

NANO-PESTICIDES: A PRECISION COMPONENT OF SUSTAINABLE PEST MANAGEMENT

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INTRODUCTION

“Nanotechnology is the art and science of manipulating matter at nanoscale”

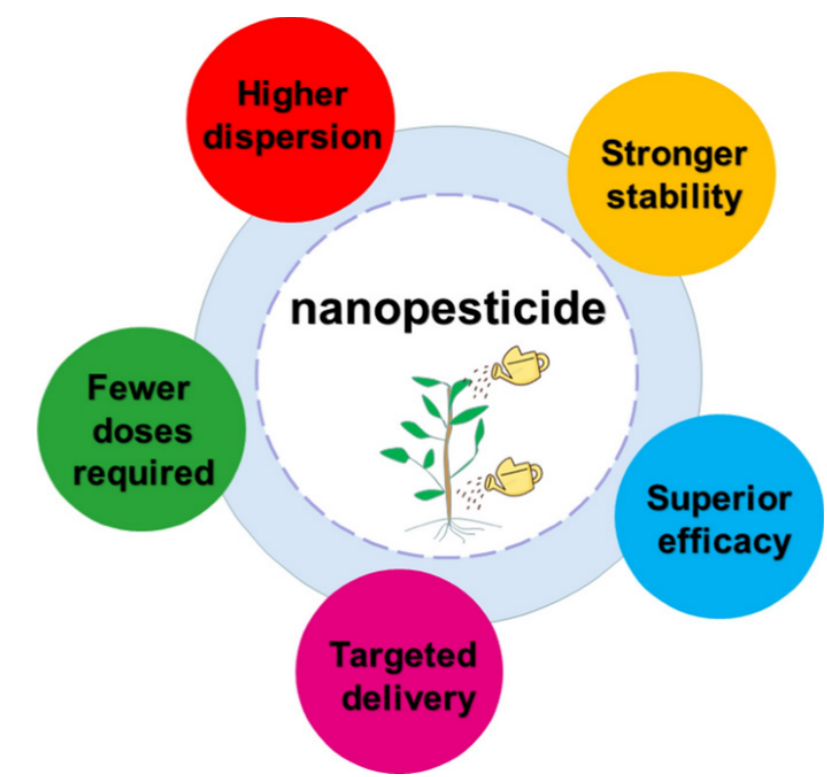
(British Standard Institution,2005)

Agriculture is always the most important and stable sector because it produces and provides raw materials for the food and feed industries. Due to the growing global population, all continents must have access to nutritious food that can fulfill their needs. We have witnessed a rise in the use of fertilizers, insecticides, herbicides, and other agrochemicals to raise agricultural production, which is related to the pressure of economic investment in agricultural commodities. Agrochemical technology is typically aimed to protect crop areas against pests (pathogens, harmful insects, parasitic weeds) that compromise production and productivity, including diagnosing soil and plantations vitality, livestock, and fishery product control.

The Indian pesticides market reached a value of around INR 212 Billion in 2021.IMAC Group expects the market to reach INR 320 Billion by 2027, exhibiting a CAGR of 7.07% from 2022-2027.

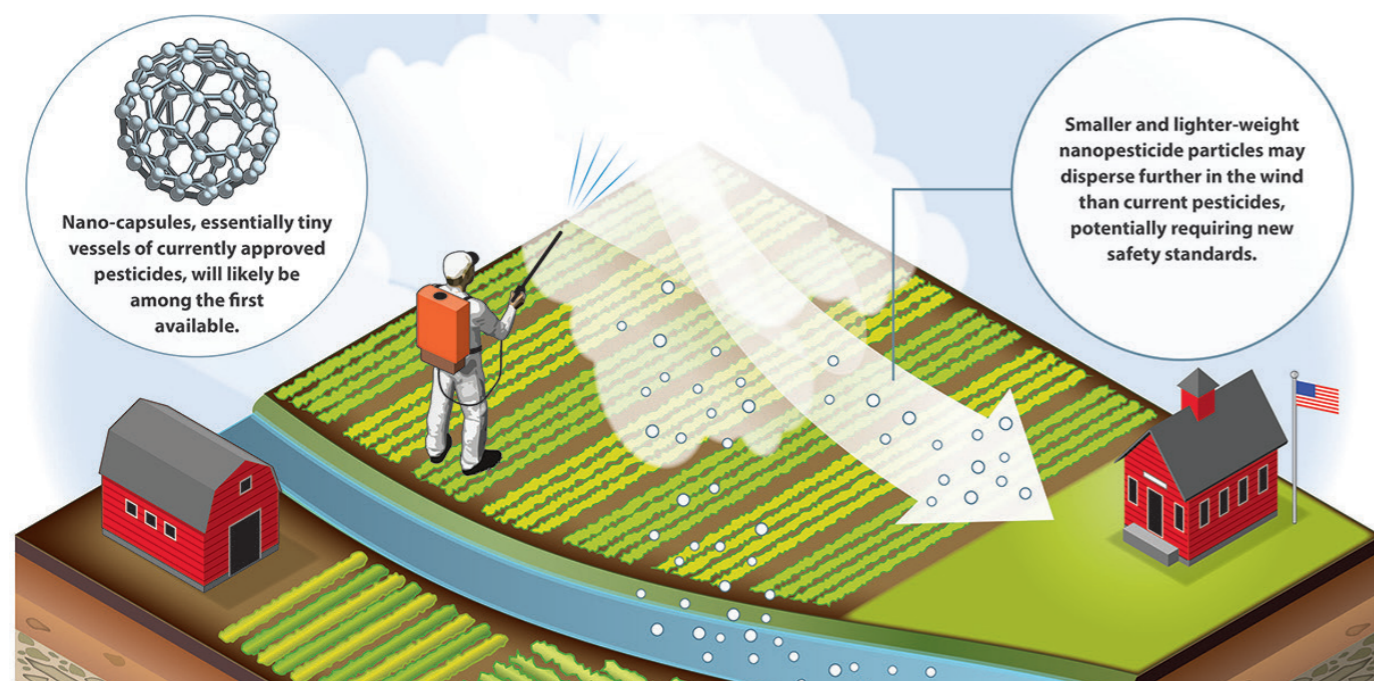
The growth of agriculture is a necessary phenomenon for eliminating hunger and poverty in the world today. Thus, to advance agriculture, we should make one bold move. In this world, most of the population lives in poverty, concentrated in rural areas where agriculture expansion has not been very successful.

