Use of nanotechnology In the Development of Organic Fertilizers and Pesticides

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Abstract

It cannot be denied that the development of technology and its use is closely related to the increase in the competitiveness of a country's industry. Greater knowledge and mastery of new technologies is needed to win competition in the age of global trade by both government and industry. An example of technology that is being discussed is nanotechnology. The use of nanotechnology is well known, including in the fields of health, cosmetics and agriculture. Basically, the principle of nanotechnology discovery is to maximize crop yield or production by minimizing the use of fertilizers, pesticides, and other necessities by monitoring soil conditions, such as roots, and applying them directly to the target so nothing goes to waste. For pesticides, if this is applied, you will be able to minimize the use of pesticides on plants because only the target insects are affected. The use of nanotechnology in fertilizers will allow the release of the nutrients contained in the fertilizer to be controlled. Therefore, only the nutrients that will actually be taken up by the plants are released, so there is no loss of nutrients, no undesirable targets such as soil, water, and microorganisms. In nanofertilizers, the nutrients can be in the form of encapsulation of nanomaterials, covered by a thin protective layer or released in the form of an emulsion from nanoparticles.

Keywords: nanotechnology, fertilizers, pesticides

A. INTRODUCTION

It is undeniable that the development of technology and its use are closely related to increasing the competitiveness of a country's industry. Greater knowledge and mastery of new technologies is needed to win competition in the age of global trade by both government and industry. An example of technology the topic of discussion is nanotechnology. Use of nanotechnology already well known, including in the health, cosmetics and agriculture industries.

Based on the origin of the word, "nano" itself comes from the Latin meaning something very small (dwarf) or one in a billion (10-9). Nanotechnology is defined as a science that deals with objects of size 1 to 100 nm, have properties different from the original material, and have the ability to control or manipulate on an atomic scale (Kuzma and Verhage, 2006). Twitching the development of nanotechnology contributes a lot to the development of new materials that are smaller and more detailed. In the field of health, this technology is aimed at developing a virus that functions as a nano-camera to see and study the sequence of cell life and the mechanism of action of the virus itself. In addition, a biotech company is working to develop Fullerenes, or Buckyball, a molecular structure with 60 carbon atoms that is expected to eliminate the HIV virus and cancer in the future.

Application of nanotechnology in agriculture including genetic engineering to obtain superior seeds. Some world scientists have carried out research to improve some of the properties of plants, for example, to produce virus-free plants. In the last ten years, the application of nanotechnology in agriculture has matured with the discovery of the unique properties of particles that are several nanometers or even tens of nanometers in size. Nanoparticles and nanoemulsions can be applied to pesticides, fertilizers, soil monitoring sensors, animal feed, animal medicine, food, herbal medicine, and antibacterial packaging and anti-gas compounding. Nanotechnology is also widely used in various ways, such as increasing the efficient use of fertilizers and natural ingredients in the soil, studying the mechanism and dynamics of nutrient elements in the soil.

B. METHOD

This research method uses the qualitative analysis method, where the qualitative research process by the researchers is carried out by studying the literature and research that is relevant to the topic. The character of qualitative research is a holistic account, in which the researcher seeks to carry out a complete study of the research problem so that the study is carried out from many aspects. In this way, it is expected that the investigation can visualize the problem clearly and completely.

C. RESULT AND DISCUSSION

Benefits of nanotechnology in agriculture

Basically, the principle of nanotechnology discovery is to maximize crop yield or production by minimizing the use of fertilizers, pesticides, and other necessities by monitoring soil conditions, such as roots, and applying them directly to the target so nothing goes to waste. For pesticides, if this is applied, you will be able to minimize the use of pesticides on plants because only the target insects are affected.

The use of nanotechnology in fertilizers will allow the release of the nutrients contained in the fertilizer to be controlled. Therefore, only the nutrients that will actually be taken up by the plants are released, so there is no loss of nutrients, no undesirable targets such as soil, water, and microorganisms. In nanofertilizers, the nutrients can be in the form of encapsulation of nanomaterials, covered by a thin protective layer or released in the form of an emulsion from nanoparticles.

Examples of applications of nanotechnology in agriculture in an effort to increase agricultural productivity are reported, among others, nanoporous, nanonutrients, slow release, nanoencapsulation, nanosensors for fertilizers, water, herbicides, soil stability, etc. The use of nanotechnology in pesticides is done by Dr. Micaela Buteler working with Prof. Weaver of Montana State University. Both researchers tested the use of NSA (nanostructured alumina) on two types of insect intruders commonly found in the process of milling, processing, and storing dry beans. Research shows that the NSA can provide cheap and affordable insecticide alternatives.

