

**RECENT PROMOTION OF AGROCHEMICAL FORMULATIONS FOR
ECO-FRIENDLY PEST MANAGEMENT**

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The indiscriminate use of traditional formulation based (dust, powders, granules, aqueous solutions and mineral oil-in-water emulsions) pesticides during production leads to accumulating pesticide residues in the food commodities after harvest along with environmental pollution. But, in the early 1980s, the consumers and Government emphasized a need for the modern pesticides which are- target specific, effective at lower concentration and safer to the environment. Therefore, the introduction of plant-based products in controlling pests became the need of an hour. But due to the immobility, inactivity of the raw components, they are being formulated and applied in the plants. Biology of the pest, environmental factors, ease of application, formulation type, cost, types of equipment availability, the target surface is the factors considered during the production of an appropriate formulation.

Types of Formulations

The most common formulations are still soluble concentrates for water-soluble chemicals, emulsifiable concentrates for oil-soluble chemicals, and wettable powders and suspension concentrates for insoluble solids. Granules and seed treatments for direct application have also been produced for many years.

Sl. No.	Formulation type	Code
1.	Granules	GR
2.	Solution concentrates	SL
3.	Emulsifiable concentrates	EC
4.	Wettable powders	WP
5.	Suspension concentrates	SC

Table 1: Types of Formulations

New Advancements Required

Pesticide formulations need to be modified to increase the benefit-cost ratio as well as to optimize the speed of its activity against the pests. The foremost issues that have been dealt with during the production of new generation formulations are- A minimum application of pesticides

- Safety in use and handling
- Disposable or re-usable packing
- Cost-effectiveness
- Reduction of all kinds of effluents and waste

Water Based Advanced Formulations

Suspoemulsions (SE): Microemulsions are transparent dispersions of two immiscible liquids, thermodynamically stable and are stable over a wide temperature range (Hiromoto, 2007). Suspoemulsions can, are mixtures of suspension concentrates and oil-in-water emulsions with added surfactants to prevent flocculation and thickeners from avoiding separation of the dispersed phases. Careful selection of the appropriate dispersing and emulsifying agents is essential to overcome the problem of hetero flocculation between the solid particles and the oil droplets, and extensive storage testing of these formulations is necessary.

Example: Fenpropimorph 24.5 + Epoxiconazole 8.2 SE (Not registered in India)

O/W Emulsions (EW): For safer handling and to lessen or eliminate volatile organic solvents (VOCs) Oil-in-water emulsions are now receiving significant attention. In the case of emulsifiable concentrates, the risk of transportation, handling and the production cost is generally much higher, whereas, oil-in-water emulsions are price worthy and risk is minimum. EW is produced by using block copolymers, non-ionic surfactants and other polymeric surfactants. Droplet size is below 2 microns (volume mean diameter VMD). To avoid separation of the oil droplets, the emulsions are usually thickened with polysaccharides such as xanthan gum and polymers such as polyvinyl alcohol are used as both emulsifier and thickener/stabiliser.

Example: Cyfluthrin 5 EW, Butachlor 50 EW etc.

Microemulsions (ME): Microemulsions are transparent emulsions and are stable over a wide temperature range. MEs have a very fine droplet size of fewer than 0.05 microns (50 nanometres) and consist of three components, namely:

- oily liquid or solid dissolved in an organic solvent
- water
- surfactant/co-surfactant system

These components form a single phase containing relatively large ‘swollen micelles’ in which the non-aqueous phase of the active ingredient and solvent are dissolved or solubilised by the surfactant system. In the preparation of microemulsions, two different types of surfactants are needed; one water-soluble and one oil soluble. In microemulsion, the concentration of surfactants can be more than 10– 30%, compared with about 5% for a typical o/w emulsion.

Example: Pyrethrin 5.4 + Quinalphos-P-Ethyl 10.6 ME

Multiple emulsions: It can be oil-in-water-in-oil (O/W/O) or water-in-oil-in-water (W/O/W). These are relatively complex formulations which require meticulous selection of emulsifiers, stabilisers and surfactant for its stability. Multiple emulsions are still in the research phase and could be of interest to reduce the oral toxicity of an active ingredient by restricting it to the primary internal emulsion droplet phase.

Aqueous flowable (AF): Aqueous flowables are concentrated 40% to 70% w/w suspensions of micronized insoluble active pesticide in water. To ensure the dispersion of the pesticide in the water, it requires an active wetting agent and an efficient dispersing agent.

