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Short Communication

Recent Advancement in Pesticide Formulations for User and Environment Friendly Pest Management

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ABSTRACT

Pesticides in developing countries of Asia and Pacific region are mainly available as dust, wettable powder, emulsifiable concentrates, solutions etc formulations for pest management. These formulations are regarded now as 'conventional'/'old'/'classical' or 'traditional' because of their characteristics i.e. dustiness or use of volatile organic components (VOCs) in preparation cause several problems. With the increasing awareness of people, there is a significant trends towards user and environment friendly new generation pesticide formulations. The developed world has progressed substantially in this area to develop eco-friendly formulations to meet the needs for operator as well as environmental safety or to improve the bio-efficacy and persistence of pesticides. These formulations would not only replace toxic, non-degradable inert ingredients/adjuvants of the conventional formulations but also increase the activity of the products through incorporating latest technologies like size reduction (Wettable Powder to Suspension Concentrate, Soluble Liquid to Microemulsion), increased coverage of applied surface area (Emusifiable Concentrates to ME formulations), reduced wastage (Dust/WP to Controlled Release Formulations) and dose rates to improve food and environment quality with minimum pesticide residues. Suspension Concentrates, Water Dispersible Granules, Emulsion in Water, Micro-emulsion, Combination Formulations, Effervescent Tablets, seed treatment formulations etc. are some of the formulation types that come under this category.

Keywords: formulation, conventional, adjuvants, new generation, bio-efficacy

INTRODUCTION

Agrochemical formulation development technology is now emerged as an established technology, which is not only adding the significant value to the formulators but also presenting the attractive products to pesticide users by improving the operator safety, reducing the dose rate along with wastage of pesticides applied to crops, thereby improving environmental quality. [1] The basic objectives of formulation technology are to optimize the biological activity of the pesticide, and to give a product which is safe and convenient for use. In the past, most of the agrochemical formulation technologies were based on simple solutions in water-miscible solvent (SL), emulsifiable concentrates in a petroleum-based solvent (EC), or dusts (DP) and wettable powders (WP). The presence of petroleum-based solvents and dusty powders in these conventional formulations

generally create safety hazards in use and have a negative impact on the environment. These types of formulations are regarded now as 'old technology' because of their increased in dose rate or repeated applications to get desired bio-efficacy and ultimately endanger the safety of humankind as well as environment. [2] Most government regulatory authorities, including the Indian Government, are now encouraging the pesticide industries to develop formulations which are cleaner and safer for the user, have minimal impact on the environment, and can be applied at the lowest dose rate. [3] This has led to the development of water-based liquid formulations such as suspension concentrates (SC), oil-in water emulsions (EW) and microcapsules (CS) etc. [Fig. 2] There has also been a move away from dusty powders towards water dispersible or soluble granules (WG/SG). [Fig. 1] These developments in formulation technology and other innovative formulation types, sometimes in special packaging such as water-soluble packs, can give products a competitive advantage, add value or extend the life-cycle of active ingredients. These types of formulations are regarded as new generation formulations or user & environment friendly pesticide formulations. [4] *This article will describe some of the changes occurring in formulation types and further trends in new formulation techniques of combining polymers and surfactants in novel ways have resulted in a relatively safe and environment friendly products.*

Why New Generation Formulations

Indian pesticide industry is facing a serious challenge owing to the rising R&D costs. It takes almost USD 250 million and 10 years in research and development to introduce a new pesticide molecule in the market. [5] The regulatory bodies do not have adequate resources and infrastructure to execute timely registration of products. The rules are also not clear and are left to the regulatory bodies for their interpretations, leading to confusions thereby adding to the complexities for the crop protection chemical companies. This prevents the companies to invest in R&D activities to introduce a new pesticide molecule rather than on the new formulations of already introduced pesticide molecule in the market which require low investments compared to introduce a new molecule. [6]

