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ORIGINAL ARTICLE

# Application of Nanotechnology in Insect Pest Management

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**ABSTRACT**

Pesticides have beneficial effect on agricultural productivity however, due to indiscriminate use, pesticides are routinely detected in environment and to some extent in food. Improvements in the delivery system of pesticides can enhance the bioefficacy and solve the problem of unintended environmental and human health consequences. In recent years, nanotechnology is used in the field of insect pest management in the form of nanoparticles. The enhanced efficacy of nanopesticides at low concentrations can benefit the farmers and reduce the pollution level in the environment. In this review, traditional strategies used for the management of insect pests and potential of nanomaterials in insect pest control as modern approaches of nanotechnology have been summarized.

**Keywords:** Nanopesticides, Nanotechnology, Insect pest, Bioefficacy.

## 1. INTRODUCTION

Pesticides have been used on crops since ages to combat losses caused by insect pests and to fight diseases. As per India pesticides market report the Indian pesticides market was worth INR 197 Billion in 2018. The market is further projected to reach a value of INR 316 Billion by 2024, reflecting their enormous economic and agricultural importance. However, due to indiscriminate use, pesticides are routinely detected in various component of the environment and also bring threat to human health. The pesticide formulation is a mixture of active ingredients and other intentionally added inert ingredients. Active ingredients are the primary drivers of their targeted toxicity and generally water-insoluble organic compounds .Other ingredients can be solvent, carrier, adjuvant, emulsifier, dispersant and other auxiliary ingredients that facilitate the spray application in field. In conventional methods, pesticides are

generally applied to crops by spraying, as a result, a very low number of agrochemicals reach the target sites of crops. The actual utilization of biological target uptake is only less than 0.1% after dust, drift, rainwater and leaching [1]. The off-target loss is the crucial problem for inefficient usage of conventional pesticide formulations [2].

Improvements in the delivery system of pesticides can enhance the bioefficacy and solve the problem of unintended environmental and human health consequences. Compared to traditional strategies, nanotechnology, in the form of nanoparticles, provides green and efficient alternatives for the management of insect pests in agriculture without adverse effect on environment and human beings. Nanoparticles can be used in the preparation of new formulations like pesticides, insecticides, insect repellents, pheromones and fertilizers [3]. Nanomaterial offer a wider specific surface area crucial for the sustainable development of agriculture systems [4].

The potential uses and benefits of nanotechnology in all stages of production, processing, storing, packaging and transport of agricultural products are enormous especially the recent advancement of nanotechnology-based synthesis of slow or controlled release pesticides is reported to be efficient over other pesticide delivery vehicles. One of the key aspects of precision farming is the delivery of agrochemicals to plants using control delivery systems. The aim of controlled delivery techniques is to release measured amount of necessary and sufficient quantities of agrochemicals over a period of time and to obtain the full biological competency with minimizing the loss and harmful effects [5]. In this review, traditional strategies used for the management of insect pests and potential of nanomaterials in insect pest control as modern approaches of nanotechnology have been summarized.

**2. Beneficial improvements of nano-based pesticide formulation**

Nanotechnology created novel nano-based pesticide formulations i.e. Nanopesticides. Nanopesticides can be prepared using emulsion, polymer, lipid, ceramics, proteins and metals. The common methods for preparation of nanopesticide are by using oil in water emulsion system (microemulsion and nanoemulsion) and the conversion of emulsion to organic nanoparticles by milling, solvent evaporation, coacervation and precipitation techniques [6]. Nano-pesticides can also be developed by directly processing into nanoparticles (nanosized pesticides) or by loading pesticides with nano-carriers in delivery systems. In nano-carrier systems, pesticides are loaded in following manner, encapsulation inside the nanoparticulate polymeric shell, absorption onto the nanoparticle surface, attachment on the nanoparticle core via ligands or entrapment within the polymeric matrix. A variety of nanoformulation types have been developed, including nanoemulsions, nanocapsules, nanospheres, nanosuspensions, solid lipid nanoparticles, mesoporous nanoparticles and nanoclays **Figure 1** [7].

