Utilization of Nanotechnology in the Development of Organic Fertilizers and Pesticides

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Abstract

The development of technology and its utilization cannot be denied that it is closely related to increasing the competitiveness of a country's industry. Increased knowledge and mastery of new technology is needed to win the competition in the era of global trade both by the government and industry. One example of technology that is being discussed hot is nanotechnology. The use of nano technology is well known, including in the fields of health, cosmetics and agriculture. Basically, the principle of nanotechnology discovery is to maximize yield or crop production by minimizing the use of fertilizers, pesticides and other needs by monitoring soil conditions such as roots and applying them directly to the target so that nothing is wasted. For pesticides, if this is applied it will be able to minimize the use of pesticides on plants because only target insects are affected. The use of nano technology in fertilizers will allow the release of nutrients contained in the fertilizer can be controlled. So only nutrients that will actually be absorbed by plants are released, so that there is no loss of nutrients there are undesirable targets such as soil, water and microorganisms. In nano fertilizers, nutrients can be in the form of nanomaterial encapsulation, coating by a thin protective layer or released in the form of an emulsion from nanoparticles.

Keywords: *Nano Technology*, *Fertilizer*, *Pesticides.*

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A. INTRODUCTION

The development of technology and its use is undeniably closely related by increasing the competitiveness of a country's industry. Increased knowledge and mastery of new technology is needed to win the competition at the era of global trade both by government and industry. One example of technology the topic of discussion is nanotechnology. Utilization of nanotechnology already well known including in the health, cosmetics and agriculture industries.

Based on the origin of the word, "nano" itself comes from Latin which means something very small (dwarf) or one by one billion (10^{-9}). Nano technology is defined as a science that deals with objects of size 1 up to 100 nm, has different properties from the original material and has the ability to control or manipulate at the atomic scale (Kuzma & 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 directed at the development of a virus that functions as a nanocamera

to see and study the sequence of cell life and the mechanism of action of the virus itself. In addition, a biotechnology company is working to develop Fullerenes or Buckyball, a molecular structure with 60 carbon atoms which is expected to kill the HIV virus and cancer in the future.

Application of nanotechnology in agriculture including genetic engineering to get superior seeds. Some world scientists have conducted research to improve some of the properties of plants for example to produce plants free of viruses. 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 nano-sized or even tens of nanometers in size. Nanoperticles and nanoemulsions can be applied to pesticides, fertilizers, sensors to monitor soil, animal feed, animal medicine, food, herbal medicines and antibacterial packaging and anti-gas composites composites. 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 qualitative analysis method, where the process of qualitative research by investigators conducted by way of study literature and researches that are relevant to the topic. Character of qualitative research is a holistic account, in which the researcher seeks to conduct a complete study of the research problem so that the study is carried out from many aspects. In this way the research is expected to be able to visualize the problem clearly and completely.

C. RESULT AND DISCUSSION

1. Benefits of Nano Technology in Agriculture

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

The use of nanotechnology in fertilizers will allow the release of nutrients contained in the fertilizer can be controlled. So only nutrients that will actually be absorbed by plants are released, so that there is no loss of nutrients there are undesirable targets such as soil, water and microorganisms. In nano fertilizers, nutrients can be in the form of nanomaterial encapsulation, coating 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, nanonutrient, slow-released, nanoencapsulation, nanosensors for fertilizer, water, herbicides, soil stability

and so on. The use of nanotechnology in pesticides is done by Buteler is working with Prof. Weaver from Montana State University. Both researchers tested the use of NSA (nanostructured alumina) in two types of intruding insects that are commonly found in the process of grinding, processing and storing dry grain. Research shows that NSA can provide cheap and affordable insecticide alternatives.

The development of nanotechnology in pesticides both chemical pesticides and organic pesticides will be able to help improve the efficiency of the use of pesticides and insecticides. Furthermore, the use of pesticides directly on the target will minimize the development of resistance mechanisms in pests and reduce the death of non-target insects. This will certainly have a positive impact on agricultural production, because there are many previous cases where certain pests have exploded due to inappropriate use of pesticides.

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

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

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

2. Nano Technology and the Environment

Nanotechnology can be used to degrade pesticide residues in water, air and soil through the mechanism of metal oxide photocatalysts by using materials made from semiconductor oxides such as titanium oxide (TiO_2) and Zinc oxide (ZnO). This material can absorb photons and initiate the oxidation reduction process (redox) so that it will break down complex organic molecules into simpler molecules. Through the process of photocatalysis, pesticide residues can be converted into useful minerals that do not harm the environment.

Photocatalysis is defined as a combination of photochemical and catalyst processes, a process of chemical transformation involving light as a catalyst that will accelerate the transformation. The process that occurs is that TiO_2 which is irradiated by ultraviolet light will produce electrons e^- and H^+. The recombination of the two on the surface will be reduced by poisons or contaminants or microorganisms. e^- will interact with O_2 to produce O_{2-} (reduction) and H^+ will interact with H_2O to produce OH^- and H_2O (oxidation).

