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Nano-Particles: Recent Advances in Insect Pest Management

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Nanotechnology is the manipulation of matter on a near-atomic scale to produce new structures, materials and devices *i.e.,* having one or more dimensions of the order of 100 nanometres (100 millionth of a millimetre) or less. The technology promises scientific advancement in many sectors such as medicine, consumer products, energy, materials and manufacturing. In the natural world, there are many examples of structures with one or more nanometre dimensions, and many technologies have incidentally involved such nanostructures for many years, but only recently has it been possible to do it intentionally.

Insects are one of the biggest animal populations with a very successful evaluative history, once they can be found chiefly in all possible environments all over the world, and the number of species and individuals. Their success can be attributed to several important evolutionary aspects like wings, malleable exoskeleton, high reproductive potential, habits diversification, desiccation-resistant eggs and metamorphosis, just to name a few. On the other hand, many insects are vectors of many diseases, and many others damages crop plantations or wood structures, causing serious health and economic issues. In order to combat the numerous losses that are caused by insects on agriculture, several chemicals have been used to kill them or inhibit their reproduction and feeding habits. (Mogul *et al*. 1996). Although naturally occurring nano-structures are being neglected, they are a potentially rich source of products that meet certain specifications (Watson and Watson, 2004)

The atom-by-atom arrangement allows the manipulation of nanoparticles thus influencing their size, shape and orientation for reaction with the targeted tissues. It is now known that many insects possess ferromagnetic materials in the head, thorax and abdomen, which act as geomagnetic sensors. In this paper, our discussion is focused on nanoparticles in insects and their potential for use in insect pest management. Leiderer and Dekorsy (2008) found that targeted nanoparticles often exhibit novel characteristics like extra ordinary strength, more chemical reactivity and possess a high electrical conductivity. Thus, nanotechnology has become one of the most promising new technologies in the recent decade. Nanoparticles possess distinct physical, biological and chemical properties associated with their atomic strength.

A good example is the ordered hexagonal packed array of structures in the wings of cicada for instance, Psaltoda claripennis Ashton and termite for example, family Rhinotermitidae (Zhang and Liu, 2006). Studies have shown that the size of the nanoparticles may vary from 200 to 1000 nm. The structures tend to have a rounded shape at the apex and protrude some 150-350 nm out from the surface plane. These wing nanoparticles help in the aerodynamic efficiency of the insect. Isolated nanoparticles of insects have diameters of about 12 and 11 nm in abdomen with petiole and head with antennae, respectively. Nanostructure components are also present in compound eyes of insects. Wings of butterflies possess bright color components and these color components are nothing but nanoparticles. Recently, a novel photodegradable insecticide involving nanoparticles has been prepared (Guan *et al*., 2008).

Nano pesticides

Nano pesticides defines as any formulation that intentionally includes elements in the nm size range and/or claims novel properties associated with these small size range, it would appear that some nano pesticides have already been on the market for several years. nano pesticides encompass a great variety of products and cannot be considered as a single category. Nano pesticides can consist of organic ingredients (e.g., *a.i.*, polymers) and/or inorganic ingredients (e.g., metal oxides) in various forms (e.g., particles and micelles).

The aims of nano formulations are generally common to other pesticide formulations and consist in:

1. Increasing the apparent solubility of poorly soluble active ingredient
2. Releasing the active ingredient in a slow/targeted manner and/or protecting the active ingredient against premature degradation.

Nano formulations are expected to

- Have significant impacts on the fate of active ingredient

- Introduce new ingredients whose environmental fate is still poorly understood (e.g., nano silver).
- The current level of knowledge does not appear to allow a fair assessment of the advantages and disadvantages that will result from the use of some nano pesticides.

It is clear that a great deal of work will be required to successfully combine analytical techniques that can detect, characterize (e.g., through size, size range, shape or nature, surface properties), and quantify the active ingredient and adjutants emanating from nano formulations, and also to understand how their characteristics evolve with time, under realistic conditions.

Table 1. Several examples of polymers often used in the nanoparticle production.

S.No.	Polymer	Active compound	Nanomaterial	Reference
1.	Lignin-polyethylene glycol-ethylcellulose	Imidacloprid	Capsule	Flores-Cespedes *et al*. (2012)
2.	Polyethylene glycol	B-Cyfluthrin	Capsule	Loha *et al*. (2012)
3.	Chitosan	Etofenprox	Capsule	Hwang *et al*. (2011)
4.	Carboxymethylcellulose	Carbaryl	Capsule	Isiklan (2004)
5.	Lignin	Aldicarb	Gel	Kok *et al*. (1999)

The nanoparticles used in biopesticides controlled release formulations

The most popular shape of nanomaterials that have been using in CRFs for biocides delivery are:

- **Nanospheres:** aggregate in which the active compound is homogeneously distributed into the polymeric matrix
- **Nano capsules:** aggregate in which the active compound is concentrated near the center core, lined by the matrix polymer
- **Nanogels:** hydrophilic (generally cross-linked) polymers which can absorb high volumes of water
- **Micelles:** aggregate formed in aqueous solutions by molecules containing hydrophilic and hydrophobic moieties.

Safety of Nano insecticides

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Presentation was made in April 2010, at the EPA Pesticide Program Dialogue Committee (PPDC) meeting. The April 2010 OPP presentation included the following: "Why is OPP (Office of Pesticide Programs) Concerned?

Potential Human Health Concerns:

a. Dermal absorption (so small they may pass through cell membranes)
b. Inhalation (go to the deep lung and may translocate to the brain *i.e.*, could cross the blood brain barrier) Potential Environmental Concerns:
c. High durability or reactivity of some nano materials raises issues on the fate in environment
d. Lack of information to assess environmental exposure to engineered nano materials."

Ethics and Potential Risks of Nanoscience

According to Larrouturou (2005) sense of ethics, reflecting man's desire to enable various generations to live together harmoniously and decently drives us to analyse the moral foundations of discoveries through open debate, turning the scientist back into a concerned citizen. In the field of nanoscience, the perspective of mastering complexity at a tiny scale is used sometimes as a fallacious argument based on fear. Even if ill founded, such negative attitudes must be taken into account: engaging in public debate about ethics is a moral obligation for scientists. A first step in this debate is undoubtedly measuring and recognizing the huge gap between our understanding of a few functions at the nanometric scale and the complexity of life.

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