Synthetic pesticides have several drawbacks, including the potential to harm beneficial arthropods, avians, and mammals as well as pollute the environment when used widely and carelessly. It is necessary to study pesticides with precise action and minimal environmental impact. Nanotechnology has gained intense attention in recent years due to its wide applications in several areas like medicine, medical drugs, catalysis, energy, and materials. Those nanoparticles with small to large surface areas (1–100 nm) have several potential functions. The development of nano-chemicals has appeared as promising agents for plant growth, fertilizers, and pesticides. Nano pesticides are the best alternative to chemical formulations that are gaining researchers' attention to solve the problems associated with chemical pesticides.



WHAT ARE NANOPESTICIDES;

The term "nano pesticides" refers to pesticides fixed on a hybrid substrate, enclosed in a matrix, or functionalized as nano-carriers for environmental or enzyme-mediated triggers. Nano-sized particles are thought to explore pesticide activities in novel formulations for nano-carriers made of a variety of materials, including silica, lipids, polymers, copolymers, ceramic, metal, carbon, and others. Nanopesticides, which are very small in size, can cover a larger surface area at a very low rate. They are durable and require a less frequent application for pest control. They are also less effective against organisms that are not the target. Silver nitrate, gold chromite, zinc oxide, zinc acetate, cadmium sulfide, zinc sulfide, and carbon are nanoparticles with pesticidal properties. They can be synthesized from different plants and natural sources.



Chemical and physical systems as carrier agents in nano pesticides formulation:

| Covalent Bond | Carrier System | Formulation | Pesticides |
|------------------------|---|---|--|
| CHEMICAL | | | |
| Co-monomers | Hybrid materials | (CNT-g-PCA) | Zineb, Mancozeb |
| Multifunctional system | Peptide-polymer | Trypsin-PEG | Modulatingoostatic factor |
| Ionic bond | Hallow sphere | Calcium-alginate | Cypermethrin |
| Electrostatic complex | Polyelectrolyte complex | Clay-gelatinepGMA-dsRNA | MCPAdsRNA |
| Cluster | Metallicnanoparticles | Cu—TM Cu0, Ag0 | Thiophanatemethyl |
| PHYSICAL | | | |
| Encapsulation | Coprecipitation Polycondensation Vesicle | Polyelectrolyticinter action. Cation vesicular surfactants | Trichlorfon Acetochlor Benzoylurea-paraquat DNA, RNA Copper |
| Emulsion | Mixed micelles Pickeringemulsion Nanoemulsion Liquid crystal Liposome | mPEG13-b-PLGA5- 3Alginate-Ca++Water-in-oil Monoolein 18-99 PC-chitosan | Pyrethriny- cyclodextrin Citronella Phytantriola- cypermethrin |
| Matrix system | Hybrid materials | mPEG-PLGA | Metolachlor |
| Porous system | Grafted-NP. Sol-gel composite | 4-ethylortho-SilicateATP- biocharcolloidal silica | Benzoylurea- Fe ₂ O ₃ Glyphosate |
| Foams | Polymericemulsion | Poly (alkylene-oxide) alkanol | Glyphosateacid Acetochlor |
| Osmotic pumps | Polymeric coating | Cellulose ester/PEG/ Inorganic salt | Diazinon |

Advantages of the use of nano-pesticides over conventional pesticides:

- Nanotechnology offers a tool for developing novel formulations of eco-friendly pesticides as the majority of nano-pesticide formulations are highly target-specific.
- Generally, targeted delivery and controlled release of nano-pesticides can improve pesticide utilization and reduce residue and pollution. For example, Nano-microcapsule formulations have slow release and protection performance because they have been prepared using light-sensitive, thermo-sensitive, humidity-sensitive enzyme-sensitive, and soil pH-sensitive high polymer materials to deliver pesticides.
- Nano-pesticide formulations improve adhesion of droplets on plant surface (reduces drift losses) which intern improves

the dispersion and bio-activity of the active ingredient of pesticide molecules.

- Nano-pesticides are extraordinary means for setting up an eco-friendly and sustainable agriculture system because they reduce overall chemical usage, decrease toxic residues, and enhance overall crop protection.

LIMITATIONS:

- ✓ It remains questionable how risky nano pesticides may be to the environment and human health.
- ✓ Since nano-pesticides are much more persistent and toxic than their traditional ones, they may also result in new types of contamination of soils and waterways.

CONCLUSION:

- ✓ Nanopesticides are an important tool for sustainable pest management
- ✓ Nanotechnology can provide green and eco-friendly alternatives for insect pest management without hampering nature by using nano-biopesticides.
- ✓ It helps to reduce the waste of conventional synthetic pesticides and environmental pollution.

FUTURE PROSPECTS:

- ✓ Evaluation of nanomaterials for hazardous effects.
- ✓ Field level application of nano pesticides.
- ✓ More concern on the bio nano pesticides.