Nanoparticles offer the advantages of effective delivery of agrochemical due to their large surface area, easy attachment and fast mass transfer [8]. Nanoparticles release agrochemicals to plants using control delivery systems compared to conventional pesticide formulation where more than 90% of pesticides run off into the environment and reside in agricultural products in the process of application. The control delivery System facilitate the sustained release of the active ingredient at the target site for an extended period of time thus increasing targeted delivery efficiency of pesticide into action targets such as plants, insects and pathogen [9], increasing solubility and dispersion for fat-soluble chemicals in aqueous solution [10], reducing pesticides application and treatment frequency by extended lasting validity period [11] enhancing the bioefficacy , reducing the chemical input to plants , solving the problem of non-target toxicity and improving chemical stability for light-sensitive compounds by restricting photo-degradation [10]. The sustained release of pesticide protects biodiversity in ecosystem [9]. The Beneficial improvements of nano-based pesticide formulations is represented in **Figure 2.**

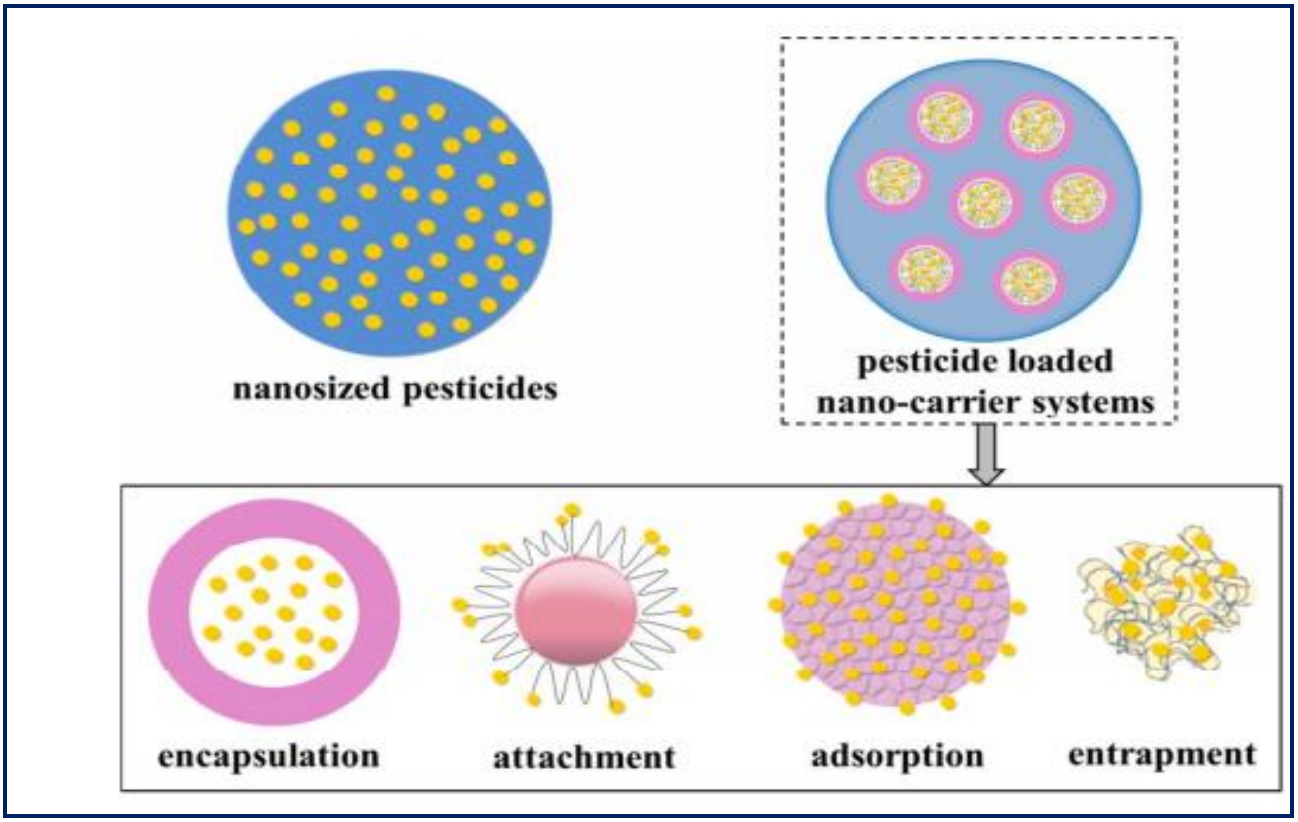


