the hydrocarbon improves solubility in organic solvents (but may reduce the rate of biodegradation).

- Sulphates are rapidly hydrolyzed by acids in an automatically process. The other types are stable unless extreme conditions are used.

Slide 13

CLASSIFICATION OF ANIONIC SURFACTANTS

ALKYL ETHERCARBOXALATE

ALKYL SULPHATE

ALKYL ETHERSULPHATE

ALKYL PHOSPHATE

ALKYL ETHERPHOSPHATE  Contd...

Slide 14

DIALKYL BENZENE SULPHONATE

DIALKYL SULFOSUCCINATE
NON-IONIC SURFACTANT

- Second largest surfactant class.
- Normally compatible with all other types of surfactants.
- Not sensitive to hard water.
- Contrary to ionic surfactants, their physico-chemical properties are not markedly affected by electrolytes.
- Physico-chemical properties of ethoxylated compounds are very temperature dependent. Contrary to ionic compounds they become less water soluble-more hydrophobic-at higher temperature. Sugar based non-ionic exhibit the normal temperature dependence i.e. their solubility in water increase with temperature.

CLASSIFICATION OF NON-IONIC SURFACTANTS

FATTY ALCOHOL ETHOXYLATE

ALKYL PHENOL ETHOXYLATE

FATTY ACID ETHOXYLATE

FATTY AMIDE ETHOXILATE

FATTY AMINE ETHOXILATE
Slide 18

ALKYL GLUCOSIDE

SORBITAN ALKANOATE

ETHOXYLATED SORBUTAN ALKONATE

Slide 19

CATIONIC SURFACTANTS

• Not used due to high cost and fish toxicity.

Example – Quaternary ammonium compound

Slide 20

AMPHOTERIC SURFACTANTS

• It contains both acidic and basic hydrophilic group and do not causes any skin or eye irritation.

Example - Amino acids and their derivatives.
NH2CH2-CONHCH(R)COOH
POLYMERIC SURFACTANTS

- Synthesized from polyalkylene glycol, polyol, aliphatic carboxylic acid
  Eg- Atlox-4914 (HLB=6)
- Used for water in oil emulsion

SURFACTANTS IN WATER

Higher surfactant concentration at interface than in the bulk

Formation of structured aggregates in the bulk with decrease in surfactant concentration at interface (CMC)

HYDROPHILIC – LIPOPHILIC BALANCE

- HLB – balance of the size and strength of hydrophilic & lipophilic groups of the emulsifier.
  Range : 1 - 20 (arbitrary scale).
  Hydrophilic surfactants which possess high water solubility & generally act as good solubilizing agents and stabilizers for o/w emulsions have high HLB value.
  Surfactants with low water solubility which act as solubilizers of water in oil and w/o emulsion stabilizers have low HLB value.
Wettable Powder and Granular Formulations

The presentation describes the conventional type wettable powder and granular formulations. It describes the steps for development of formulations and the quality parameters to produce quality product. Paper discusses the test parameters for granular formulation.

Slide 1

WP & GRANULE FORMULATIONS

Slide 2

SELECTION OF FORMULATION

The physical limitations of the active ingredients.
Market needs and competing products.
The status of technology at the time of formulation is developed.
**Slide 3**

**FORMULATION DESIGN INPUTS**

Compound Inputs – Physical, Chemical & Biological properties.

Application Input – Pest, Plant, Equipment, Climatic, Public Health.

Marketing Input – User friendly, Attractiveness, Safety, Durability, Economy.

Manufacturing Input – Prod. Equipment, QC facilities.

---

**Slide 4**

**PESTICIDES**

Solubility in Water

- Insoluble
- Sparingly soluble
- Soluble

Does not form water soluble salt

Forms water soluble salt

Gets hydrolysed

Stable against hydrolysis

- Water insoluble pesticide
- SP (2,4-D- Na Salt)
- SP, WSC
- SP (METHOMYL)

---

**Slide 5**

Water Insoluble Pesticides

Solubility in Hydrocarbon

- Insoluble
- Soluble

m.pt. < 50°C

m.pt. > 50°C

m.pt. > 50°C

m.pt. < 45°C or liquid

- WP
- WP
- WP, EC
- EC, WP
difficult
Slide 6

**STEPS FOR DEVELOPMENT (FORMULATION)**

- Preliminary Studies - Lab preparation
  - Physical & Chemical tests
- Investigational Stage - Bio-efficacy
  - Phytotoxicity
  - Shelf Life
  - Analytical Method Development
  - Small scale field trials
  - Toxicology
- Commercial - Process of Formulation
  - Tank mix compatibility
  - Packaging development

Slide 7

**REQUIREMENTS OF WELL-DESIGNED FORMULATIONS**

- Should be biologically effective when used as recommended with no undesirable side effects.
- Presented in form where active ingredients give max. biological effect at min. cost.
- Should be applicable by chosen means to provide effective and reliable dispersion.
- Large scale manufacture at acceptable cost.
- Should be safe during manufacture, packing, storage and transportation.
- Should have adequate shelf life.
- Should be acceptable to registration authorities and consumer.

Slide 8

**WETTABLE POWDER**

Is defined as a pesticide in a dry form with surfactant, often mixed with, or coated on, a fine solid carrier for dispersion in water to form a suspension. (GIFAP 1989).
ROLE OF SURFACTANT

1. Wetting results by the addition of surfactant which lowers the surface tension till the minima at some conc. (known as cmc ). Further increase in surfactant conc. results in no change in surface tension and instead forms aggregates.

2. Dispersion results by the addition of surfactant till it reaches the conc. level. The surfactant absorbs at the interface and provides stability to the dispersed particles by stearic and electrostatic repulsions.

SURFACTANT

1. ANIONIC
   Major part contains net –ve charge
   a) CARBOXYLATES – (RCOO⁻) (M⁺)
      soaps & Amino carboxylates
   b) SULFONATES - RSO₃M
   c) LAS
   d) Lignosulfonates – do not reduce surface tension at low conc.
   e) DOSS – Susc. to acid/alk., sensitive to oxi.
   f) N-acyl-N-alkyl-Taurates – Stable to acidic/alk.
      Strong detergent/strong wetting. BIODEGRADABLE.
   g) B-Sulfo esters – Unaffected by hard water but sens. to hydrolysis.
   h) AOS – Less toxic, biodegradable better than LAS.

SULFATES

Sulphated Alcohols – SLS – Stable to hard water but sensitive to aci./alk.

Sulfated alkanolamides – Lauryl ethanolamide – good foaming

Ethoxylated sulphated alkyl phenols – wetting & foaming

Phosphate Esters – alkyl orthophosphates
2. NON-IONIC

- Polyoxylethylene – 20-40% as defoamer, oil soluble detergent.
- Ethoxylated alkyl phenols – (C_{12}-C_{18} oleyl, lauryl, etc.)
- Carboxylic Esters – Glycerol esters, PEG esters low foaming but hyd. aci./alk.
- Carboxylic Amides – Cocomo & cocodi foam stabilizers & detergents

3. CATIONIC

- Amine Oxides – foam builders, wetting agent.
- Imidazolines – Wetting, dispersion, corrosion inhibitors.

4. AMPHOTERICS

- Cationic & anionic depending on pH
  \[ C_{12}H_{25}N^{+}(CH_{3})_{2}COO^- \]
EMULSOL FOR EC/SL/EW/ME

- Emulsol 4000:5000  General pair
- Emulsol 371A:371M:371M
- Emulsol 36:45
- Emulsol KIL 06A:06N  Fenvalerate
- Emulsol SPA:SPN  Lamdacyhalothrin
- Emulsol TZA:TZN  Triazophos
- Emulsol T210A:11N
- Emulsol T2AKR:TZNKR
- Emulsol HCA:HCN/22A:22N  Hexaconazol
- Emulsol ETA:ETN  Ethion
- Emulsol PRA:PRN/PTA:PTN  Pretilachlor
- Emulsol PPA:PPN  Propanil
- Emulsol PQT  Paraquat
- Emulsol CCA:CCN  Cypp +CPP
- Emulsol 2,4Dx:2,4Dx  2,4 D Ethyl ester
- Emulsol PPT-3A/PPT-4N  Prponil+Triclopyer
- Emulsol 48A:48M  CPP
- Emulsol 3522:7066L  Lindane
- Emulsol DLX A: DLX N  Deltamethrin
- Emulsol BUTA A :BUTA N  Butachlor
- Emulsol GL07  Glyphosate
- Emulsol IMD 7000  Imida
- Emulsol 2040 M  Monocrotophos
- Emulsol PM 21A:21N  Pendimethlin
- Emulsol 3522 DF : 3144 DF  Dicofol
- Emulsol MAL A :MAL N  Malathion
- Emulsol MP A : MP N  Methyl parathion
- Emulsol 2240 : 2162  Endosulphan, CPP
- Emulsol 99/WT/WT  Hexa , Imida SC
- Emulsol NB  Nitrobenzene EW
- Emulsol B 25  Buta EW
- Emulsol ME 100  Cyper ME

