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Controlled Release Formulations (CRF): A Sustainable Tool for Agriculture

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Introduction

Controlled release formulations (CRF) of pesticides are which release their biologically active constituents into their environment over a defined period. In these formulations, the substances are chemically bound or physically incorporated into a polymer matrix utilizing different techniques. The migration of the substances is, therefore, preceded by chemical reactions for bond cleavage or physical transport processes in and through polymers, which can be mathematically modeled. The reduction of the toxicity of the substances and undesirable side effects on non-target organisms as well as the prevention of premature disappearance of the active substances from the place of application as a result of degradation and transport processes under environmental conditions are the prominent characteristics of these formulations. As opposed to these, there are several disadvantages, such as the increased build-up of resistance. The development of an ideal controlled release pesticide formulation is just as difficult as developing the ideal pesticide, which is the reason why further R & Dwork is urgently needed.

Applied conventional agrochemicals (90%) never reach their objective to produce a desired biological response at the precise time and in precise quantities required, due to nonspecific and periodic application of active agents. Both factors, besides increasing treatment costs, produce undesirable side effects on plants or the environment. The widespread application of different polymeric materials as reactive molecules is based on the potential advantages of specifically active functional groups and characteristic properties of polymeric molecules. Application of convectional synthetic agrochemicals results in groundwater contamination. Also, over-application and point source contamination increase pollution potential. Replacement of these formulations by controlled-release systems not only helps to avoid treatment with excess amounts of active substances but also offers, besides

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ecologic and economic advantages, the most suitable technical solution in special fields of application (in aquatic weed control and pest management in paddy fields.

Controlled-release formulations (CRF)

Controlled-release formulations are used to maintain the effective local concentration of active ingredients in the soil and to reduce runoff. Conventional application of agrochemicals provides an initial concentration far in excess than required and causes toxicity problems for organisms and also produces undesirable side effects in the environment.

Controlled release is the technique by which active agents are made available to the target site at a rate and duration designed to accomplish the intended effect on the targeted pest.The pesticide is formulated in such a way that on the one hand there is a slow continuous decomposition of pesticide and on the other, there is a continuous release of pesticide.

Advantages of CRF over conventional formulations

- ✓ Activity prolongation by providing a continuously low amount of pesticide, a level sufficient to perform its function over a long period.
- ✓ Reduce the number of applications over a long period of activity duration.
- ✓ Cost reduction by eliminating time and cost of repeated and over applications; Extending activity duration of less persistent pesticide, which is unstable under an aquatic environment.
- ✓ CRF converts technical pesticide liquid into a solid formulation, resulting in easily transported material with a reduction of flammability.
- ✓ Mammalian and phytotoxicity reduction by lowering the high mobility of pesticides in soil and hence reducing their residue in the food chain. High cost involved in manufacturing of these formulations, an excessive amount of polymer used, and polymeric herbicide is the fate of polymer matrix.

Disadvantages of CRF

- ✓ Long development efforts
- ✓ High cost of R&D
- ✓ Out-of-specification production is not workable.
- ✓ The limited scope of water-soluble pesticides.

Registered CRF product

- ✓ Natural pyrethrinnano capsules

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- ✓ Spinosadnanocapsules
- ✓ Chlorantraniliprolenanocapsules
- ✓ S-ethyl dipropylthiocarbamate
- ✓ azoxystrobin microcapsules

Impacts of CRF on improving bio-efficacies of pesticides, environment, and human health

Controlled release formulations have been prepared using light-sensitive, thermo-sensitive, humidity-sensitive, and enzyme- and soil pH-sensitive high polymer materials to deliver pesticides. These materials are prepared via processes such as adsorption, coupling, encapsulation, and embedding. Such formulations can protect pesticideactive ingredients and enhance stability, control the release of core materials, reduce or obscure odors, decrease volatility, and isolate. In particular, their targeted delivery and controlled release of active ingredientshave improvised pesticide utilization and reducedthe problem of residue and pollution. Due to their small size, improvable pesticide droplet ductility, wettability, and target adsorption when spraying fields- these methods provide efficient and environmentally friendly advantages. Also, they reduce the chance of mammalian and phytotoxicity by lowering the high mobility of pesticides in soil and hence reducing their residue in the food chain.

Conclusion

The desire for sufficiently lengthy effectiveness of these compounds, to avoid routinely repeated application, and the intention to minimize contamination of non-target sites just go in concert with the demand for ecological acceptability of pesticides. To some extent, controlled release formulations of non-persistent biologically active chemicals can help to satisfy these conflicting demands on the properties of the active component and application strategies. Research carried out in this field in the last two decades has made it clear, that the scientific approach to solving the ecological as well as the economic problems of pesticide application using such formulations is justified in respect of many fields of application. In some domains of being used (like mosquito control in freshwater ponds), the gradual release of the active ingredients necessitates excessive treatment volumes; in other situations, it may be the reason why resistance develops quickly (e.g., in the case of ectoparasites in livestock). Hydrocolloids are concurrently produced when pesticidal active

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ingredients co-migrate from carrier systems like PVC, some of which (such diethyl hexyl phthalate) are thought to be responsible for severe illnesses including liver tumors.The majority of the polymers employed as matrix degrade slowly in the environment. The breakdown products of these polymers are frequently unknown. These environmental factors must be taken into account and precautions made in the case of non-removable application forms, such as microcapsules and pellets, to prevent unfavourable side effects. It's indeed apparent that these long-range preparations are not economically viable in all sectors due to the comparatively high production costs of controlled-release pesticide formulations when compared to traditional preparations (EC or WP). Instead, for well-defined application sectors, the controlled release technique may make highly developed and problem-adapted specializations available. Therefore, the research and development of controlled-release pesticide formulations will also be of major importance in the future.

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