Nanomaterial Applications in Agricultural Pesticides

The repercussions of decades of chemical pesticide use are becoming apparent as more species of plants and insects become resistant to chemical insecticides, herbicides, and fungicides. The indiscriminate antibiotic nature of these chemical pesticides results in an accelerated acquired evolutionary resistance to pesticides. Species that survive the effects of pesticides are able to breed or pollenate with others, entrenching the resistance to these chemicals as a trait. The result of this acquired resistance is pests and weed outbreaks that are more severe, while their biological predators?checks that create balance in the ecosystem?are unable to adapt as easily.

For these reasons, researchers have been examining biological and nanomaterial alternatives to conventional organophosphate pesticides. Among potential nanomaterial pesticides, there are two prominent formulation approaches being researched. Researchers are currently designing formulations that are similar to conventional formulas, but reducing the particle sizes of the polymers, surfactants and metals to create nano-formulations that are more soluble, slower releasing, and do not prematurely degrade. The other area of nanopesticide research is in novel formulations that use either new ingredients such as nano-silver, or new delivery mechanisms such as nanoencapsulation.

In either case, the government is developing the regulatory framework necessary to manage nanoscale pesticides. The EPA has recently released rules that require new ingredients to be conditionally registered with the EPA. This rule retroactively covers all pesticides that contain nanoscale ingredients regardless of the active or inactive nature of the ingredient. According to the EPA, these rules also apply to ingredients that have identical non-nanoscale ingredients previously registered under pesticide related acts PRIA and FIFRA.

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Development Stage:

- Commercial
Key Words:

- Nanopesticides [8]
- Fate and Transport [9]
- Sustainable Agriculture [10]
- EPA [4]

Mechanism:


Summary:

The function of nanopesticides [8] is to improve the water solubility and effectiveness of conventional pesticides [2] or to create novel pesticides [2] that are more efficient and sustainable.

Function:

- Improved Efficacy [13]

Source:

Nanopesticides: Weighing the Risks and Benefits in U.S. Policy [14]

Source:

Nano-pesticides: state of knowledge, environmental fate and exposure modelling Nanopesticides: state of knowledge [15]
Nanopesticides: Weighing the Risks and Benefits in U.S. Policy [14]

Benefit Summary:

The potential benefits of developments in nanopesticides [8] are immense. Nanopesticides [8] may be more effective and degrade slower in their intended environment, making them more cost effective and reducing overall pesticide consumption while maintaining crop yields and food security. This will likely have a secondary benefit of reducing the resource inputs into pesticide manufacturing and reducing the amount of pollution, but more research is necessary to confirm
these industry claims.

**Benefit:**

- Resource Efficiency [16]
- Environmental Quality [17]

**Risk Summary:**

The risks associated with nanoscale pesticides [2] are complex and uncertain. The fate, transport and bioaccumulation of nanoscale materials [18] is poorly studied. However, scientific reviews of nanopesticides [8] conclude that the fate and transport [9] of these pesticides [2] will be much different from that of conventional pesticides [2]. The EPA [4] has acknowledged this and incorporated a list of required tests into their conditional registration of new nanoscale ingredients in pesticides [2]. Nanoparticles [19] have are small enough to enter deep into the lungs and enter the blood stream, making materials [18] that are biologically benign in large particle form cytotoxic at the nanoscale. Additionally, it is not understood how the pesticides [2] will bioaccumulate in crops and whether or not this will have human health [20] and condition impacts in the mid-to long term. There is already debate over how chemical pesticides [2] have impacted human health [20] to this point. Additionally, the rush to DDT during the green revolution posed significant ecological and human health [20] risks before being banned. Regulators are taking a middle ground approach of approving these pesticides [2] before they have been studied comprehensively, but forcing manufacturers to perform tests and studies upon registration.

**Risk Characterization:**

- Complex [21]
- Uncertain [22]

**Risk Assessment:**

- Ecological Risks [23]
- Explosive Risks [24]
- Health Risks [25]
- Human Condition Risks [26]

**Facility:**

- Food Systems [27]
Substitute:

- **Pesticides** [28]

Challenge Area:

- **Biodiversity and Natural Open Spaces** [29]

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[1] https://nice.asu.edu/nano/nanomaterial-applications-agricultural-pesticides
[2] https://nice.asu.edu/keywords/pesticides
[3] https://nice.asu.edu/keywords/nanoencapsulation
[4] https://nice.asu.edu/keywords/epa
[8] https://nice.asu.edu/keywords/nanopesticides
[10] https://nice.asu.edu/keywords/sustainable-agriculture
[12] https://nice.asu.edu/keywords/water
[13] https://nice.asu.edu/function/improved-efficacy
[16] https://nice.asu.edu/benefit/resource-efficiency
[17] https://nice.asu.edu/benefit/environmental-quality
[18] https://nice.asu.edu/keywords/materials
[19] https://nice.asu.edu/keywords/nanoparticles
[20] https://nice.asu.edu/keywords/health
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[28] https://nice.asu.edu/substitute/pesticides
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