RECEIPE DESIGN

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Solid a.i.</th>
<th>Waxy a.i.</th>
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</thead>
<tbody>
<tr>
<td>Active</td>
<td>up to 90%</td>
<td>up to 50%</td>
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<tr>
<td>Wetting</td>
<td>1-5%</td>
<td>1-55</td>
</tr>
<tr>
<td>Dispersing</td>
<td>3-10%</td>
<td>3-10%</td>
</tr>
<tr>
<td>Stabilizer,etc</td>
<td>0-5%</td>
<td>0-5%</td>
</tr>
<tr>
<td>Silica</td>
<td>0-15%</td>
<td>up to 40%</td>
</tr>
<tr>
<td>Filler</td>
<td>q.s.</td>
<td>q.s.</td>
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Slide 18

<table>
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<tr>
<th>MILL SELECTION</th>
<th>Type of mill</th>
<th>Av fineness</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Raymond</td>
<td>40 micron</td>
<td>gets heated</td>
<td></td>
</tr>
<tr>
<td>Micro pulverizer</td>
<td>30 micron</td>
<td>gets heated</td>
<td></td>
</tr>
<tr>
<td>ACM</td>
<td>20 micron</td>
<td>gets heated</td>
<td></td>
</tr>
<tr>
<td>Air jet mill</td>
<td>&lt; 10 micron</td>
<td>suitable for</td>
<td>heat</td>
</tr>
</tbody>
</table>

Slide 19

PRECAUTIONS IN GRINDING

- Softer materials are converted to smaller particles more rapidly than harder ones.
- **MOISTURE CONTENT**
  - Increase in moisture content - Most common as surface contact area increases.
  - Decrease in moisture content - Water present in form of hydrates - cavities rupture and exposes water to evaporate.
- **ABRASION OF GRINDING SURFACE**
  - Mechanical wear contaminations.
- **ALTERATION OF SAMPLE COMPOSITION**
  - Grinding heat may loose volatile components.
- **CAKING**
  - Due to moisture, heat, accumulation of static charge and fusion of particles under pressure.

Slide 20

PROCESS FLOW

FILLER - SURFACTANT - STABILIZER

PRE MIXER - PULVERISER - CYCLONE SEPARATOR

LAB SAMPLE - PACKAGING - FINE DUST COLLECTOR

DESPATCH
Slide 21

**CHARACTERISTICS**
* Quick wetting
* Complete dispensability
* Suspension stability
* Low foaming
* No caking during storage
* Chemical stability of active ingredient
* Compatibility with other products in tank mixes.
* Correct fineness, adhesivity and resistance to weather conditions.
* Chemical compatibility with water soluble sachets.

Slide 22

**QUALITY PARAMETERS**
1. Description
2. Active Ingredient
3. Acidity/Alkalinity
4. Particle Size
5. Wettability
6. Suspensibility
7. Persistent foam

Slide 23

**GRANULE FORMULATION**
Solid formulation comprising particles of defined size > 80 µm diameter, for application without further dilution, usually to soil.

(IUPAC – 1998)

A free flowing solid formulation of defined granule size range ready for use

(FAO – 1999)
Granules consist of an active ingredient extended on a carrier and then transformed into granules of 4-80 mesh size, with or without a binder. These can also be prepared by impregnating or coating the active ingredient on the pre-fabricated blank granules. The concentration of active ingredient in granules varies from 1 – 40% depending upon nature of active ingredients and carrier. It depend on factors such as the potency of insecticides, pest to be controlled, release rate of active ingredient mode and rate of application etc.

COMPONENTS OF GRANULE FORMULATION

1. Blank Granules
2. Toxicant
3. Deactivator / Stabilizer / Surfactant

GRANULE FORMULATION (WHY)

1. Pesticide action is required through soil in standing crop.
3. Convenience of application Ease of handling & safety.
4. Particle size 250 μm to 10 mm Dust free, free flowing.
5. Cheaper & disposable packing can be used.
Slide 27

**TEST METHOD FOR KEY REQUIREMENTS OF GRANULES**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Test Method</th>
<th>CIPAC</th>
<th>BIS</th>
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<tbody>
<tr>
<td>Active Ingredient</td>
<td>As per Specification for a given pesticide</td>
<td></td>
<td>As per specification for a given pesticides</td>
</tr>
<tr>
<td>Acidity / Alkalinity</td>
<td>MT – 31</td>
<td></td>
<td>11.3 of IS 6940 (1982)</td>
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<tr>
<td>Ph Range</td>
<td>MT – 75</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Sieve (1982)</td>
<td>MT – 58.3</td>
<td></td>
<td>12.1.2.2 of IS 6940</td>
</tr>
<tr>
<td>Dust Formation Description</td>
<td>MT – 171</td>
<td></td>
<td>2.2.1 of IS 11009 (1984)</td>
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</table>

Slide 28

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Test Method</th>
<th>CIPAC</th>
<th>BIS</th>
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</thead>
<tbody>
<tr>
<td>Storage Stability</td>
<td>MT – 46</td>
<td></td>
<td>2.2.4 of IS 11009 (1984)</td>
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<tr>
<td>Attrition resistance</td>
<td>MT – 178</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

Slide 29

**TYPICAL PROPERTIES OF BLANK GRANULES FROM COMMON MATERIALS**

<table>
<thead>
<tr>
<th>Property</th>
<th>Sand</th>
<th>Bentonite</th>
<th>Gypsum</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Cont. Max (% m/m)</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Bulk density g/m</td>
<td>1.4-1.7</td>
<td>0.8 – 1.2</td>
<td>0.9 – 1.2</td>
<td>0.6 – 1.0</td>
</tr>
<tr>
<td>Acidity as H₂SO₄ (% m/m)</td>
<td>-</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Liquid Holding Cap (% m/m)</td>
<td>-</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Material Passing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Through 2mm sieve</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>250 mm sieve</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>75 mm sieve</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Emulsifiable Concentrates

The paper describes importance of surfactant in emulsifiable concentrate formulation. It discusses the various emulsifiers used in the agro-industry. Various properties of EC formulation like emulsification, storage stability are discussed in details.

Slide 1

<table>
<thead>
<tr>
<th>REGION</th>
<th>INSECT</th>
<th>DISEASE</th>
<th>WEEDS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRICA</td>
<td>13.0</td>
<td>12.9</td>
<td>15.7</td>
<td>41.6</td>
</tr>
<tr>
<td>ASIA</td>
<td>20.7</td>
<td>11.3</td>
<td>11.3</td>
<td>43.3</td>
</tr>
<tr>
<td>N. AMERICA</td>
<td>9.4</td>
<td>11.3</td>
<td>8.0</td>
<td>28.7</td>
</tr>
<tr>
<td>CHINA + USSR</td>
<td>10.5</td>
<td>9.1</td>
<td>10.1</td>
<td>29.7</td>
</tr>
<tr>
<td>S. AMERICA</td>
<td>10.1</td>
<td>15.2</td>
<td>7.8</td>
<td>33.0</td>
</tr>
<tr>
<td>EUROPE</td>
<td>5.1</td>
<td>13.1</td>
<td>6.8</td>
<td>25.0</td>
</tr>
<tr>
<td>OCEANIA</td>
<td>7.1</td>
<td>12.6</td>
<td>8.3</td>
<td>27.9</td>
</tr>
<tr>
<td>WORLD</td>
<td>12.3</td>
<td>11.8</td>
<td>9.7</td>
<td>33.8</td>
</tr>
</tbody>
</table>
Slide 3

**TYPES OF AGRO FORMULATIONS**

- Water Soluble Concentrates
- Emulsifiable Concentrates
- Wettable Powders
- Microemulsions
- Suspension Concentrates
- Aqueous Flowables

Slide 4

**Which formulation ???**

**SELECTION or DESIGN OF FORMULATION**

**New or Generic** –
New -- Own R&D by large multinational (patented)
Generic – A lot help from IPFT and other supplier of emulsifiers

Active ingredients properties - Physical, Chemical & Biological properties.
Market needs
competing products
Manufacturing Input