The development of nanotechnology in pesticides, both in chemical pesticides and in organic pesticides, may help to improve the efficiency in the use of pesticides and insecticides. In addition, using pesticides directly on the target will minimize the development of resistance mechanisms in pests and reduce non-target insect kills. This will undoubtedly have a positive impact on agricultural production, because there are many previous cases in which certain pests have exploded due to the inappropriate use of pesticides.

Nanotechnology in organic pesticides can be done by developing toxic materials contained in plants or organic materials to the size of nanoparticles so that it is easier to hit the target and the amount of pesticides needed is even less. But like other technologies, the use of nanotechnology in pesticides has two different sides. Some experts believe that nanometer-sized pesticides may be dangerous to humans because they can infect the skin or be inhaled and enter the lungs and then reach the brain. It is still a debate whether this technology can be used and developed or, better yet, cannot be used.

The development of organic pesticides is increasing rapidly in line with the growing public understanding of the dangers of synthetic chemicals in pesticides in use today. Nanotechnology is expected to be able to solve this problem. The effectiveness of pesticides, which can be increased many times by converting them into nanoparticles, can be used as a base for the application of organic pesticides of plant origin such as rosemary, cloves, lavender, basil and some other essential oils that have the potential to become pesticides of plant origin. With the nanotechnology approach, active substances from natural ingredients can be a powerful weapon to control plant pests and can replace chemical pesticides.

Organic pesticides made from extracts of various plants, as mentioned above, have great potential as natural ingredients to make pesticides that are applied in agriculture to control plant pests. A study presented by scientists at the 238th national meeting of the American Chemical Society in Canada claims that some of the natural substances in some plants called "essential oil pesticides" or "killer spices" are potential natural pesticides that are friendly to the environment. and relatively less risky for human and animal health. It's just that this organic pesticide is not long lasting because it is volatile and breaks down easily in sunlight. The role of nanotechnology in the development of organic pesticides is expected to be an answer to how to make this organic pesticide able to compete with pesticides that have long been circulating in the community for both their toxic properties and their ability to survive in nature with slow release technology.

Nano Technology and Environment

Nanotechnology can be used to break down pesticide residues in water, air and soil through the mechanism of metal oxide photocatalysts using materials made from semiconductor oxides such as titanium oxide (TiO2) and oxide of zinc (ZnO). This material can absorb photons and initiate the oxidation-reduction (redox) process to break down complex organic molecules into simpler ones. Through the process of photocatalysis, pesticide residues can be turned into useful minerals that do not harm the environment.

Photocatalysis is defined as a combination of photochemical and catalytic processes, a chemical transformation process in which light intervenes as a catalyst that will accelerate the transformation. The process that occurs is that TiO2 that is irradiated with ultraviolet light will produce e- and H+ electrons. The recombination of the two on the surface will be reduced by poisons, contaminants, or microorganisms. e- will interact with O2 to produce O2- (reduction) and H+ will interact with H2O to produce OH- and H2O (oxidation).

The oxidizing power has been shown to destroy contaminants and harmful microorganisms. The same method is expected to be capable of degrading contaminants from pesticide residues in the environment. The limited availability of ultraviolet in nature is one of the factors that inhibits the application of this technology. The effort developed as an alternative is to add dopen, which is a semiconductor that has a relatively wider bandgap, for example, by adding manganese, lead, sulfur, and nitrogen. This semiconductor will be able to transfer electrons to the photocatalyst system. In this way, the material will have a greater capacity to absorb visible light, so it will not be too dependent on ultraviolet light.

Nanotechnology features

The specialty of the properties of nanomaterials is that they can penetrate faster and their properties can be very different from the properties it possesses when the substance is still larger in size. For example, aurum (gold) will be highly toxic when nanometer in size, copper (Cu) has harder properties, and ferromagnetic will be superparamagnetic at 20 nm in size. This method can be adapted for chemicals made from organic materials such as pyrethrin, which is produced from pyrethrium and synthesized for use as an insecticide. Nano-sized pyrethrin is expected to be more toxic and more optimally penetrate target insects, although side effects on humans and the environment, such as the potential for humans to inhale it and how long it can last, need to be looked at again. degrade in nature. .

According to the research results, the nanometer-sized material has a number of chemical and physical properties that are superior to large-sized materials such as micro.

