

Influence of Titanium Oxide (IV)

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Titanium Oxide gets (IV) ultraviolet rays, which decomposes water and produces active oxygen species have high oxidizing power and attack biological components such as nucleic acids and proteins. In addition, inhalation of Titanium Oxide particles may cause cancer when they reach the alveoli. Both Titanium Oxide and active oxygen species are thought to be toxic to humans, but it is not clear whether the same is true for plants, which do not have organs similar to alveoli. Therefore, we hypothesized that active oxygen species would have more adverse effects on plants than Titanium Oxide alone. As a result of our experiments, we found that Titanium Oxide alone had no adverse effect on plants, but active oxygen species were harmful to plants.

1. Introduction

Titanium Oxide is active in a wide range of fields. For example, it is used as a photocatalyst to cover windows because it has high hydrophilic. When ultraviolet light hits Titanium Oxide, a chemical reaction occurs between Titanium Oxide and water in the air, and the surface of the Titanium Oxide photocatalyst is covered with a layer that is soluble in water. As a result, photocatalytically coated materials become susceptible to contamination. Next, Titanium Oxide is found in cosmetics. Titanium Oxide has a higher refractive index than diamond and can scatter light. This makes it suitable for cosmetics used to hide or color the skin. However, it is dangerous for us as we could get cancer when we breathe in Titanium Oxide nanoparticles. In February, 2020, EU made a rule called CLP regulation. It prohibits bringing foods which contain Titanium Oxide to the market. This regulation also forced such products containing more than 1% Titanium Oxide to attach warning labels.

Moreover, when ultraviolet rays are irradiated on Titanium Oxide, electron-hole pairs are generated. Electrons produce superoxide anion which is one of active oxygen species by the reaction of oxygen in the air. Holes generate hydroxyl radicals by reacting with water in the air. These have high oxidizing powers. For this reason, they can oxidize most organic matter such as viruses and biological components.

Now that Titanium Oxide is widely used, it is necessary to know how it affects us and our surroundings. We wondered about the effects of Titanium Oxide on living organisms, and started this study. Reactive oxygen species can act on both human body and plant components, and are considered to be toxic to both. However, humans develop cancer when Titanium Oxide particles are inhaled and reach the alveoli, while plants do not

have organs corresponding to alveoli, so it is not clear whether active oxygen species are toxic to plants.

Therefore, we hypothesized that the growth of plants is not affected by Titanium Oxide itself, but is inhibited by active oxygen species, and conducted this experiment.

2. Material and Method [Experiment 1]

In Experiment 1, we researched the negative effects of feeding Titanium Oxide to plants. The goal of this study was to investigate how Titanium Oxide affects the growth of plants. We thought that we could conduct the experiment more stably and efficiently by using radish, which grow quickly and relatively easily.

In addition, we thought that plants could take Titanium Oxide into their bodies more efficiently by having them absorb it through their roots. For this reason, we used a Titanium Oxide suspension mixed with pure water. Since the CLP regulation requires products containing more than 1% Titanium Oxide to be labeled with a warning, the maximum mass-percent concentration of the Titanium Oxide suspension was set at 1%, and we prepared 0.1% and 0.01% Titanium Oxide suspensions and pure water to investigate how the results would change depending on the concentration. We used mass percent concentration instead of molar concentration because Titanium Oxide is not soluble in water. In this experiment, we used the germination rate as an index to investigate the growth of plants. In order to calculate the germination rate, we defined "germinated" as the state in which a part of the seed emerged from the shell, as shown in (3) below.

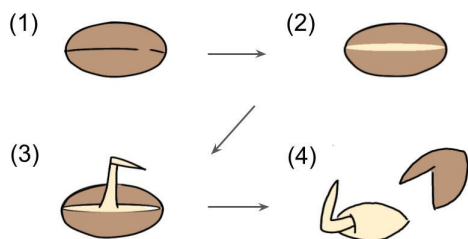


Fig. 1 Process of germination

Material

- Titanium Oxide suspensions
Concentration : 1%, 0.1%, 0.01%, 20ml each
- Pure water 20ml
- Radish seeds 10×4 (pieces)
- Petri dish 8 sheets
- Cotton 4×2 (sheets)

Method

1. We prepared two each of 1%, 0.1%, and 0.01% Titanium Oxide suspensions and pure water.
2. We poured the prepared solutions into 8 petri dishes covered with cotton, and place five radish seeds in each petri dish.
3. We grew in a sunny place for 3 days.
4. We calculated the germination rate and examine how the growth was inhibited.

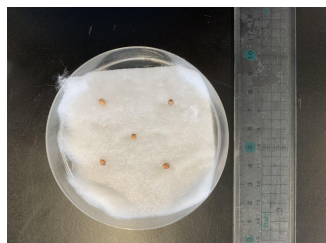


Fig. 2 Experimental device I

3. Result [Experiment 1]

Concentration	Pure water	0.01%	0.10%	1.00%
Generation rate	90%	33%	20%	0%

Fig. 3 Results of Experiment 1

It was sunny on all three days, and the average temperature during the day was 22°C. The feeding of Titanium Oxide had a negative effect on the growth

of plants. As the concentration increased, plant growth was inhibited to a greater extent. One radish seed fed with 0.01% Titanium Oxide suspension was lost during growth, but the germination results of the lost seed did not affect the correlation between the higher concentration and the greater inhibition of growth.