Slide 5

**PESTICIDES**

Solubility in Water

- Insoluble
- Sparingly soluble
- Soluble

- Does not form water soluble salt
- Forms water soluble salt
- Gets hydrolysed
- Stable against hydrolysis

- Water insoluble pesticide
- SP (2,4-D- Na Salt)
- SP, WSC
- SL
Slide 6

**Water Insoluble Pesticides**

- Solubility in Hydrocarbon
  - Insoluble
    - m.pt. < 50°C
    - WP
  - Soluble
    - m.pt. > 50°C
    - WP
    - m.pt. > 50°C or liquid
    - WP, EC
    - EC, WP difficult

Slide 7

**EMULSIFIABLE CONCENTRATE**

A liquid, homogeneous preparation to be applied as an emulsion after dilution in water. *(GIFAP )*  

**ADVANTAGES**
- Low cost of production.
- Very simple technology.
- Often better biological activity.

**DISADVANTAGES**
- High amount of solvent.
- Often low flash point.
- Dermal activity.
- Packaging disposal.

Slide 8

**Pesticide Formulation: Emulsifiable Concentrate (EC)**

- Soln. of pesticide in aromatic solvent with surfactant
- Forms emulsion with water
- Emulsifies due to interfacial effects by the surfactants
  - Easy to develop and manufacture
  - Self-emulsification due to surfactants is the key feature of Emulsifiable concentrates
EC FORMULATION

General composition:
- Active ingredient
- Solvents – Co solvents
- Emulsifiers
- Stabilizers, stickers, antifoams, etc.

EC FORMULATION – manufacturing process
- Mix the Active ingredient and the Solvents (Co solvents if required)
- Add the required amount of Emulsifiers. And other performance improving chemicals (like Stabilisers, stickers, antifoams, etc.)
- Check for Quality parameters

LOOKED -- MUCH SIMPLER ????
CAUTION : THY DROWN over confident of swimming

EC FORMULATION – manufacturing process
- Machinery Required
  - Mixing Vessels
  - Agitator
  - Filter
  - Filling machine
  - QA Laboratory
• **Properties of the AI**

  Consistent quality
  Regular supply
  Soluble in aromatic solvent
  Stable over period of time

• **Properties of the Solvent**

  • Should be able to solublize the AI
  • NON-toxic
  • High flash point (closed cup Flash point apparatus)
  • Consistent quality (check by GC graph, boiling range method)
  • Regular supply
  • Cost effective
  Example – Reliance, IPCL (India), EXXON
  AROMAX, HA, Mixed Xylene, NMP DMSO, Solvesso

• **Properties of the Co-Solvent**

  • Helps in better solvancy
  • Regular supply
  • Cost effective
  • High flash point (closed cup Flash point apparatus)
  • Consistent quality (check by GC graph, boiling range method)
  • Example – IPA, n butanol etc
Slide 15

- **Properties/selection of the Emulsifiers**

- Very important ingredient
- Generally supplied by suppliers
- For best choice by formulator chemist, one should know basics of emulsifiers and its effect on the ECs
- Thump rule combination of anionic and non-ionic.

Slide 16

**Emulsifiable Concentrates: How It Works?**

CASE - I
- Blank Drop with No Surfactant
- cmc ~ 10^{-7} g/cm^2
- Surfactant solution
- Surfactant at interface
- Slow diffusion of pesticide without any bloom
- No self emulsification

CASE - II
- EC Drop with 8 x 10^{-3} g/cm^2 Surfactant solution
- Water
- Surfactant at interface above cmc
- Instant Diffusion
- High surfactant conc. at interface during addition of EC to water results in self emulsification

Assumptions:
- Surfactant Mwt = 350 and area 50 A^2
- Surfactant CMC = 10^{-7} g/cm^2
- 0.004 g of surfactant in 0.04 cm^3 or 0.5 cm^2 area of EC means 8 x 10^{-3} g/cm^2 of surfactant at interface

Slide 17

**SCREENING OF SUITABLE EMULSIFIER**

If a water insoluble compound in organic solvent is added to an aq. soln. of a surfactant there is possibility of:

**OIL IN WATER EMULSION**

Oil phase dispersed as globules in continuous water phase. System is opaque and white. Unstable on standing. High electrical conductivity.

**WATER IN OIL EMULSION**

Water phase dispersed as globules in continuous oil phase. System is opaque and white. Unstable on standing. Low electrical conductivity.

**MICROEMULSION**

Oil dissolves or disappears in the aq. solution. Transparent solution. System is stable & do not separate on standing. High electrical conductivity.
HLB NO. | APPEARANCE ON ADDING TO WATER
---|---
1 -- 4 | INSOLUBLE
4 -- 7 | POOR DISPERSION UNSTABLE
7 -- 9 | STABLE OPAQUE DISPERSION
10 – 13 | HAZY SOLUTION
13 – 20 | CLEAR SOLUTION

FOR NON IONIC SURFACTANTS

HLB = HYDROXYL VALUE / 5

---

**Emulsifiable Concentrates: Surfactants and Effects**

<table>
<thead>
<tr>
<th>Surfactant</th>
<th>Chemistry</th>
<th>Nature</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Alkyl Benzene Sulphonate (CABS)</td>
<td>C₅₋₆H₄(--SO₃)Ca⁺⁺</td>
<td>Anionic</td>
<td>Blooming + Thickens + Glass Wetting</td>
</tr>
<tr>
<td>Ethoxylates:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* NF – nEO</td>
<td>C₅₋₆H₄(--O–[C₈H₃O₃]–nH)</td>
<td>Nonionic</td>
<td>Low interfacial tension + Dispersion</td>
</tr>
<tr>
<td>* Castor Oil – nEO</td>
<td>R–CH₂OOCR₁(OC₂H₄O)n–OH</td>
<td>Nonionic</td>
<td>Self emulsification + Hardness tolerance + Stability</td>
</tr>
<tr>
<td>* Fatty Alcohol-nEO</td>
<td></td>
<td>Nonionic</td>
<td>Good shelf life</td>
</tr>
</tbody>
</table>

- Combinations demonstrate synergistic performance
- Binary system of emulsifiers having synergistic mixtures are used for ECs

---

**Emulsifiers Used in Agrochemicals**

**Emulsifiers with Low HLB**
- **Anionic**: CaDBS
- **Nonionic**: Alkyl Phenols with 3 – 6 EO
  - Fatty Alcohols with 2 – 5 EO

**Emulsifiers with High HLB**
- **Anionic**: NaDBS (or Amine Salt)
  - Soap
- **Nonionic**: Alkyl Phenols with 8 – 30 EO
  - Castor Oil with 20 – 60 EO
To evaluate a 2-component ("matched pair") system requires 11 blends.
Each point represents a unique blend of "A" and "B".

Three-Component (A + B + C) Evaluation
- Builds upon single- and two-component blending

1. A
2. A
3. B

- The "A" in line #1 is the same as the "A" in line #2
- The "B" in line #1 is the same as the "B" in line #3
- The "C" in line #2 is the same as the "C" in line #3
- Overlapping what is the same forms a:
Each ratio of A : B : C can be assigned a number that reflects its unique composition:

Evaluate the "10 primary screening points" to identify region of performance:

- Type of nonionics play major role
- Solvent change leads to ratio shift
### Parameters For Evaluation Of ECs

<table>
<thead>
<tr>
<th>Effects</th>
<th>Definition</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersion</td>
<td>Spreading of droplet of EC on contact with water.</td>
<td>• Take one drop of EC and put in 98ml of 342 ppm hard water. Check the movement of droplets in water.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Take one drop of EC and leave it from middle of water in the cylinder in 98ml of 342 ppm hard water. Check the movement of droplets in water.</td>
</tr>
<tr>
<td>Blooming</td>
<td>Intense turbulence in the water with formation of thick fine clouds on addition of EC.</td>
<td>Take 2 ml of EC and put in 98ml of 343 ppm hard water.</td>
</tr>
<tr>
<td>Glasswetting (GW)</td>
<td>The emulsion sticking on the glass surface.</td>
<td>Shake the emulsion well in the 100ml cylinder and observe whether the emulsion stick on the glass.</td>
</tr>
</tbody>
</table>

**Slide 29**

### Parameters For Evaluation Of ECs

<table>
<thead>
<tr>
<th>Effects</th>
<th>Definition</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of hardness</td>
<td>Changing water hardness affect the surfactant</td>
<td>2ml of EC put in 98ml of water and performance is observed for the characteristics of emulsion</td>
</tr>
<tr>
<td>Creaming / Sediment</td>
<td>The separation in the emulsion may appear after certain period of time if right ratio is not chosen or if the surfactant is either low dosage or not right quality</td>
<td>Separation can be observed after making the emulsion till after 24 hours. The volume of sediment or cream is noted.</td>
</tr>
</tbody>
</table>

- Creaming: if separation appear on the top.  
- Sediment: if separation appears in the bottom.