Seed treatment formulations: As a kind of pesticide preparation with film-forming characteristics used for coating of plants and other plant seeds, the seed coating agent is generally prepared by technical material, dispersant, wetting agent, film former, pH regulator, antifreeze, defoamer, other auxiliaries and water (Dayer *et al.*, 2007). Although most pesticide formulations are applied by spraying onto crops or weeds, a significant amount of fungicide and insecticide products are applied onto seeds directly before planting into the soil.

Products for seed treatment fall into four categories:

water slurriable powders for seed treatment	WS
flowable suspensions for seed treatment	FS
powders for dry seed treatment	DS
non-aqueous solutions for seed treatment	LS

Table 2: Seed Treatment Formulations

Advanced Dry Formulations

Dispersion concentrates (DC): These are formulations of active ingredient dissolved in a water-miscible, polar solvent together with a dispersing or emulsifying agent, designed to dilute in the water giving stable, fine particle size dispersions. DC formulations are alternative to SL, SC, EC and ME formulations, being suitable for active ingredients whose physical, chemical or biological properties preclude the use of these more conventional formulations.

Water dispersible granules (WG): Water dispersible granules (also called dry flowable), developed as attractive alternatives to wettable powders and suspension concentrate, and also a relatively new type of formulation which is safer and more economically viable.

Example: Endosulfan 50 WG, Mancozeb 75 WG, Cypermethrin 40 WG, Captan 83 WG etc

Controlled Release Formulations

Combined/mixed formulation technology: In this unique formulation, two different active ingredients in such a way that one active ingredient, i.e. chlorpyrifos will be quickly available/effective just after application on target pests for quick knock-down effect and on the other hand, the other pesticide, i.e. lambda-cyhalothrin will be efficacious slowly in a controlled manner for long term target pest management

Microencapsulation/capsule suspensions (CS): in recent years, microencapsulation or the polymer membrane technique has become popular among the consumers. Well, a known method of microencapsulation uses the principle of interfacial polymerisation. A typical microencapsulated suspension (CS) formulation is shown below: -

Ingredients	% by weight
Active ingredient	10–30
Solvent	5–15
Emulsifier	1–5
Anti-settling agents	1–3
Polymer	10–15
Water	to 100

Table 3: Microencapsulated Suspension Formulation

Nanotechnology

Nanoemulsions: Nano-emulsions have a particle size of less than 200 nm, which makes the systems inherently transparent/translucent and kinetically stable. Pesticides formulated with nano-emulsions having a lower surfactant concentration than microemulsions and surfactants are considerably more environmentally friendly and are cost-effective and economically applied to produce nanoemulsions, the energy stored could promote smaller-sized nanoparticles of longer life.

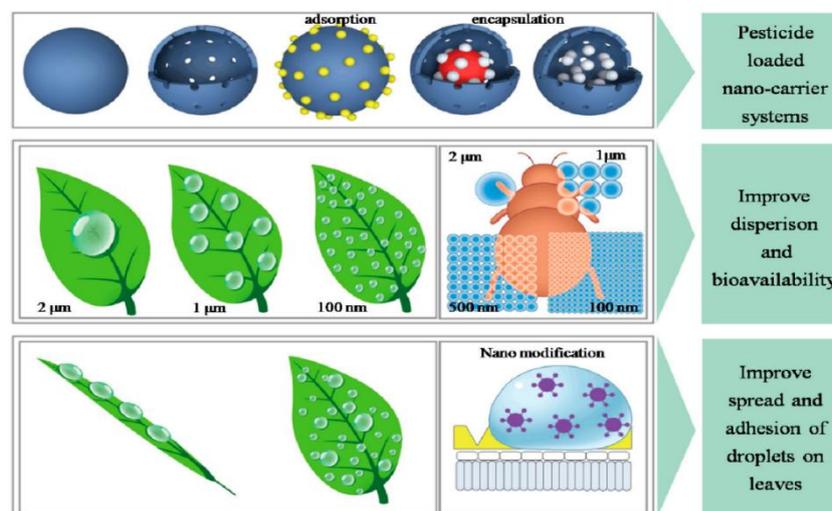


Fig.1. Nano-based pesticide formulation increases the bioavailability and efficacy(O’Sullivan *et al.*, 2010; Sarwar, 2014).

Conclusion

This article has described some of the changes occurring in formulation types employed and the further trends that are driving technologies such as examples of water-

based dispersion formulation technology for oil-in-water emulsions, suspensions, micro-emulsions etc. New product introduction is an essential factor in brand refreshment, and new formulation technology can impact this considerably. Moving with a lustrous record of providing quality products to its customers and for sustainable pest management, scientists are now shifting its focus towards 'nanotechnology', keeping in view the hazardous effects of highly toxic pesticides.

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