

# Comparison of nanomaterial Ag and nanomaterial TiO<sub>2</sub> in food fields

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**Abstract.** With the development of society, nanotechnology is being used in all aspects of life. Concerns about the application and safety of nanotechnology in the food industry are also increasing. In this study, the hidden risks and benefits of nanotechnology in the food industry will be analyzed and discussed in depth. The main purpose of the study is to research the uses, benefits and drawbacks of two nanomaterials, Ag and TiO<sub>2</sub>, in the food sector. This paper initially discusses the use of Ag and TiO<sub>2</sub> in three distinct food-related domains and the advantages and disadvantages of nanomaterials Ag and TiO<sub>2</sub> in this field. Finally, the benefits and drawbacks of the two materials in three different sectors are contrasted. According to the study's findings, each of the two nanoparticles has benefits over the other when it comes to fighting bacteria in food. The whitening qualities of TiO<sub>2</sub> nanoparticles make them excellent food additives. For storing and preserving food, experts prefer to choose Ag nanoparticles. TiO<sub>2</sub> nanoparticles may effectively destroy harmful germs in contact with food when exposed to ultraviolet light, enhancing food safety. According to this study, scientists can further allay public concerns about nanoparticle technology and increase the safety of using nanotechnology in food in the future.

**Keywords:** Nanoparticles Ag, Nanoparticles TiO<sub>2</sub>, Comparison, Food fields.

## 1. Introduction

Food is an indispensable necessity in human life. With the continuous progress of science and technology in the world, scientists pay more attention to the food field, so as to improve food production, packaging, and transportation. According to a paper titled "Production and Application of Nanomaterials in Food" written in 2017, new foods, additives, and food packaging materials are where nanomaterials are used in food the most. An essential area of development for food additives is the use of nanoencapsulation materials that are loaded with active chemicals. They can be used to extend food's shelf life and improve the bioavailability of bioactive components because they are filled with active compounds [1].

It is very important for the research of nanomaterials in the food field. Nanomaterials include many kinds, such as nanomaterials silver, chitosan, zinc oxide and titanium dioxide. Different nanomaterials play distinct roles in the application of food. What is the impact of these nanomaterials on food safety? What role do different nanomaterials play in the food field? What are the advantages and disadvantages of these materials? These questions cannot only answer some of people's doubts in the field of food in life but also have great significance for scientists to explore nanomaterials in food.

This study describes the applications of nanomaterials Ag and TiO<sub>2</sub> in food fields separately, which are food production, food preservation packing, and antibiosis or antibacterial activity. The benefits and drawbacks of the two materials are compared at the same time. Finally, the study compares two nonmaterial to present their similarity and difference.

## 2. Nanomaterial Ag

### 2.1. Application of Nanomaterial Ag for Food Additive

According to research, nanoparticles are typically added directly to food additives as ingredients, but they can also enter food additives through synthesis or nanoscale packaging materials. One of these is nanosilver [2]. There is not much application of nanomaterial silver that can add to food directly as a food additive. The application of nanoparticles silver as a food additive is related to nanoparticle synthesis. Ascorbic acid which is also called Vitamin C is a natural food additive. Silver nanoparticles are used as food additives through the synthesis of ascorbic acid. Silver nano seeds are produced by the reduction of silver ions in the presence of ascorbic acid, and the continued precipitation of silver atoms in the presence of vinylpyrrolidone continues to grow [3]. In this process, the ascorbic acid plays an important role.

### 2.2. Application of Nanomaterial Ag for Food Preservation Packing

Nanoparticle silver is one of the most common materials applied to food packing. Because nano silver can have a specific oxidation effect on ethylene oxidation, it has a good preservation effect. By including the proper amount of nano-silver in the food preservation packaging materials, the ethylene oxidation rate can be sped up. Second, stable nanosilver is difficult to wave and dissolve [4]. Researchers discovered that cucumbers and creamy strawberries may efficiently retain their storage quality when wrapped in nano-silver cling film. Another discovery was that nanosilver composite coating enhanced coating stability and reduced the growth of germs in eggs [5]. Those examples explain why Nano Ag is popular in food packing.