*Above parameters help in determining the shelf-life of ECs*
### Slide 30

**Emulsifiable Concentrate: Quality Criteria**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Significance</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Emulsion</td>
<td>Quality &amp; Ratio of Emulsifier</td>
<td>Drops of thick emulsion stick well on the surface &amp; fall slowly</td>
</tr>
<tr>
<td>Emulsion Stability</td>
<td>Creaming / Sedimentation</td>
<td>No Creaming / formation of layer at the surface No sedimentation at bottom</td>
</tr>
<tr>
<td>Cold test</td>
<td>Suitability for usages</td>
<td>No solidification or sedimentation at low temperature</td>
</tr>
</tbody>
</table>

### Slide 31

**Emulsifiable Concentrate: Quality Criteria**

<table>
<thead>
<tr>
<th>Effects</th>
<th>Definition</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue opalescence</td>
<td>Light passing through the wet glass surface appears blue opalescent</td>
<td>Take 2ml of EC in 98ml of hard water of 342 ppm and shake it properly in the cylinder and observe the bluishness on the surface of the glass</td>
</tr>
<tr>
<td>Thickness</td>
<td>Thick milky emulsion</td>
<td>Thickness is observed visually by shaking the emulsion and observing the fall of emulsion droplet on the sides of cylinder. Drops of thick emulsion stick well on the surface and fall slowly.</td>
</tr>
<tr>
<td>No. of ratios</td>
<td>Number of combinations of two components emulsification</td>
<td>EC of the two emulsifiers with same dosage are mixed in ratio from 0:100 to 100:0 and performance checked</td>
</tr>
</tbody>
</table>

### Slide 32

**Problems in EC formulation**

- Crystallization
- Gelling
- AI degradation
- Emulsion break or unstable
Slide 33

QUALITY CONTROL METHODS

The specifications of the ECs that one must look for:
- Local countries specifications (in India BIS)
- Customers specification
- CIPAC
- FAO/WHO

Slide 34

CONTROL METHODS

The specifications that EC must comply are:
- 1. GENERAL DESCRIPTION
  - clear solution without suspended matter, sediment or crystals

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CONTROL METHODS

The specifications:
- 2. STABILITY
  - Active ingredient content stable over the shelf life
    - Below 10%
    - Between 10 to 50%
    - Above 50%
CONTROL METHODS
The specifications

3. Emulsion stability and re-emulsification (CIPAC 1 – MT 36)
   - 1 Hrs (in India)
   - 2 hrs, 24 hrs, and 24,5 hrs in CIPAC

CONTROL METHODS
The specifications

4. pH (CIPAC 1 – MT 75)

CONTROL METHODS
The specifications

5. Flash point
This is to ascertain the fire hazard from the formulation while in storage and transport
CONTROL METHODS

The specifications

> **6. Storage :**
  
  **Low temp. stability**
  - At 10 degree C for 1 Hr (in India)
  - At 0 degree C for 7 days (CIPAC 1 – MT 39)

  **High temp. stability**
  - At 54 deg C for 14 day (CIPAC 1 – MT 46.1.3)

Better performances can be achieved with components of changeable physico – chemical characteristics, water with different hardness and temperature, by balancing the ratios of the emulsifiers.

---

Conclusions

For an EC with long shelf-life and excellent performance:

- Ensure proper selection of: a) Solvent, b) Emulsifier
- Ensure right dosage of emulsifier
- Ensure consistent quality of all ingredients specially solvent
- Quality control at all level, RM, In process and final good
- No contamination during manufacturing

Development of Emulsifiable Concentrate is a science and not an art.
Concentrated Emulsions and Micro-emulsions

The paper describes the advantages of this type of latest variety of formulations. The method of preparation of such type of formulations was discussed. Use of micro-emulsion in agriculture was discussed.

Slide 1

Concentrated Emulsions and Microemulsions

Slide 2

Water Based Pesticide Formulations

- Suspension Concentrates
- Capsulated Suspensions
- Concentrated Emulsions
- Multiple Emulsions
- Microemulsions
PREPARATION OF CONCENTRATED EMULSIONS

LIQUID PESTICIDE CONTAINING LOW-HLB-EMULSIFIER

ADDED WITH VIGOROUS STIRRING TO WATER CONTAINING HIGH HLB-EMULSIFIER

\[ W = Y_1,2 \times \Delta S \]

WHERE

- \( W \) IS THE WORK DONE
- \( Y_1,2 \) IS THE INTERFACIAL TENSION BETWEEN THE TWO PHASES.
- \( \Delta S \) IS THE CHANGE IN SURFACE AREA

COMPOSITION

<table>
<thead>
<tr>
<th>EC</th>
<th>EW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticides tech.-50%</td>
<td>Tech-50%</td>
</tr>
<tr>
<td>Organic Solvent-44%</td>
<td>Water-44%</td>
</tr>
<tr>
<td>Emulsifier/Surfactant-6%</td>
<td>Emulsifier/Surfactant-6%</td>
</tr>
</tbody>
</table>

Slide 4

- INTERNAL AREA IS GREATLY INCREASED.
- INTERFACIAL FREE ENERGY OF THE SYSTEM WILL INCREASE AND OPPOSE THE PROCESS OF BREAKDOWN OF BIGGER PARTICLES INTO SMALLER ONES.
- AT THE SAME TIME ENTROPY OF THE SYSTEM INCREASES AND IT WILL FACILITATE THE BREAKDOWN PROCESS BUT ITS VALUE IS RELATIVELY SMALL AS COMPARED TO INTERFACIAL FREE ENERGY.

FROM THE SECOND LAW OF THERMODYNAMICS,

The free energy of formation of smaller particles

\[ \Delta G_{\text{Form}} = \Delta A Y_{1,2} \gg -T \Delta S \]

Therefore,

\[ \Delta G_{\text{Form}} \] is Larger and Positive.

HERE THE PROCESS OF EMULSIFICATION OR COMMINUTION IS NONSPONTANEOUS AND HENCE WITH THE TIME THE DROPLETS AND PARTICLES TEND TO AGGREGATE AND/OR

Slide 5

**Creaming**
Slide 6

Sedimentation

Slide 7

Coalescence

Slide 8

Flocculation
Slide 9

Ostwal Ripining

Slide 10

Phase Inversion

Slide 11

C_{12}H_{25}-C_{6}H_{5}-SO_{3}Na
SODIUM DODECYL BENZENE SULPHONATE
Slide 12

I. CONCENTRATION

HYDROPHILIC

HYDROPHOBIC

OIL

WATER

Typical Non-Ionic Type

C_{18}H_{37}(CH_{2}CH_{2}O)_{n}H

Ethoxylated Nonyl Phenol

Typical Anionic Type

C_{12}H_{25}SO_{3}^{-}Na^{+}

Sodium Dodecyl Benzene Sulfonate

Interface

C.M.C

Slide 13

A microemulsion is thermodynamically stable, isotropically clear dispersion of two immiscible liquids, consisting of microdomains of one or both liquids stabilized by an interfacial film of surface active molecules.

• Thermodynamically stable.
• Pure systems appear isotropic, clear, translucent, low viscosity.
• Oil + water + surfactant (+ cosurfactant).
• Surfactant and cosurfactant have greatly dissimilar chain length.
• Their formation is independent of the order of mixing of components.
• Droplets diameter 100~1000Å. Less than 1/4th of the wavelength of light.

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Conditions for Formulation of Microemulsions

- Large adsorption of an emulsifier (E) or emulsifier/co-emulsifier (CE) mixture at the O/W interface – Right choice of E or E/CE mixture with proper HLB
- High fluidity of the interface – A proper co-emulsifier or an optimum temperature
- Optimum curvature – Oil penetration in the E/CE interface
Coemulsifier-free W/O Microemulsions

Conditions for formation

- Near equal partitioning of emulsifier between the liquid phases
- Maximum linear extension of hydrophobic or hydrophilic end of the molecule or both
- Fluid interfacial film
- Hydrocarbon volume (V), effective chain length (L) and head group size (h) should satisfy the conditions for formation of microemulsion systems.