Oxidation power is proven to destroy pollutants and harmful microorganisms. The same method is expected to be able to degrade pollutants from pesticide residues in the environment. 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 semi conductor which has a relatively wider bandgap, for example by the addition of manganese, lead, sulfur and nitrogen. This semi conductor will be able to transfer electrons to the photocatalyst system. In this way the material will have the ability to absorb visible light will be higher so it is not too dependent on ultraviolet light.

3. Features of Nano Technology

The specialty of nanomaterial properties is that it is able to penetrate faster and its properties can be very different from the properties it possesses when the substance is still in a larger size. For example aurum (gold) will be very toxic when nano-sized, copper (Cu) has harder properties and ferromagnetic will be superparamagnetic at a size of 20 nm. This method can be adapted for chemicals from organic materials such as pyretrin which is produced by pyretrium and is synthesized for use as an insecticide. Pyretrin in nano size is expected to be more toxic and to penetrate more optimally on target insects although it has to be seen again the side effects on humans and the environment such as the possibility of inhalation by humans and how long it can be degraded in nature.

According to the results of research nanometer size material has a number of chemical and physical properties that are superior to large size materials such as micro. These properties can be changed through 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 holds enormous potential for the development of nanotechnology. The diversity of Ecuador's biological natural resources, tropical nature and volcanoes scattered throughout the territory of Ecuador is a provider of climate and soil fertility minerals that are ideal for growing various plants both food crops, hardwoods and medicine. Through nanotechnology engineering, medicinal natural ingredients (herbs) can be used as medicines (biopharmaca). Similarly, plant material that has the potential to control pests can be used as an effective, efficient and environmentally friendly organic pesticide by utilizing nanotechnology.

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

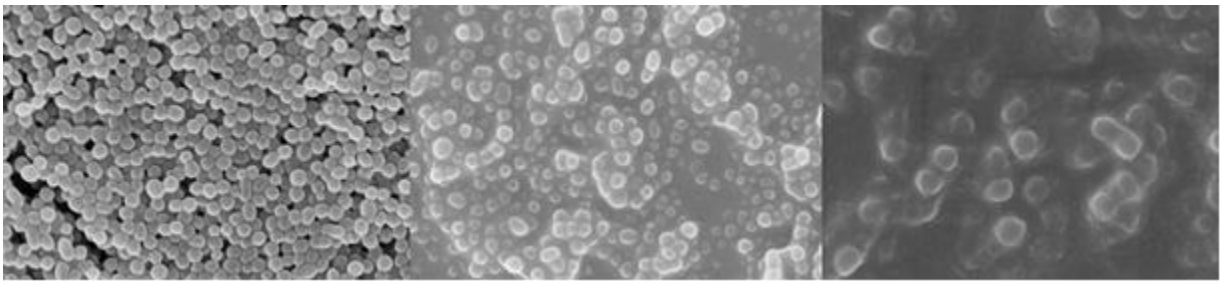

Figure 1 Nanocapsules Containing Neem Extract with Various Magnifications using SEM

Capsules that have been filled on average have a larger size than capsules that have not been filled, as shown by Kalyanasundaram research (figures 2a and b), Kalyanasundaram uses PVP (Polyvinylpirrolidone) emulsion as a material for making nanocapsules. It can be seen from the picture that the capsules that have been filled with larvicides are larger than the empty capsules (Kalyanasundaram, 2013).

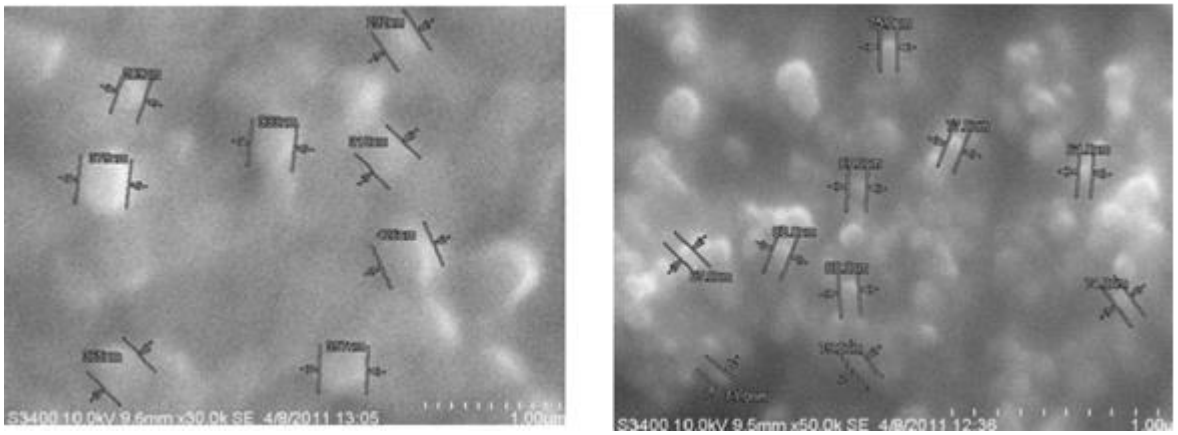

Figure 2 PVP Nanocapsules without Larvicides and Contain Temefos

4. Some Methods for Producing Nanoparticles

Coprecipitation Method

It is a synthetic method 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 particle size so the time required is relatively short. Usually the precipitating agent used is hydroxide, carbonate, sulfate and oxalate. The use of this method is expected to produce particles that are smaller and more homogeneous than the solid-gel method and larger than the sol-gel method.