### 2.3. Application of Nanomaterial Ag for antibiotic or antimicrobial activity.

Nanomaterial silver is by far the most studied antibacterial nanoparticle by scientists because of its extensive inhibitory effect against gram-positive and gram-negative bacteria, yeasts, molds, and viruses. The bactericidal properties of silver nanoparticles increase as surface area increases and size decreases [1]. In general, nanoparticles cannot be larger than 50 nm without negatively affecting their performance. The antibacterial activity is improved when the nanoparticle's diameter is reduced since it means the particle can penetrate the bacterial mucosa more effectively. The nanoparticles Ag take these traits as their advantages. A 15 nm-diameter cluster of AgNPs is present in the silver-water dispersion solution, which was created using an electro-colloidal method [6]. Researchers examined the effectiveness of modified nano TiO<sub>2</sub>-soy protein isolate antibacterial cling film and discovered that it had the best antibacterial performance against *Listeria* and *Escherichia coli* [7]. Hence, the nanoparticles Ag are most popular antibacterial nanoparticle.

## 3. Nanomaterial TiO<sub>2</sub>

### 3.1. Application of Nanomaterial TiO<sub>2</sub> for Food Additive

Nanoparticles TiO<sub>2</sub> have wide applications in food additives. Since titanium dioxide has been proved in studies to have brightening and whitening properties, it is frequently used as a food additive pigment in products like candy, chocolate, bread, and snacks. It is titanium oxide found naturally. [8]. Wine, nuts, dried vegetables, sunflower seeds and mustard greens, which are non-white foods, have titanium dioxide in their flavor enhancers and food additives [1]. The major application of nanoparticles TiO<sub>2</sub> in the food industry and processing is to be a food additive. The use of TiO<sub>2</sub> in food additives has received approval

from the European Union and the U.S. Drug and Food Administration since 2002. The amount of titanium dioxide added is restricted by the US Food and Drug Administration to one percent of the mass. The European Union does not, however, establish a cap [9].

### *3.2. Application of Nanomaterial $\text{TiO}_2$ for Food Preservation Packing*

Nanomaterial  $\text{TiO}_2$  is also a wonderful material in the application of food preservation packing because of its good antibacterial properties, high mechanical strength and strong barrier ability.

$\text{TiO}_2$  is more effective in blocking UV light, which makes it a good choice for food storage [10]. By avoiding direct UV exposure, foods like meat are protected from vitamin and aromatic component oxidation as well as food degradation [4]. During the preservation of fruits and vegetables, ethylene is broken down into water and carbon dioxide using the photocatalysis of titanium dioxide. Fruits and vegetables could be preserved for a longer amount of time if this reduces the level of ethylene [11]. Nanoparticle  $\text{TiO}_2$  is very important in the application of food preservation packing.

### *3.3. Application of Nanomaterial $\text{TiO}_2$ for antibiosis or antibacterial activity*

According to researchers found, the nanoparticle  $\text{TiO}_2$  has around 30 nm diameters. This diameter is not good for a nanoparticle that plays in the field of antibacterial, but when God closes a door, he always opens a window. Scientists represented that titanium dioxide nanoparticles have better chemical and physical properties, and its non-toxic crystal structure that is stable [12]. Researchers examined the effectiveness of modified nano  $\text{TiO}_2$ -soy protein isolate antibacterial cling film and discovered that it had the best antibacterial performance against *Listeria* and *Escherichia coli* [11]. Consequently, nanomaterials  $\text{TiO}_2$  are incredible nanoparticles in antibacterial activity applications.