Optimum curvature, Ro = Radius of Sponatnous Curvatures.
Critical Packing Parameter

The critical packing parameter (CPP) can be calculated as follows:

\[ \text{CPP} = \frac{v}{a \cdot l} \]

Where \( v \) is the partial molar volume of the hydrophobic portion of the surfactant; \( a \) is the optimal head group area; and \( l \) is the extended surfactant chain length.

Effect of solution conditions on the head group size.

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Slide 20

• When the head group of surfactant is of greater volume than its hydrophobic tail, O/W micelles will invariably form in the presence of oil.

• Whereas surfactants with head groups of smaller volume than their hydrophobic tails will form W/O micelles in the presence of oil.

• When the volumes of head group and surfactant chains are similar, bi-layer structures are favored.
• A decrease in the effective head group area of ionic surfactant will occur on increasing ionic strength, due to the shrinking of the double layer and the screening of the head groups. Similarly, the addition of hydrophilic molecules such as glycerol and sorbitol influence optimal head group in the aqueous phase.

• Generally, w/o microemulsion can be formed with a low HLB range of 3-8.
The volume of microemulsion generated per weight of surfactant added to an oil/water mixture is commonly described as the surfactant “efficiency.”

The surfactant efficiency can be influenced by:
(i) Surfactant type
(ii) Molecular weight
(iii) Temperature
(iv) Host formulation variables

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Slide 26
Slide 27

**Microemulsions**

- 10-1000 A^2
- Clear
- Thermodynamically Stable
- High interfacial surface area
- Form spontaneously
- Low interfacial tension
- High emulsifier level
- Superior biological efficacy
- High tolerance for electrolytes
- Sequence of ingredients is not important
- Can be prepared from MEC by dilution with water or can be presented as a stable prediluted formulation

**Macroemulsions**

- >1 µ
- Milky white
- Kinetically stable
- Low interfacial surface area
- High mixing energy
- High interfacial tension
- Low emulsifier level
- Good to excellent biological efficacy
- Low tolerance for electrolytes, unless specific anionics are used
- Sequence of ingredient is important
- Prepared from Ecs by dilution with water just prior to use

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Phase Transition from Oil-in-Water to Water-in-Oil Microemulsion via Middle Phase Microemulsion

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The transition of the microemulsion from lower-to middle-to upper phase microemulsion can be experimentally observed by changing any of the following parameters:

- Increasing salinity
- Decreasing oil chain length
- Increasing alcohol concentration
- Decreasing temperature for anionic surfactant
- Increasing total surfactant concentration
- Increasing brine/oil ratio
- Increasing molecular weight of surfactant
Microemulsion: Characteristics

- Ultra-Low Interfacial Tension
- Large interfacial area
- Large solubilizing capacity
- Unaffected by the destabilization mechanisms (creaming, flocculation and coalescence)
- Thermodynamic stability means that they are formed only in specific ranges of T, P and composition
- Pesticide Formulations does not have a complete freedom in system design.

Characterization of microemulsion system:

- Viscosity
- Conductivity
- Interfacial tension
- Laser scattering
- N.M.R.
- I.R.
- Neutron scattering

Characterization of microemulsion

<table>
<thead>
<tr>
<th>Properties</th>
<th>Characteristics of ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical appearance</td>
<td>Clear, Transparent may be viscous liquid</td>
</tr>
<tr>
<td>Oil/Water (oil-in-water)</td>
<td>Properties of OW microemulsion (aqueous based) when diluted with water remain clear and transparent. Any microemulsion when diluted with dispersed/bulk medium remains clear/transparent.</td>
</tr>
<tr>
<td>Solubilization of water insoluble materials</td>
<td>The system (surfactants aggregated system) is not a normal aqueous system but it contains droplets (micelles/microemulsion droplet) having hydrophobic cavity which can solubilized water insoluble materials.</td>
</tr>
<tr>
<td>Thermal Stability</td>
<td>Stability range of clear microemulsion. Below and above the specified temperature range it becomes turbid i.e., microemulsion.</td>
</tr>
<tr>
<td>Droplet size</td>
<td>10—1000 Å</td>
</tr>
</tbody>
</table>
Advantages of Microemulsions

- Transparent quality: helpful in developing clear, transparent pesticides formulations.
- Small drop size:
  - Provide excellent contact between the pesticide and aqueous phase- advantageous in solubilization
  - play a role in pesticide release
  - Solubilization: protect solubilized components from unwanted degradative reactions
  - Super stability: an added benefit during processing and storage
  - Ability to incorporate solutes within the dispersed droplets: reaction/ extraction media.

ADVANTAGE OF MICROEMULSION FORMULATIONS

- THEMODYNAMICALLY STABLE.
- VERY LOW PARTICLE SIZE SO BETTER BIOEFFICACY.
- HIGH FLASH POINT.
- DOSES CAN BE REDUCED.
- HIGH FLASH POINT.
- FORM SPONTANEOUSLY, NO MECHANICAL ENERGY IS REQUIRED FOR THEIR FORMATION

DISADVANTAGE OF MICROEMULSION FORMULATION

- HIGHER AMOUNT OF SURFACTANT USED.
- LOADING OF A.I CONTENT IS LESS
Suspension Concentrates

The paper discussed the industrial scope of suspension concentrates and its advantage in agrochemical sector. The requirements, selection of surfactant, method of preparation and instrument/machinery required in the manufacture of suspension concentrates were discussed in the paper.

Slide 1

SUSPENSION CONCENTRATES

Slide 2

A safe & effective pesticide formulation

- Good Bioefficacy with minimum a.i.
- Minimum exposure hazard
- Minimum use of solvents
Slide 3

SUSPENSION CONCENTRATES (SC)

- Popularly known as flowables
- Good Bioefficacy
- Solvent free
- Easy to dilute and spray

Slide 4

SUSPENSION CONCENTRATES

Definition
Stable dispersion of micronised active ingredient in a liquid medium.

Application
Sprayed on target site after dilution

Slide 5

TYPES OF SUSPENSION CONCENTRATES

OIL FLOWABLE
If the dispersion medium is oil (Mineral / Vegetable)

AQUEOUS FLOWABLE
If the dispersion medium is water
(More commonly used)
ADVANTAGES

• Dust free
• Solvent free
• Easy to handle
• Excellent spray tank dilution
• Good bio-efficacy
• better adhesion & penetration on target

SELECTION OF A.I.

• Technical material in solid form
  (m.p. above 60° – 70°)
• Water Insoluble (Solubility < 200ppm)
• Hydrolytically Stable

Examples: sulphur, thiram, isoprouton, atrazine, hexaconazole

COMPOSITION OF S.C

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Ingredient</td>
<td>5-50</td>
</tr>
<tr>
<td>Wetting Agent</td>
<td>1-2</td>
</tr>
<tr>
<td>Dispersing Agent</td>
<td>3-6</td>
</tr>
<tr>
<td>Anti freezing (Glycols)</td>
<td>5-10</td>
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<tr>
<td>Thickeners</td>
<td>0.05-0.5</td>
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<tr>
<td>Water</td>
<td>q.s.</td>
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</table>
INERT INGREDIENTS

<table>
<thead>
<tr>
<th>INGREDIENT</th>
<th>TYPE</th>
<th>FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetting agent</td>
<td>Ethoxylated nonyl phenols, alkyl</td>
<td>Rapid wetting of the new formed surface during milling.</td>
</tr>
<tr>
<td></td>
<td>naphthalene sulfonates</td>
<td></td>
</tr>
<tr>
<td>Dispersing agent</td>
<td>Naphthalene sulfonates, Lignin</td>
<td>Electrostatic &amp; stearic repulsion between particles</td>
</tr>
<tr>
<td></td>
<td>sulfonate</td>
<td></td>
</tr>
<tr>
<td>Anti freezing agent</td>
<td>Glycols</td>
<td>Depression in freezing point. Avoid drying on sides</td>
</tr>
<tr>
<td>Thickeners</td>
<td>Polysaccharides Gums</td>
<td>Viscosity enhancement. Strong suspending</td>
</tr>
</tbody>
</table>

STABILISATION OF SOLID PARTICLES

Ionic repulsion by-
Surfactant molecules adsorbed on surface of solid particles

STABILISATION OF SOLID PARTICLES

Steric repulsion by -
Non ionic / polymeric surfactant molecules adsorbed on surface of solid particles
Slide 12

STABILISATION OF SOLID PARTICLES

Gravitational Stabilisation by-
Polysaccharide Gum crosslinked structure in the suspension