These properties can be changed by controlling the size of the material, setting the chemical composition, modifying the surface, and controlling the interaction between particles. The wealth of Ecuador's natural resources has enormous potential for the development of nanotechnology. The diversity of Ecuador's biological natural resources, the tropical nature and the volcanoes scattered throughout the territory of Ecuador is a provider of minerals for the fertility of the climate and soil that are ideal for the cultivation of various plants, both food crops, hard and medicinal woods. Through nanotechnology engineering, natural medicinal ingredients (herbs) can be used as medicines (biopharmacy). Similarly, plant material that has the potential to control pests can be used as an effective, efficient, and environmentally friendly organic pesticide through the use of nanotechnology.

Plant pesticides that have been made into nanoparticles include the plant pesticide neem (Azadirachta indica) (Forim, 2011). The many uses of neem pesticides cannot be separated from the efficacy of these pesticides on various types of plant pests (Kardinan, 1999). Forim fabricated nanocapsules (Figure 1) with average diameters ranging from 150 to 250 nm.

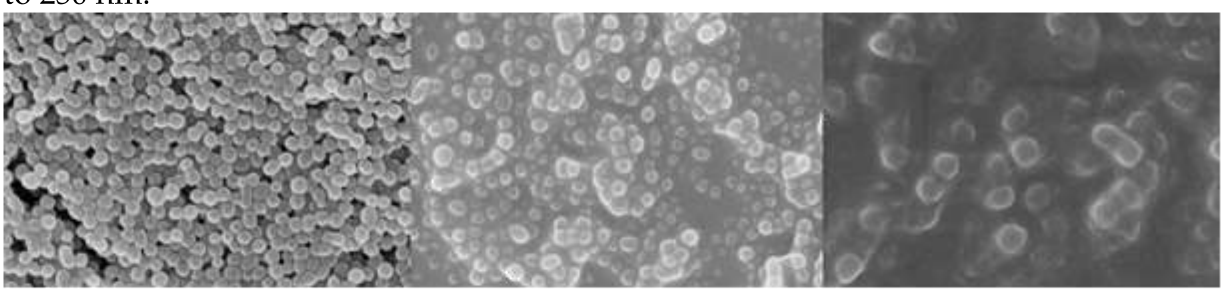

Figure 1. Nanocapsules containing neem extract at various magnifications using SEM.

Capsules that have been filled are on average larger in size than capsules that have not been filled, as shown by Kalyanasundaram's research (Figures 2a and b), Kalyanasundaram uses PVP (polyvinylpyrrolidone) emulsion as a material to make nanocapsules. In the image it can be seen that the capsules that have been filled with larvicides are larger than the empty capsules (Kalyanasundaram, 2013).

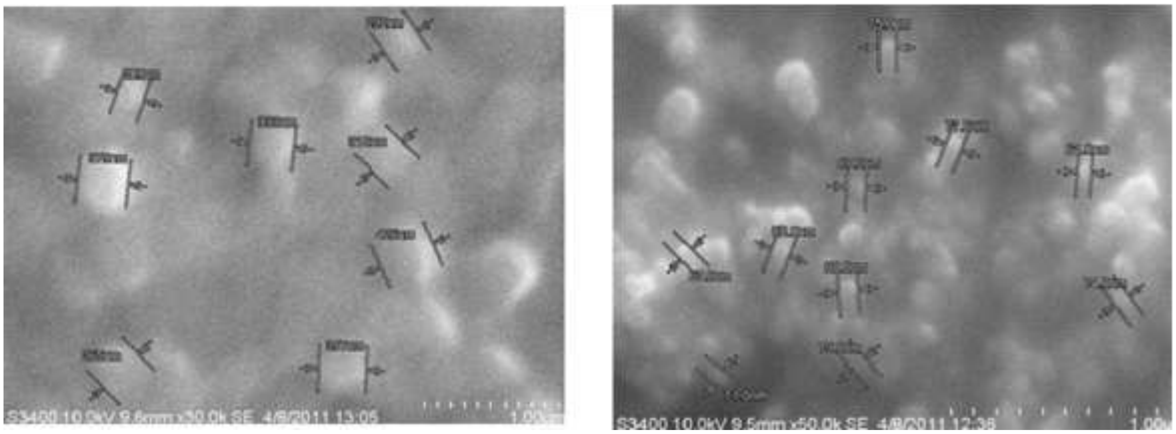

Figure 2 . PVP nanocapsules without larvicides and contain temephos

Some methods to produce nanoparticles

1. **coprecipitation method**

   It is a method of synthesis of organic compounds based on the deposition of more than one substance together when it passes through a saturation point. The process uses low temperatures and is easy to control the size of the particles, so the time required is relatively short. Normally, the precipitating agent used is hydroxide, carbonate, sulfate and oxalate. Using this method is expected to produce smaller and more homogeneous particles than the solid-gel method and larger than the sol-gel method. There are two important types of coprecipitation that are related to the adsorption on the surface of the particles exposed to the solution and the second is the one that is associated with the occlusion of foreign substances during the crystalline growth process of the primary particles.