## **4. Comparison of Nanomaterial Ag and $\text{TiO}_2$**

### *4.1. Comparison of Nanomaterial Ag and $\text{TiO}_2$*

For the application of food additives, the nanomaterial silver could not be directly used in food additives, but  $\text{TiO}_2$  has a great advantage because of its brightening and whitening qualities. Nanoparticle silver is formed and lives under the presence of ascorbic acid. Different from silver,  $\text{TiO}_2$  is a good substance for food additives because it can boost the bioavailability of nutrients or product attributes while also enhancing food stability during manufacture and storage. For the food preservation packing, both materials have excellent barrier, antibacterial, and mechanical qualities for food preservation, which makes them comparable. However, how they function is different. Due to its oxidation effect on ethylene oxidation, nanosilver can speed up the oxidation rate of ethylene, preserving food freshness. Nanoparticle  $\text{TiO}_2$  could be a good food additive because of avoiding UV light. This is key to preserving fresh food. The biggest difference between nanoparticle silver and nanoparticle  $\text{TiO}_2$  is for food safety. A study demonstrates that there is still cause for concern over nanosilver's migration from food packaging into food due to its hazardous effects on human health [14]. Contrastively, due to the effective barrier properties of nanomaterial  $\text{TiO}_2$ , food packaging can assist automated cleaning when it becomes contaminated.  $\text{TiO}_2$  is a material that is free of pollution since it can decompose pollution [4]. Finally, for the antibiosis or antibacterial activity, the physical difference is diameter. The diameter of  $\text{TiO}_2$  is nearly greater than Ag, which are closely 30nm and 15nm. However, they are used in different color. As an antibacterial particle, silver nanoparticles are the focus of research because of their inhibitory effect on many bacteria, especially Gram-negative and Gram-positive bacteria. The nanoparticle titanium dioxide is used in *Listeria* and *Escherichia coli*. Since pathogenic microorganisms in contact with food can be effectively eliminated by nano-grade titanium dioxide when exposed to ultraviolet light, this increases food safety [1]. Table 1 is specific to introduce more similarities and differences between nanoparticle Ag and  $\text{TiO}_2$ .

**Table1.** Mechanism of action and characteristics of commonly used nano-metal antibacterial agents [14].

Type of the nano-particles	Proposed mechanism of antimicrobial action	Main characteristics as anti-microbial agent	The main factors that influence antimicrobial activity
Ag nano-particles	The disruption of metabolic processes is caused by ion release, the development of pits and holes in bacterial membranes, and interactions with disulfide or sulfhydryl groups of enzymes. Due to DNA damage (in the case of Ag <sub>2</sub> O), DNA loses its capacity to replicate, and the cell cycle stops in the G2/M phase.	High stability, nontoxicity, antifungal activity on spore-producing fungal plant diseases, and antibacterial activity against both bacteria and drug-resistant bacteria.	Size and form of the particles.
TiO <sub>2</sub> nano-particles	Oxidative stress is brought on by ROS production, and lipid peroxidation makes membranes more flexible while impairing cellular integrity.	High stability, appropriate photocatalytic characteristics, and an efficient antifungal for fluconazole-resistant strains.	Crystal size, shape, and composition.

#### 4.2. Food Safety problem and discussion

With the rapid development of the society, people pay more attention to food safety. Governments are also focusing more on food hygiene requirements. As mentioned above in the application of nano-material Ag in food packing, the nanoparticles actually have food non-safety problems. Absolutely, research into determining and quantifying food-grade TiO<sub>2</sub> in commercial foods has lately grown due to growing concerns about the application of nanoparticles in food. However, the validity of the methods employed for TiO<sub>2</sub> measurement has not been fully established. In reality, diverse organic food substrates can alter the accuracy and precision of TiO<sub>2</sub> characterization and quantification, making it difficult to isolate TiO<sub>2</sub> from complex food substrates and quantify it in the presence of food constituents. Particularly, it is known that nanoparticles create particle matrix corona when they are covered by environmental substrates including biological and dietary substrates. This phenomenon undoubtedly affects particle size distribution, surface characteristics, and fate. To dissolve the organic substrate, which is important for both qualitative and quantitative analysis, it is therefore necessary to create the proper pretreatment techniques based on the kind of food substrate [15]. To identify nanomaterials and quantify nanoparticles in food matrices for prospective regulatory testing of distribution and migration of modified particles in food, safety procedures are being developed before nanoparticles are incorporated into food. This will significantly boost consumer confidence in products made with nanoparticles, ensuring product quality control and shelf protection [16].

#### 5. Conclusion

The outcomes demonstrated that the two nanoparticles were quite important in meals. TiO<sub>2</sub> nanoparticles have the benefit of being used as food additives, which is brightening and whitening qualities. The advantage of nanoparticle Ag, however, is in the preservation and storage of food packaging. Both nanoparticles is good at antibiosis or antibacterial activity. The two nanoparticles may not be completely safe for humans, according to the most recent studies, so perhaps more can be done to comfort the public in the future. Even though some nanoparticles cannot be used in food, scientists will eventually find better applications for them. Scientists are still open to using more nanomaterials in daily life in the future. If food safety regulations are implemented appropriately, there are additional advantages for the

environment and public health. Corresponding reports will also provide the general public confidence in the safety of their food.

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