Slide 13

STRUCTURE OF GUM IN SUSPENSION

Slide 14

ADDITIONAL INGREDIENTS

• Defoamers (silicon emulsion)
• Preservatives
• Colouring agents (Dyes)
• Stabilisers / Buffers
PROCESS

Preparation of S.C. is three step process:

1. Premixing
2. Wet milling
3. Post blending

STEP I – PRE MIXING

High Shear Mixer is used

- Water
- Surfactants
- Defoamer
- Pesticide

Homogenous lump free slurry

STEP II – WET MILLING

- Wet grinding mill (e.g. Dyno mill) is used
- A closed cylinder with rotating shaft & agitation disks
- Grinding medium (glass, steel beads)
- Average Particle size reduced to 2-3 µ
- Batch or continuous process
STEP III – POST BLENDING

- De-aeration of milled slurry
- Blending with solution of thickner
- Low mixer speed to avoid air entrapment
- Add small amount of defoamer

FLOW SHEET FOR PRODUCTION OF SC

PHYSICO-CHEMICAL PROPERTIES

- Long storage stability (2 years)
- Optimum viscosity
- Low package sticking
- Minimum spray tank mixing (good blooming)
- Good stability of diluted suspension.
RHEOLOGICAL PROPERTIES

- High viscosity of suspension if kept undisturbed
- Reduction in viscosity upon stress (Pseudoplastic)
- Optimum viscosity
  - 6 rpm > 3500 cps
  - 60 rpm < 400 cps

EFFECT OF SHEAR RATE ON THICKENERS

SUSPENDING POWER OF THICKENERS

Different thickeners used in suspension of silica —
- Minimum (5%) settling in Xanthan Gum.
- Maximum settling in Sodium Alginate
QUALITY TESTS

1. a.i. content
2. pH range (CIPAC : MT – 75)
3. Pourablity (CIPAC : MT – 148)
4. Viscosity (Brookfield)
5. Spontaneity (CIPAC : MT – 160)

7. Particle size (wet sieve test) (CIPAC : MT – 148)
8. Persistent foam (CIPAC : MT – 47.2)

9. Cold Test : 0±1°C for 7 Days (CIPAC : MT – 148)
10. ATS: 54±1°C for 14 Days (CIPAC : MT – 148)

LIMITATIONS

• Stability problem on long storage.
• Long development efforts.
• Package disposal problems
• High process cost compared to WP
• Active content range upto maximum 50%
Water Dispersible Granules

The paper discussed this new type of formulation, its advantages and disadvantages. The composition of a standard WDG was described in the paper. Various methods of manufacture of WDG such as pan granulation, spray drying, fluid bed granulation, extrusion, etc. were discussed. The presentation also included quality control parameters.

Slide 1

**Water Dispersible Granule (Dry Flowable, WG)**

Slide 2

**Water Dispersible Granule (Dry Flowable, WG)**

“Formulation containing granules which readily disperse in water to form a suspension”

-(GI FAP, 1989)
Slide 3

**Features of Water Dispersible Granules**

- Hard, uniform sized (60-100 mesh), free flowing granular particles
- Containing negligible amount of dust
- Disperse or disintegrate readily in water
- Yield a homogenous sprayable suspension
- Overcome several problems associated with the use of dust, dispersible powder and other similar products

Slide 4

**Advantages**

- Being free flowing, the granules can be easily, quickly and completely transferred from the package into the spray tank
- There is insignificant quantity of dust during handling and slurry preparation which avoids hazard to workers and their surroundings
- Spillage does not lead to clinging of granules to the clothing and spilled material can be readily swept

Contd-

Slide 5

**Advantages**

- The packed granules can be readily and safely quantified before use.
- The granules can even be packed in standard water soluble packs, completely avoiding the problem of disposal of container.
- The dispersions obtained from such granules are often better than those obtained from WDP

Contd-
Advantages

- The transport and storage is economic and safe.
- Problems like settling, thickening etc. associated with wet flowables, are missing in dry flowables.
- If required, these granules can also be used like ordinary granules.

Disadvantages

- Formulation is sensitive to process variables and raw materials
- Requires capital expenditure somewhat high
- Packaging may be more expensive due to the low bulk density of granules than WP
- Skilled operators are required

Composition of WDG

A. Active ingredient (50-75%): This can be a mixture of more than one active
   - Melting point
   - Particle size and shape distribution
   - Water solubility
   - Plasticity
   - Hydrolytic stability
   - Crystal surface structure and energies
   - Explosivity
   - Toxicity
Composition of WDG

B. Diluent (0-45 %) : Most often a mineral filler is used, but inert soluble salts have been tried
   Ex Kaolin

C. Dispersant (1-7 %) : Most commonly a surfactant
   EX Naphthalene formaldehyde condensate and lignosulfonates

D. Wetting agent (0-2 %) : Most commonly a surfactant

E. Suspending agent (0-3 %): Can be either a surfactant or a mineral or organic swelling agent

F. Binder (0.5-2%) : Usually a lignosulphonate but can be a gum or similar product

Methods of Manufacture

A. Pan Granulation
B. Spray Drying
C. Fluid Bed Granulation
D. Extrusion
E. High Shear Agglomeration
Slide 12

Pan Granulator

Dry powder is continuously fed on to the pan and at the same time Water is sprayed on to the powder

Rotation of the pan causes the powder to aggregate

Larger particles accumulates on the surface of the powder

Slide 13

Spray Drying

Basic principles-

The liquid feed is broken up into droplets in some form of spray device at the top of a tall tower.

These droplets are mixed with hot air in the column.

As the droplets pass down the tower, the water evaporates and the droplet dry.

The dried droplets are finally separated from the air.

Slide 14

Spray Drying

[Diagram showing the process of spray drying]
Fluid Bed Granulation

Homogeneous granules.

Gentle product handling.

Intensive mixing of the solid material.

Uniform spraying of all particles in the fluid bed.

Working Principle

The AGGLOMASTER is a multi-purpose Fluidized Bed Processor which can transform powders or slurries in granulated products.

Spray drying and agglomeration in one unit

Production of coarse, dense granules

Energy-saving

Compact

Spouted Fluid bed Technology

Bottom and top spray
Continuous turbulent flow instant mixer for homogeneous agglomeration of fine powders into larger particles. Aids in dust control, reduced segregation and increased bulk density.

Quality Control

FAO (1999) describe the requirements with CIPAC test:

a) Acidity or alkalinity (MT3) or pH range (MT 75)

b) Wettability test (53.3)

c) Wet sieve test (MT 167)

d) Degree of dispersion (MT 174)

e) Suspensibility (MT 168)

f) Persistent foam (MT 47.2)

g) Dustiness (MT 171)

h) Flowability (MT 172)

i) Stability at elevated temperature (MT 46)

When material is packed in a sealed water soluble bag

j) Suspensibility (MT 168)

K) Persistent (MT 47.2)
Slide 21

**pH (MT 75)**

The pH of a 10% dispersion must be measured as part of the regulatory submission but it is also important if the chemical stability of the a.i. is pH dependent.

Slide 22

**Wetting time (MT 53.3)**

This is generally important for products with very low particle size distributions e.g. those made by spray drying.

The test should use relatively high weights of formulation to mimic addition to an induction tank.

Slide 23

**Wet Sieve Analysis (MT 167)**

A 75 micron sieve is usually used to mimic spray nozzle filters. CIPAC stipulates 10 g of formulation, but this should generally be increased to 50-100 g during development for most use rates.
Dispersibility (MT 174)

The CIPAC test for this property is cumbersome. Most companies measure disintegration times by usually observing the granule breaking up in specified condition.

Five g granules are poured into a 250 ml measuring cylinder containing 250 ml CIPAC hard water. The cylinder is then inverted end to end once a second. After 5 inversions, the contents are examined for undispersed granules. All granules must be dispersed after 10 inversions.

Suspensibility Test (MT 168)

This typically involves analyzing the lower 10% of a dilute suspension after settling for half an hour. Gravimetric and chemical analysis may lead to different results.

Particle Size of Dispersion

This method is very useful for comparing the particle size distribution of the diluted granules with those of the formulation ingredients prior to granulation. It may also correlate with biological activity.
Slide 27

**Foam (MT 47.2)**

This property is very dependent on formulation use rate and is best tested in a small or full size spray tank.

Slide 28

**Dustiness (MT 171)**

The CI PAC method requires 30 g of formulation to be dropped into a box through which an air stream at a specified flow rate is passing. The dust levels are measured gravimetrically or by light scattering. This test is very equipment dependent and weights greater than 30 g should be used if WDG will be applied at over 1kg / ha.