2. **The sol-gel method**

   It is the process of formation of inorganic compounds through chemical reactions in solution at low temperatures, where a phase change occurs from the colloidal suspension (sol) to form a continuous liquid phase (gel). The advantage of this method is a good level of thermal stability, high mechanical stability, good resistance to solvents, and surface modification can be done in various ways. Commonly used precursors are organic metals or inorganic metals that are surrounded by reactive ligands, such as alcosides, which are mainly used because they are easy to react with water.

   The stages of the sol-gel process:

   a. Hydrolysis: in this stage the precursors are dissolved in alcohol and hydrolyzed with the addition of water under acidic, neutral or basic conditions and produce a colloidal sol. This process is influenced by the water/precursor ratio and the type of catalyst used.

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B. Condensation: the sol-to-gel transition involves a hydroxyl ligand to produce a polymer with a MOM bond
C. Maturation: a reaction in the formation of gel tissue that is stronger, stiffer, and shrinks in solution
D. Drying: The process of evaporating liquids and unwanted liquids to obtain a sol-gel structure having a high surface area. Compared with conventional methods, this method has several advantages, namely: better homogeneity, higher purity, relatively low process temperatures, does not react with residual compounds, solvent losses can be reduced, and air pollution can be reduced. The disadvantages are the price of expensive raw materials, there is a significant shrinkage of the materials on drying, the use of organic compounds that can endanger health and produce hydroxyl and carbon residues, as well as time-consuming processes.

3. **microemulsion method**

In early 1943, Hoar and Schulman reported that a combination of water, oil, surfactants, and alcohols or amines that were cosurfactants produced a clear, homogeneous solution called a microemulsion. In general, microemulsions can be distinguished from forward (oil-in-water) microemulsions and inverse (water-in-oil) microemulsions.

4. **Hydrothermal/solvothermal method**

The German chemist Robert Whilhelm Busen (1839) used an aqueous solution as a medium and placed it in a tube at a temperature greater than 2000C and a pressure greater than 100 bar. The solvothermal process involves the use of a solvent above its boiling temperature and pressure so that it results in an increase in the solubility of the solids and the rate of reaction between the solids. This process must occur in a closed state to avoid loss of solvents when they evaporate. Posthydrothermal is a treatment of a material after undergoing a sol-gel process with the aim of increasing the crystallization of the particles. This method uses supercritical solvents with several considerations, namely:
1. It has a low surface tension, so its dissolution capacity is high
2. Low viscosity
3. High diffusivity so it has an effect on increasing solubility.

5. **Template synthesis method**

The template used is called a nanoreactor. The smooth and uniform pore size helps nanoparticles to form according to their size and controls the size distribution in the final product. There are two types of methods used to introduce semiconductor nanoparticles into the pore of the mesoporous material, namely:

1. In situ/post-treatment process that mixes nanoparticle precursors with micelles prior to formation of mesoporous material.
2. Directly graft/attach nanoparticles onto the pore surface.

6. **Organic Semiconductor Nanoparticles**
It is a semiconductor that uses organic material as the active material. Organic semiconductors are easier to synthesize and more mechanically flexible. The main mechanism of this semiconductor involves conduction via pi electrons or unpaired electrons. The method used to make organic nanoparticles is a precipitation method with a mechanism of solute solution of the starting material in the water that is infused into the water so that the solubility of the substance changes suddenly and causes the nanocrystal to form solute.

D. CONCLUSION

The use of nanotechnology is well known, including in the fields of health, cosmetics and agriculture. Basically, the principle of nanotechnology discovery is to maximize crop yield or production by minimizing the use of fertilizers, pesticides, and other necessities by monitoring soil conditions, such as roots, and applying them directly to the target so nothing goes to waste.

Nanotechnology can be used to break down pesticide residues in water, air and soil through the mechanism of metal oxide photocatalysts using materials made from semiconductor oxides such as titanium oxide (TiO2) and oxide of zinc (ZnO). Through the photocatalyst process, transforming pesticide residues into materials that do not endanger the environment.

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