4. Discussion [Experiment 1]

We found that Titanium Oxide inhibited the growth of plants. However, it was not clear whether Titanium Oxide or active oxygen species affected the plants more. Therefore, in Experiment 2, we examined the effect of Titanium Oxide itself on plants by growing plants under conditions in which active oxygen species were not generated.

5. Material and Method [Experiment 2]

In Experiment 2, we examined the effects of Titanium Oxide on plants by not generating active oxygen species. In order to block out the light, the plants were covered with aluminum foil and grown. Therefore, it can be expected to germinate sufficiently even in the absence of light if there are appropriate temperature, humidity, and oxygen. In Experiment 2, the plants were grown in an incubator at a temperature of 22°C, because the average temperature during the daytime in Experiment 1 was 22°C during three days. Since the germination rate was 100% in all conditions, we measured the length of the roots and calculated the average value to see if there was any difference in growth.

Material

- Titanium Oxide suspensions
Concentration : 1%, 0.1%, 0.01%, 20ml each
- Pure water 20ml
- Radish seeds 10×4 (pieces)
- Petri dish 8 sheets
- Cotton 4×2 (sheets)
- Incubator

Method

1. We prepared two each of Titanium Oxide solutions of 1%, 0.1%, and 0.01% concentration and pure water.
2. We poured the prepared solutions into eight petri dishes, and placed five radish seeds on each petri dish.

3. We covered the petri dishes with aluminum foil and grew them for three days in an incubator set at 22°C.
4. We measured the length of the roots, calculated the average value, and examined how the growth was inhibited.

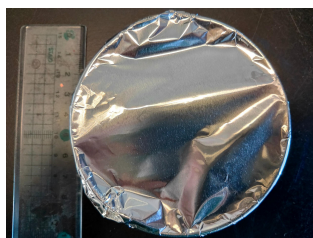


Fig. 4 Experimental device II

6. Result [Experiment 2]

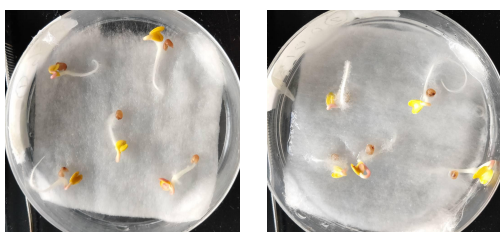


Fig. 5 Seeds fed with pure water

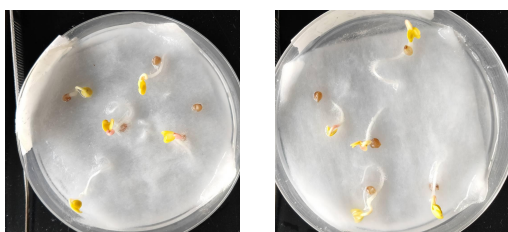


Fig.6 Seeds fed with 0.01% Titanium Oxide suspensions

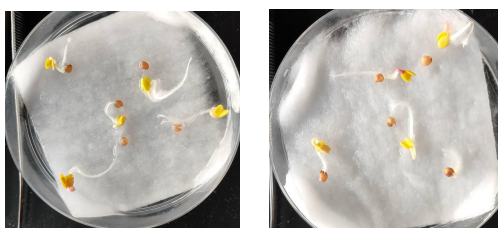


Fig.7 Seeds fed with 0.1% Titanium Oxide suspensions

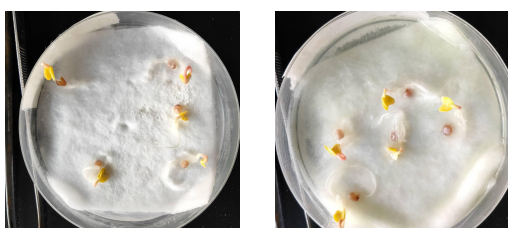


Fig.8 Seeds fed with 1% Titanium Oxide suspensions

Concentration	Pure water	0.01%	0.10%	1.00%
Length of roots (Average)	2.3cm	2.4cm	2.0cm	2.2cm

Fig. 9 Results of Experiment 2

When the concentration of the Titanium Oxide suspension was changed, the root length of all radish was about 2 cm, and the growth of radish was not inhibited by the Titanium Oxide suspensions.

7. Discussion

In Experiment 1, growth of radish seeds was inhibited under the condition that Titanium Oxide was given and active oxygen species were generated. In Experiment 2, under the condition that Titanium Oxide was given but no active oxygen species were generated, growth of radish seeds were not inhibited. These results suggest that it was the active oxygen species that inhibited plant growth, and that Titanium Oxide alone did not affect plant growth.

8. Future Prospects

This experiment was just a basic experiment to investigate the effects of Titanium Oxide on plants. Titanium Oxide is a substance that is familiar to us because of its high hydrophilicity and hiding power, and it is used in a wide range of fields. Titanium Oxide is expected to be used in various ways in the future, although it has been regulated due to the risk of carcinogenesis. In addition, Titanium Oxide is a substance that does not exist in nature. Therefore, we are concerned about the problem of Titanium Oxide leakage into the natural world due to inappropriate treatment and disposal of garbage. Therefore, we need to know the effects of Titanium Oxide on our surroundings. Therefore, we would like to conduct experiments based on the results of this experiment, assuming specific situations that may actually occur in the future.

【References】

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