Slide 29

**Dry Sieve Analysis (MT 170)**

Granule size distribution affects many of the properties of the product. It is important to do sieve analysis in order to make valid comparisons between formulation recipes.
Bulk Density (MT 169)

This is typically a tap density method. It is generally used to set packaging specification.
Controlled Release Formulations

The presentation discussed the importance of controlled released formulations and mode of release of pesticides in such type of formulations. The paper also describes method of preparation of controlled release formulations and their advantages over the conventional type of formulations.

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Working Principle

The AGGLOMASTER is a multi-purpose Fluidized Bed Processor which can transform powders or slurries in granulated products.

Granulation or micro granulation of ultra fines powders, spray granulation from slurry are the typical applications of this new generation of fluid bed processors.
Slide 17

Main Features of the Agglomaster SD

- Spray drying and agglomeration in one unit
- Production of coarse, dense granules
- Energy-saving
- Compact
- Spouted Fluid bed Technology
- Bottom and top spray

Slide 18

High Shear Agglomeration

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Bulk Density (MT 169)

This is typically a tap density method. It is generally used to set packaging specification.
Recent Advances in Vector Control & Household Formulations

The paper describes public health pesticides which are generally used in vector control; as household pesticides and as professional pest control products to control diseases like malaria, dengue, filariasis, Japanese encephalitis. Treatments such as insecticide residue spray, fogging, insecticidal treated nets, long lasting insecticide treated nets etc. have been discussed in the paper. New technology formulations including household and profession pest control products are discussed in the paper.

Slide 1

VECTORS & HOUSEHOLD PESTS
CHALLENGING HUMAN BEINGS

• Biological warfare
• We lose in the battles !
• Aim is to win the war ?

• Ecological imbalance, Unplanned human activities
• Current vector Control methods are effective, but NEED more innovative tools & techniques !
• Need of the day, ENVIRONMENTAL MANIPULATION !!
Slide 2

Whether it is a chemical or biological,
the technology should be user friendly, cost effective, less
labour intensive, innovative, long lasting
but safe to humans and his environment.

Slide 3

• Pests & Problems
• Categories
• Formulations
• Innovative Technologies
• Chemical and Biological Profile

Slide 4

Pests & Problems
MOSQUITO
Malaria-Chikungunya-Dengue-Filariasis-Japanese Encephalitis
HOUSEFLY
Dysentry-Cholera-Food poisoning-Eye Infections
COCKROACH
Leprosy-Dysentry-Dust Allergy-Food contamination
RAT
Plague-Leptospirosis
SANDFLY
Kala Azar or Leishmaniasis
TICKS & LICE
Skin allergy, Scrub typhus
TERMITE
Weakens buildings-Eating away wood structures
Slide 5

**CURRENT**
- Effective against vectors/pests
- Need frequent applications, so high cost
- Resistance inevitable, complex issue
- Resurgence is a common problem
- Environmental & Human risks
- Effect diluted due to soil and ecological factors
- Region specific vector/pest control tools unavailable

**NEW TECHNOLOGIES**
- Very effective against vectors
- Less frequency of applications
- Innovative, user friendly
- Manipulates environmental biology of pests
- Multiple mode of action with long lasting effects

Slide 6

**CATEGORIES OF PUBLIC HEALTH PESTICIDES**

(user group based classification)

Slide 7

[Diagram of PUBLIC HEALTH PESTICIDES: I VECTOR CONTROL PESTICIDES, II HOUSEHOLD INSECTICIDES, III PROFESSIONAL PEST CONTROL PRODUCTS]
Slide 8

**VECTOR CONTROL PESTICIDES**

Government takes responsibility to protect people from vector borne diseases

- Malaria, Chikungunya, Dengue, Filariasis, Kala-Azar, Japanese Encephalitis, Leishmaniasis

Slide 9

**HOUSEHOLD INSECTICIDES**

Individuals are taking greater responsibility for personal protection themselves

- Mosquito, Cockroach, Housefly, Rats, Termites

Slide 10

**PROFESSIONAL PEST CONTROL PRODUCTS**

Trained professional pest management experts provide pest control services for Residential, commercial premises, public health programs

- Mosquito, Cockroach, Housefly, Rats, Termites
I. VECTOR CONTROL

PESTICIDES

Slide 12

Vector Control Pesticides

Residual Sprays (IRS)
- DDT
- Malathion
- Deltamethrin
- Cyfluthrin
- Lambda-cyhalothrin
- Alpha-cypermethrin
- Cyphenothrin
- Bifenthrin
- Permethrin

Fogging/Space Sprays
- Natural Pyrethrum
- Malathion
- Deltamethrin
- Lambda-cyhalothrin
- Alpha-cypermethrin
- Cyphenothrin

Bednets
- Deltamethrin
- Lambda-cyhalothrin
- Alpha-cypermethrin
- Permethrin

Larviciding
- Pyrethrum Oil
- Fenthion
- Temephos
- Rimoiphos methyl
- Diflubenzuron
- Pyriproxyfen
- Novaluron
- MMF
- Neem Oil
- Mineral Oil

Slide 13

Evolution of Vector Control Technology

Insect Growth Regulators (IGR)
- Monomolecular Film
- Bacterial Corn Granules (BCG)
- Larviciding

Larval Control
**Slide 14**

Evolution of Vector Control Technology

- **Adult Mosquito Control**
  - Long Lasting Insecticide Treated Nets (LLIN)
  - Long Lasting Insecticide Treated Plastic Sheets (ITPS)
  - Mosquito Traps
  - Insecticide Treated Nets (ITN)
  - Fogging/Space Spray

**Slide 15**

**Adult mosquito control**

Insecticide Residual Spray (IRS)

- Widely used important tool in malaria control
- Walls sprayed with thin film of contact insecticide
- Adult mosquitoes when rest indoor are killed
- Short residual effect 3-6 months
- Poor residual effect on mud surfaces
- Manual spraying, highly labour intensive
- Resistance common occurrence

**Slide 16**

Adult mosquito control

Fogging/Space Spray

- Right tool for emergency situations
- Contact insecticides used for immediate kill
- High cost of application
- Polluting environment due to heavy smoke
- Resistance common occurrence
Slide 17

**Adult Mosquito Control**

**Insecticide Treated Nets (ITN)**

- Effective tool in reducing malaria incidence
- Manual impregnation of nets
- Cumbersome process of impregnation
- Short residual life of insecticides on net
- Uneven distribution of insecticides on net
- Repeat impregnation at shorter intervals
- Failure to impregnate nets
- Malaria resurgence an issue

Slide 18

**Adult Mosquito Control**

**Long Lasting Insecticide Treated Nets (LLIN)**

**NEW FORMULATION TECHNOLOGY**

- WHO approved & recommended technology
- Long lasting insecticide polymer formulation
- Coating/incorporation with insecticides
- Excellent compatibility of Plastic-Pyrethroids
- Wash proof & dust proof product
- Withstands 20 normal washes with 80% efficacy
- Product life 3-4 years
- Ideal tool for refugee camps/complex emergencies
- WHO recognises this a powerful tool in RBM

Slide 19

**LLIN Technologies Available Today**

**IMPREGNATION OF POLYMER**

- Insecticide coating around yarn
- Coating of yarn with a special resin
- Polyester netting
- Long lasting efficacy
- Wash proof & Dust proof
- Insecticide coating around yarn

**INCORPORATION INTO POLYMER**

- Insecticide mixed with polyethylene
- Polyethylene netting
- Long lasting efficacy
- Insecticide within yarn
Slide 20

Long lasting Insecticide Treated Plastic Sheets (ITPS)

ZeroFly® Technology
• Insecticide incorporated into plastic
• Migration of insecticide to surface
• Long lasting efficacy

Usage
• Malaria & other disease control
• Displaced populations
• Refugee camps
• Tribal shelters
• Slum settlements
• Army tents
• Disaster situations
• Complex emergencies
• Storage of food grains

Slide 21

Household Insecticides

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<tr>
<th>Coil/Incense Sticks</th>
<th>Mat/Liquid Vaporiser</th>
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<td>16hr/30hr/60hr/90hr</td>
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</tbody>
</table>

Slide 22

NEW TECHNOLOGY MOLECULES

• Transfluthrin
• Metofluthrin
• Imiprothrin
• Natural Pyrethrum
• Imidacloprid
• Fipronil
• Novaluron
**Transfluthrin - Biological Properties**