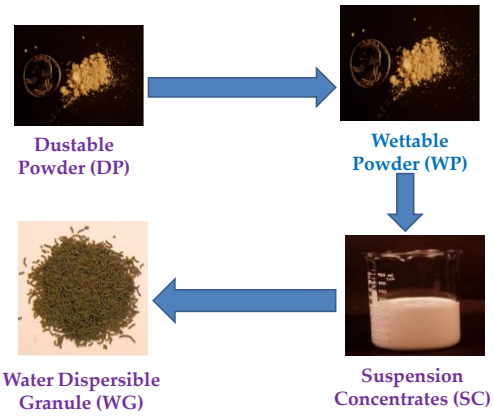

Fig 1: Gradual improvement from dusty formulations to dust free formulations

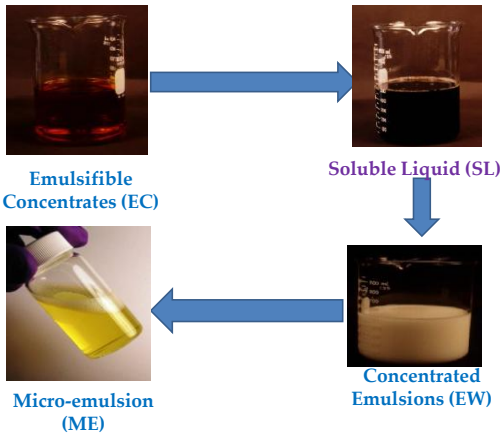

Fig 2: Gradual improvement from volatile organic solvent based formulations to water based formulations

Importance of Selection of Right Formulations:

There are many factors influencing residue dissipation rates during application and the different rate of dissipation

processes affecting residues level in / on the different parts of plant or plants of the same field. [7] One of the most important factors was the formulation itself. The differences between pesticide formulation types of the same active ingredient may lead to differences in pre-harvest internals (PHI's) values due to the nature of additives affecting the product and its physico-chemical properties as well as its behavior on the plant after treatment. [8] We should point out that it is necessary to use a formulation type that is convenient to use, more effective at much lower application rates, less toxic to non-target organism, with lower residue levels and a lower impact on the environment in general.

Trends towards Safer Formulation Technologies

All demerits of conventional formulations are increasing pressure to develop of improved formulation and adjuvant technologies have increased enormously to meet the needs for operator as well as environmental safety or to improve the activity and persistence of the active ingredient. [1] In all the above formulations, considerable attention has been paid in recent years to achieve a number of objectives:

- Enhancement of bioefficacy.
- Solvent reduction and safer solvent selection.
- Safer surfactant components with low toxicity enhanced biodegradability.
- Longer term physical and chemical stability.
- Controlled and sustained release of active ingredients.
- Compatibility of various formulations in tank mixes.

Water Dispersible Granules (WG)

Water dispersible granules, or dry flowables is a relatively new type of formulation and being developed as safer and more commercially attractive alternatives to wettable powders and suspension concentrates formulations. They are becoming more popular because of convenience in packaging and use, non-dusty, free-flowing granules which should disperse quickly when added to water in the spray tank. They therefore represent a technological improvement over wettable powders. The dispersion time in water is a very important property and to ensure that no problems should occur during mixing in the spray tank. It is necessary for all the granules to disperse completely within two minutes in varying degrees of water temperature and hardness. [9]

Example: *Mancozeb 75 WG, Endosulfan 50 WG, Captan 83 WG, Cypermethrin 40 WG, Thiomethaxam 25 WG, Deltamethrin 25 WG etc*

Suspension Concentrates (SC)

Suspension concentrate technology has been increasingly applied to the formulation of many solid crystalline pesticides since the early 1970's. [3] Pesticide particles maybe suspended in an oil phase, but it is much more usual for suspension concentrates to be dispersed in water. The use of surfactants as wetting and dispersing agents has also led to a great deal of research on the colloidal and surface chemistry aspects of dispersion and stabilization of solid/liquid dispersions. Farmers generally prefer suspension concentrates to wettable powders because they are non-dusty and easy to measure and pour into the spray tank.

Example: *Fipronil 5 SC, Sulphur 52 SC, Hexaconazole 10 SC, Carbendazim 50 SC etc*

Microencapsulation/Capsule Suspensions (CS)

The polymer membrane, or microencapsulation technique, has become popular in recent years. [10] A well-known method of microencapsulation uses the principle of interfacial polymerization. The rate of release of the active ingredient can be controlled by adjusting the microcapsule/droplet size, the thickness of the polymer membrane and the degree of cross-linking or porosity of the polymer. [11] Further innovations are expected in microencapsulation technology over the next few years which may contribute to safer pesticide use.