There are two important types of coprecipitation that are related to adsorption on the surface of particles exposed to the solution and the second is that which is associated with occlusion of foreign substances during the process of crystal growth of primary particles.

The sol-gel method

It is the process of forming inorganic compounds through chemical reactions in solution at low temperatures, where there is a change in the phase of 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 solvent resistance and surface modification can be done with various possibilities. Commonly used precursors are organic metals or inorganic metals which are surrounded by reactive ligands such as alkosides which are mostly used because they are easy to react with water.

The stages of the sol-gel process:

a. Hydrolysis: at 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.
b. Condensation: the transition from sol to gel involves a hydroxyl ligand to produce a polymer with an M-O-M bond
c. Maturing: a reaction in the formation of gel tissue that is stronger, stiffer and shrinks in solution
d. Drying: the process of evaporation of liquids and unwanted liquids for get a sol-gel structure that has a high surface area. Compared to conventional methods, this method has several advantages, namely: better homogeneity, higher purity, relatively low process temperatures, no reaction 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 materials when drying, using organic compounds that can endanger health and produce hydroxyl residues and carbon as well as processes that require a long time.

So that the results obtained in accordance with the desired there are several factors that must be considered, namely:

a. Compounds: precursors must be soluble in the reaction media and must be sufficiently reactive in gel formation
b. Catalysts: Acid or base catalysts are usually used even though there are some that do not use catalysts
c. Solvents: the most widely used is alcohol because it has a higher vapor pressure at room temperature
d. Temperature: temperatures higher than room temperature will produce faster hydrolysis rates and gels will form more quickly

Microemulsion Method

Early in 1943 Hoar and Schulman reported that a combination of water, oil, surfactants and alcohols or amines which were co-surfactants produced a clear and homogeneous solution called microemulsion. In general, microemulsions can be distinguished from direct microemulsions (oil in water) and reverse microemulsions (water in oil).

Hydrothermal/Solvothermal Method

The German chemist Busen (1839) used aqueous solution as a medium and placed it in a tube at temperature above 2000C and pressure above 100 barr. The solvothermal process involves the use of a solvent above its boiling temperature and pressure so that it will result in an increase in the solubility of the solids and the speed of reaction between solids. This process must occur in a closed state to prevent the loss of solvents when evaporated. Post hydrothermal is an amterial treatment 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:

a. Has a low surface tension so that its ability to dissolve is high
b. Low viscosity
c. High diffusivity so that it has an effect on increasing solubility.

Templated Synthesis Method

The mold used is called a nanoreactor. Smooth and uniform pore size helps nano particles form according to their size and control distribution size on the final product. There are two types of methods used to enter semiconductor nanoparticles into the pore of mesoporous material, namely:

a. In situ/post treatment process that is mixing nanoparticle precursors with micelles before the formation of mesoporous material.
b. Grafting/attaching directly nanoparticles into the pore surface.

Organic semi-conductor nanoparticles

Is a semiconductor that uses organic material as a material active. Organic semiconductors are easier to synthesize and more flexible mechanic. The main mechanism of this semiconductor involves conducting through pi electrons or unpaired electrons. The method used to make Organic nanoparticles are a method of precipitation with a solute solution mechanism from the starting material in the water is infused into the water so that the solubility of the substance will change suddenly and cause 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 yield or crop production by minimizing the use of fertilizers, pesticides and other needs by monitoring soil conditions such as roots and applying them directly to the target so that nothing is wasted. Nanotechnology can be used to degrade pesticide residues in water, air and soil through the mechanism of metal oxide photocatalysts by using materials made from semiconductor oxides such as titanium oxide (TiO2) and Zinc oxide (ZnO). Through the photocatalyst process, changing pesticide residues into materials that do not endanger the environment.

The specialty of nanomaterial properties is that it is able to penetrate faster and its properties can be very different from the properties it possesses when the substance is still in a larger size. For example aurum (gold) will be very toxic when nano-sized, copper (Cu) has harder properties and ferromagnetic will be superparamagnetic at a size of 20 nm. Some methods for producing nanoparticles include: Coprecipitation Method, The sol-gel method, Microemulsion Method, Hydrothermal/solvothermal method, Meode Prints, and Nano pertikel organic semiconductors.

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