- First chemical insecticide with **GREEN tox triangle**
- Very safe toxicity profile
- High vapour pressure
- Amenable for heating, burning, self vaporising products
- Can vaporise at ambient temperature at mild air current
- Vaporise at ambient temperature
- Highly effective against flying insects
- Effective at very low concentrations
- Fast dispersal into air
- Fast knockdown agent
- Great gift for innovative products

**Metofluthrin - Biological Properties**

- First ambient temperature vaporising pyrethroid
- Very high vapour pressure
- Volatile in porous medium
- Vaporise at ambient temperature without any energy
- Amenable for self vaporising, burning, heating products
- Highly effective against flying insects
- Effective at very low concentrations
- Fast dispersal into air
- Fast knockdown agent
- Revolutionary product

**Imiprothrin - Biological Properties**

- Super fast knockdown pyrethroid
- Contact insecticide
- Unique flushing action in aerosols
- Quick knock down effect on all cockroaches
Slide 26

**Natural Pyrethrum-Biological Properties**

- Super fast knockdown herbal product (!!!)
- Good Contact insecticide
- Unique flushing action in aerosols (!!!)
- Quick knockdown on mosquitoes/flies & cockroaches
- Best herbal powerful insecticide (!!!!)
- Efficacy on par with chemical insecticides
- Technical Grade 25% Pyrethrum registered
- Great scope for many herbal household products (?)
- Time to REINVENT Pyrethrum

Slide 27

**Imidacloprid-Biological Properties**

- Neonicotinyl compound
- Stomach poison require insect to consume
- Suitable for Gel & Granule Baits
- Cockroach Gel Bait
- Ant Granule Bait
- Good Termicide-Non Repellent
- Animal ectoparasite control

Slide 28

**Fipronil-Biological Properties**

- Phenyl pyrazole compound
- Good contact insecticide
- Suitable for Gel & Baits
- Cockroach Gel Bait
- Ant Granule Bait
- Good Termicide-Non Repellent
- Animal ectoparasite control
Slide 29

Transfluthrin Formulations

Conventional products
- Mosquito Coil
- Mosquito Mat
- Liquid Vaporiser
- Aerosols
- Ready To Use sprays

Innovative products
- Membrane Vaporisers
- Fan type vaporisers
- Moth repellent paper
- Stored grain protectant paper

Slide 30

Transfluthrin
Innovative Products

Membrane Vaporiser (MV)
- Transfluthrin gel form
- Packed in a metal tray
- Fitted with vapour permeable plastic membrane
- 1.5g gel effective for 30 days
- Excellent efficacy on all mosquitoes
- Super fast knockdown
- Good spreading property in air

Slide 31

Transfluthrin
Innovative Products

Fan type Vaporiser
- Transfluthrin in low concentration
- Impregnated in paper card board
- Air current required to through active ingredient
- Vaporises at ambient temperature
- Excellent efficacy on all mosquitoes
- Super fast knockdown
- Good spreading property
Slide 32

**Transfluthrin**
Innovative Products

**Moth repellent paper**
- Transfluthrin in very low concentration
- Impregnated in cellulose papers
- Moth repellent

Slide 33

**Transfluthrin**
Innovative Products

**Stored Grain Protectant Paper**
- Transfluthrin at low concentration
- Impregnated in cellulose paper
- Vaporises at ambient temperature
- Keeps away all grain pests
- Kills all grain pests
Registration Aspects of Pesticide Formulations

The paper described the registration system and data requirements for the registration of pesticide formulations in India.

**Slide 1**

Registration Aspects of Pesticide Formulations

**Slide 2**

**Significance of the Topic**

- Registration
- Aspects
- Pesticide
- Formulations
Pesticide (Insecticide)

- Any substance included in the Schedule to the Insecticides Act, 1968.
- Any substance that shall be included in the Schedule to the Act as per procedure.
- Any preparation containing one or more such substance(s).

Registration

- A Legal Requirement The Insecticides Act, 1968.

  (To be referred hereafter as the Act).

- To ensure that insecticides, when used according to registered label directions, will be effective and efficient for the purpose claimed and safe.

The Insecticides Act, 1968

Regulates

- import
- manufacture
- sale
- transport
- distribution
- use

of insecticides ..... TO......
Slide 6

**Regulatory Policy**

- Use of a pesticide is permitted only if the benefits outweigh the risks involved.
- It is ensured that potential benefits from insecticides are obtained without any adverse implications because the damage to ecosystem may lead to
  - reduced agricultural production;
  - decreased quality of environment;
  - economic losses outside agriculture

Slide 7

**Registration**

**Who registers?**

- A Registration Committee.

**Who should apply?**

- Any person desiring to import or manufacture an insecticide.

Slide 8

**Registration**

**How many types?**

- Provisional [Section 9 (3B)]
  - First time introduction of a new molecule into the country.
  - For a period of two years.
  - On conditions as may be specified.


### Slide 9

**Registration (Types)**

- **Regular Original [Section 9 (3)]**
  
  After fulfilling
  
  - the pending enquiry or
  
  - conditions
  
  as specified at the time of provisional registration.

### Slide 10

**Registration (Types)**

- **Regular Repeat [Section 9 (4)]**
  
  If an insecticide
  
  - has been registered regularly in the name of any person, then
  
  - on the same conditions
  
  any other person desiring or import or manufacture the same insecticide is granted a repeat registration on making an application and paying the fee.

### Slide 11

**Registration**

How to apply?

- An application in Form-I.
- Requisite Fee.
- Legal requirements - Proof of establishment and manufacturing premises.
- Technical data
  - Chemistry
  - Bio-efficacy
  - Toxicity
  - Packaging
- Onus of data rests with the applicant.
Data Requirement

Varies case to case, viz.

- Nature of insecticide: Chemical or Bio-pesticide.
- Section of the Act: 9 (3B), 9(3) or 9(4).
- Type of product: Technical or formulation.
- Purpose: Indigenous manufacture or import.
- Usage (Domestic Consumption or Export).
- Sector of Use – Agriculture, Public Health or Household.

Details of Data requirement

- Registration Committee frames and follows guidelines.
- More than 20 categories.
- For formulations
  - Formulation import, with or without registering technical grade insecticide under Section 9 (3B), 9 (3) or 9 (4).
  - Formulation Indigenous manufacture under Section 9 (3B), 9 (3) or 9 (4).
  - New Formulations.
  - Bio-pesticide formulations u/s 9(3B)/9(3).
  - Export u/s 9(3).

Data requirement in Brief

Chemistry: about 17 parameters

- Source
- Chemical Composition and Identity
- Physico-chemical Properties
- Specifications and method of analysis
- ATR
- Shelf-life Data
- Process of manufacture
- Effluent Treatment
- Sample testing at CIL

Data on technical too, if formulation is registered alone.
Data requirement in Brief

Bio-efficacy: about 16 parameters
- Bio-efficacy and phyto-toxicity
- Effect on parasites and predators
- Studies on translocation, metabolism and persistence in soil, water and plants
- Residues in soil and water
- Tolerance limits in other countries
- Compatibility with other chemicals in use

Data requirement in Brief

Toxicity: about 26 parameters
- Acute studies
- Sub-acute studies
- Eco-toxicity
- Supplementary studies

Data requirement in Brief

Packaging: about 27 parameters
- Labels & leaflets
- Details of contents of label
- Details of contents of leaflets
- Type of packaging (C-C-C)
- Manner of packing, Specs for I, II and III.
- Manner of labeling
- Performance of packaging (S-S Test)
Data requirement in Detail

Website

www.cibrc.nic.in

Bio-pesticides

To promote Integrated Pest Management (IPM) Approach of Plant Protection and also to reduce the use of chemical pesticides, the registration Committee

- encourages registration of bio-pesticides
- has framed simplified guidelines for data requirement for their registration
- allows commercialization during provisional registration u/s 9 (3B).

Bio-pesticides

- Biological Origin
  - Botanicals
  - Bio-control agents, etc.
- Based on Neem, *Bacillus*, *Trichoderma*, *Pseudomonas*, *Beauveria*, *Metarizium*, *NPV*, etc.
Slide 21

**MRLs as pre-requisite to grant of registration**

Pesticide Residues could
- effect human health
- influence international trade

Certain categories of registrations exempted from this requirement, viz. Use in Seed treatment, Use in Households, Export, Floriculture...

Slide 22

**Essence**

Registration procedure has to be such that
- it suits to the specific needs of the country
- ensures that only pesticides with desired and accepted properties are permitted for use.

Ultimate goal of Regulatory Control on pesticides is to provide the Society with adequate protection from adverse effects of pesticides while not denying access to benefits from their use.