Example: *Lambda Cyhalothrin 10 CS, Lambda Cyhalothrin 25 CS etc*

O/W Emulsions (EW)

Oil-in-water emulsions are now receiving considerable attention reduced or eliminated volatile organic compounds (VOCs) for safer handling. [12] They are water based, oil-in-water emulsions can have significant advantages over emulsifiable concentrates in terms of cost and safety in manufacture, transportation and use. The active ingredient must have very low water solubility to avoid crystallization issues.

Example: Butachlor 50 EW, Cfluthrin 5 EW, Tricontanol 0.1 EW etc

Flowable Suspension (FS)

Flowable suspensions are concentrated 40% to 70% w/w suspensions of micronized insoluble active pesticide in water. FSs must be formulated for low viscosity and good fluidity, so that transfer to the spray tank is easy and complete. This requires an effective wetting agent and an efficient dispersing agent to ensure adequate dispersion of the pesticide in the water. Since the active ingredients in FSs are insoluble, good suspension stability is essential. [2] If the suspension settles and leaves sediment at the bottom of the container, the application of the pesticide may be too weak to be effective. A combination of smectite clay (bentonite) and xanthan gum works synergistically to provide excellent long term suspension stability at low viscosity and at low cost.

Example: Thiram 40 FS, Thiomethoxam 30 FS, Tebuconazole 5.36 FS

Microemulsions (ME)

Microemulsions are thermodynamically stable transparent dispersions of two immiscible liquids and are stable over a wide temperature range. [12] They have a very fine droplet size of less than 0.05 microns (50 nanometres). The total concentration of surfactants for a microemulsion can be as high as 10–30% or more, compared with about 5% for a typical o/w emulsion. Microemulsions have relatively low active ingredient concentrations, but the high surfactant content and solubilisation of the active ingredient may give rise to enhanced biological activity. [9]

Example: *Neemazal 30 MEC, Pyrithiobac Na 5.4 + Quizalofop-P-Ethyl 10.6 ME etc*

Oil Dispersion Formulations

One of the latest formulation types is oil dispersions (ODs). This technology allows very efficient and environmentally friendly agrochemical formulations. In ODs the solid active ingredient is dispersed in the oil phase, making it especially suitable for water-sensitive or non-soluble active ingredients. [1] The oil-phase can comprise different oils such as mineral oils, vegetable oils or esters of vegetable oils. Special attention is needed with the auxiliaries in ODs: suitable oil-compatible dispersing agents and emulsifiers adjusted to the type of oil which forms a stable emulsion after dilution with water.

Example: Cyantraniliprole 10.26OD

ZW Formulation of CS & EW

A mixed formulation of CS and EW is a stable suspension of microcapsules of the active ingredient and fine droplets of active ingredient(s) in fluid, normally intended for dilution with water before use. In the case of microcapsules, the active ingredient is present inside discrete, inert, polymeric microcapsules. [11] The formulation is intended for dilution into water prior to spray application. Mixtures of active ingredients one of which is encapsulated are used to provide a broader spectrum of pest control. Formulating the active ingredients together eliminates the need for tank mixing (which can lead to incompatibilities).

Example: Lambda Cyhalothrin-25.0 CS + Chloropyriphos-10.0 EW

Floating Tablets

The floating tablets are slow release tablets which after application in water bodies floats on the surface of water due to low specific gravity and specific inert ingredients. [] It slowly releases the active ingredient into the water. The floating tablets offer a simple and practical approach to achieve increased surface-residence time for the dosage form and sustained active ingredient's release. It can reduce the frequency of dosing required for mosquito larval control and decrease variation in larvicidal concentration. Preparing the larvicides in a floating dosage form can control the extent of bioavailability for such poorly water-soluble active ingredients. [3]

CONCLUSION

With the many pressures on product performance, formulation is becoming a key technology by which agrochemical companies can differentiate their products and add significant value. New product introduction is an important factor in brand refreshment and new formulation technology can impact this considerably. This article has described some of the changes occurring in formulation types and further trends in new formulation techniques of combining polymers and surfactants in novel ways have resulted in a relatively safe and environment friendly products.

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