**Figure 1. Nano-based pesticide formulation**

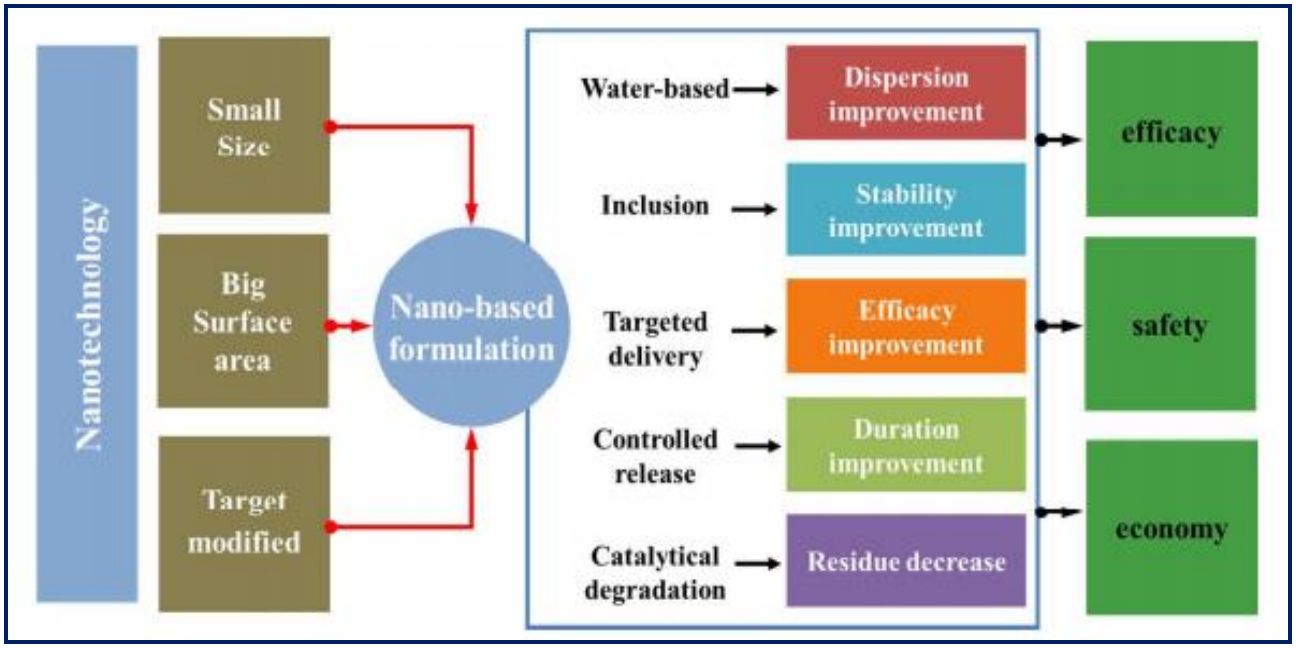


**Figure 2. Beneficial improvements of nano-based pesticide formulations**

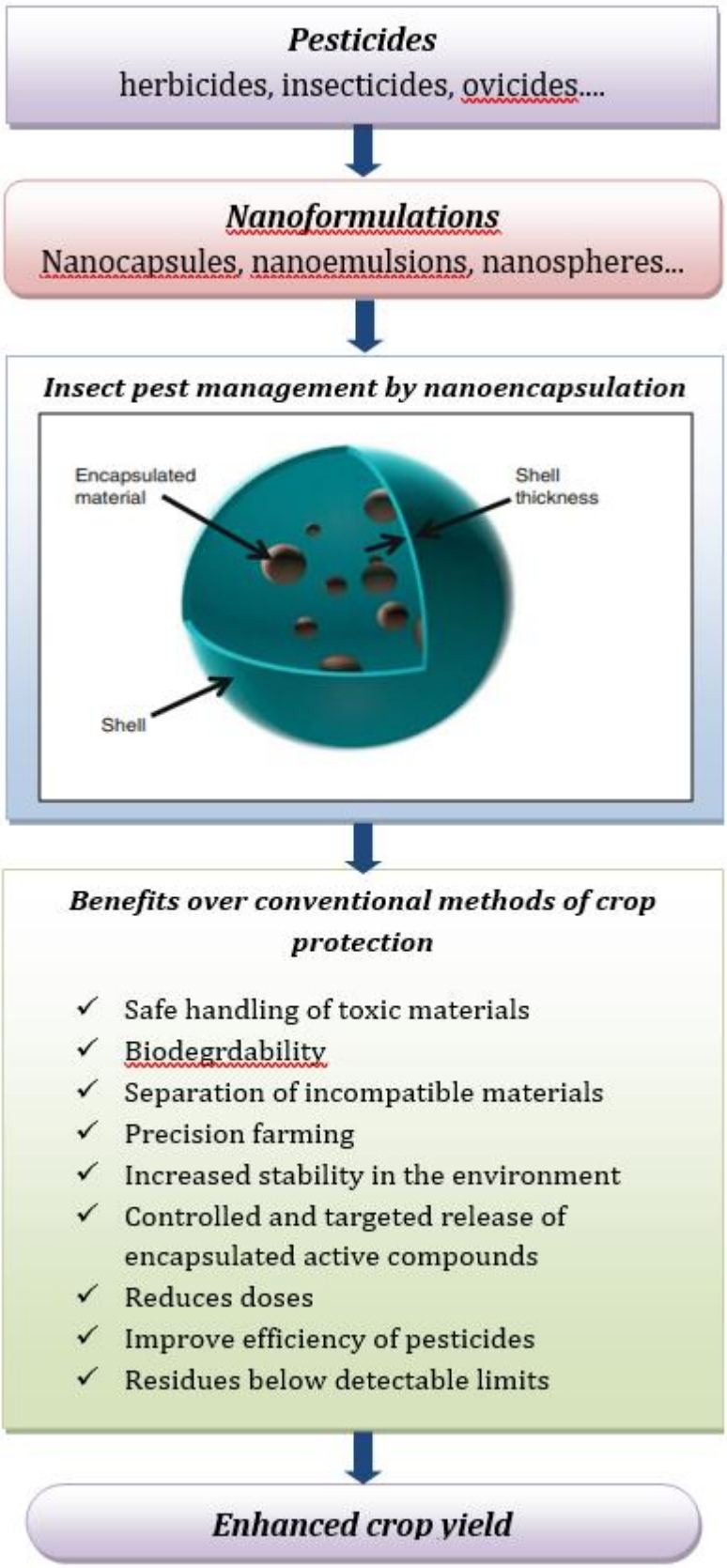


**Fig 3. Nanoencapsulation and benefits**

**3. Nanoencapsulation for smart delivery of pesticides to control insect pest**

Nanoencapsulation is another part of nanotechnology that offer variety of desirable features that include reduction in human exposure to active ingredients, controlled release, longer residual concentrations, elimination of organic solvents and increased efficacy [12]. Encapsulation formulations have revolutionized the application of pesticides due to the development of nanotechnology in insect pest management as it reduces the doses compared to the conventional pesticide to get maximum effect with more target oriented action of the pesticides .In this method the core material (pesticide) is coated i.e encapsulated by capsulation material or shell and the size of the pesticide reduces up to the nano size.

In nanoencapsulation, insecticide is slowly and efficiently released for insect pest control. In this process individual particles or droplets of solid or liquid core material are surrounded or covered with a continuous film of polymeric material and pesticide is released only in the targeted environment like in specific pH (e.g., in the stomach or inside a cell) , specific temperature ,moisture, external ultrasound frequency or in the occurrence of explicit compounds . Some encapsulation is done in such way that it gets absorbed in the surface of the plant and facilitates protract release which lasts for longer time compared to conventional pesticides which is washed away in the rain thus prevent frequent use of pesticides as represented in **Figure 3.**

## 4. CONCLUSION

Nanoformulations or nanoencapsulations have many advantages over conventional formulations of pesticides due to high target delivery and smart controlled release mechanism. Doses of pesticides required is also minimal as a result, pests fail to develop resistance. Studies has also shown that some controlled release formulations recorded higher crop yield and control over pests compared to commercial formulation and even the residues of pesticides in seed or soil at harvest were below the detectable limits. Clearly nanopesticides hold promise for reducing the environmental footprint left by conventional pesticides.

**Conflict of interest**

No conflict of interest influenced in this research.

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