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Continued Use of Nano Plastic Products

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ABSTRACT

Microplastics are small pieces of plastic that are broken down in the environment or reused to make additional plastic products. In recent years, the impact of microplastics on wildlife has attracted attention, and this has contributed to the reduction in the use of these products. Nanoplastics are very fine pieces of plastic. Although they are encompassed in the term microplastic, they are further fragmented into another substance, which is still used in household items. While microplastics are considered harmful substances that result from deterioration and decomposition as opposed to useable products, nano plastics are produced by the decomposition of microplastics but are still widely used. In this study, we show the toxicity and positioning of microplastics, introduce the use of microbeads (sometimes called microcapsules) as a representative example of nano plastic products, and provide our opinion on their toxicity.

INTRODUCTION

Microplastics are generally defined as plastic particles or fragments that are less than 5 mm in diameter[1], while nano plastics are often described as pieces with diameters≦of 100 nm. Microplastics are considered tiny plastic particles that are present in the environment, and nanoplastics are part of these, although finer in size (more precisely, microplastics are generally between 100nm and 5mm in diameter)[2].

Both are made of the same material and are only discriminated by their size. However, the two are handled handling differently. Microplastics are generated in the decomposition process during exposure to such things as ultraviolet rays and seawater in the environment after plastic products have been discarded, and are considered to be harmful to many organisms, including humans[3]. These materials are not usually reprocessed for human use. Some processed products used by humans as household items use nano plastics, although this is not commonly known. Nanoplastics are considered to have either the same environmental toxicity as microplastics or stronger toxicity as a result of further miniaturization. Despite this, currently, there is the little restriction in their use, at least in Japan. This is in contrast to the introduction of restrictions on the use of plastic products as a result of discussions regarding microplastics in the media[4),5].

In this study, we discussed the toxicity of microplastics as well as that of nanoplastics. In addition, we introduced household items that use nano plastics and clarified that their toxicity levels are equal to or greater than that of microplastics. We distinguished between microplastics and nanoplastics by size and noted if any distinction of these was present in previous research.

Definition and occurrence of microplastics

Microplastics (which may includenanoplastics) are tiny (less than 5 mm in diameter) plastic particles present in the environment and are of great concern, especially in regard to pollution in marine systems[1]. Microplastics originate from plastic trash such as shopping bags, lunch boxes at convenience stores, and PET bottle lids. Most plastic products are composed of petroleum. Approximately 400 million tons of plastic products are manufactured annually worldwide, and close to half of them are used for items such as containers and packaging[6]. Japan has the largest production volume and the second-largest usage volume globally. Many of these are disposable products that are discarded as soon as they are used, and a typical

product is a plastic shopping bag[7]. Approximately 30 billion plastic shopping bags are currently consumed annually in Japan, and several hundred grams of plastic waste is generated per household per day. If properly separated and processed by humans, this plastic waste will not have an impact on environments such as the sea. In contrast, plastic that is disposed of without considering the disposal location, and that overflowing from receptacles and left untreated can invade rivers and sewage, and be blown by the wind, eventually reaching the sea. Most microplastics that pollute the ocean originate from human emissions from daily activities[4].

There are two types of microplastics[7),8)]. Primary microplastics are plastic raw materials of small beads used in facial cleansers, cosmetics, and industrial abrasives (smaller ones for home use are considered nano plastics), as well as rice grain-sized resin pellets used as raw materials for manufacturing various plastic products. Secondary microplastics are small pieces of plastic that flow out into the environment and gradually deteriorate and collapse due to external factors (ultraviolet rays, the salt content of seawater, *etc*.) (although this explanation is for microplastics, nano plastics are also included). Those manufactured in large sizes are crushed and subdivided to ≤ 5 mm in the natural environment. This occurs mainly when PET bottles and plastic bags are exposed to ultraviolet rays and deteriorate. Both primary and secondary plastics are considered to have adverse effects on the human body and the environment, and in many cases, the location of secondary plastics is not properly controlled. One of the challenging factors of the widespread use of plastic products today is the difficulty of their degradation. Plastic pieces that have moved to the ocean are crushed into smaller pieces or dissolved in water over a long period of time. However, the length of time to accomplish this is unclear[8]. It is difficult to estimate the duration required for solid plastic to decompose and the toxicity of the materials involved.

To investigate whether plastic pieces, particularly microplastics, were unintentionally ingested into the animal body or were contained in food, coexisting substances were decomposed under harsh conditions such as acid or alkali treatment and viewed under a microscope[9]. Since plastic is harder to break down than other substances, it decomposes slowly and maintains its shape for a long period, even in the environment. Understanding this, heat-treating with a strong acid and strong alkali causes inorganic substances, such as metals, and organic substances, such as proteins, which are coexisting substances, to be decomposed and removed. Subsequently, the number and weight of the microplastic pieces

can be confirmed by observation under an optical microscope, although it is difficult to detect small nano plastics using this method (large particles can be observed with an optical microscope, but those with a diameter ≤ 1 nm are difficult to observe and must be examined using an electron microscope)[8].

Impact of microplastics

The details of the impacts of microplastics are summarized in Table 1. Plastic waste that is floating in the sea is accidentally swallowed by marine organisms (mainly microplastics, but alsonanoplastics)[8]. In the case of seabirds, the gastrointestinal tract can be clogged with plastic pieces or plastic can damage the inside of the gastrointestinal tract. As a result, food cannot be ingested, which poses the major threat of malnutrition. In addition to these physical obstacles, there are growing concerns regarding the toxicity of chemical substances. Several additives used in plastics have been reported to be harmful, and these remain in the material even after it has been reduced to microplastics. Furthermore, survey results have indicated that harmful substances (PCBs, DDTs, *etc*.) are detected at high concentrations in drifting plastics[2]. This is likely due to adsorption onto the surface while present in the environment. In comparison with the concentration of seawater, the substances are concentrated 10^4–10^6 times[8]. There have been reports of cases in which the fat of seabirds that accidentally swallowed plastic is enriched with toxic chemicals that have been dissolved in the body, raising further concerns.

Approximately 80% of microplastics are produced by the decomposition of large pieces of plastic in the environment[8]. Some examples are plastic bags, PET bottles, fishing nets, and plastic films that are used in agriculture and construction. The remaining 20% is released directly into nature due to processes such as tire wear, clothes washing, and cosmetic use (many of the latter are nano plastics). Therefore, plastics that humans have discarded have moved into the environment and then return to be re-consumed. According to to2019 study, it is estimated that humans ingest an average of five grams of plastic each week, which is equivalent to the size of one credit card[10]. The largest amount is likely through the intake of PET bottled water, shellfish, beer, and salt. Although the scientific basis remains unclear, microplastics may be harmful to human health.

What is clear from these research results is that if the recovery of plastics released into the environment is not treated as urgent, it will have a serious impact on humans; therefore, it is

necessary to actively execute this recovery in a way that will not cause further release into the environment. At present, the recovery of plastics found on coastlines is performed by private organizations such as volunteers, with less involvement in the recovery of plastics in the greater ocean. The situation has not been undertaken by national or local governments, and no measures have been initiated to prevent plastic waste from being generated in the environment.

Use of nano plastic products

Table 2 shows an example of the use of nano plastic products in cosmetics, and Table 3 lists the ingredients contained in one product. In recent years, fine plastic particles (microbeads) used in such things as facial cleansers have passed through sewage treatment and entered the sea, thereby affecting the food chain of the ecosystem[8)]. Microbeads are small spherical beads made of plastic, such as polyethylene and polypropylene, and are included in the primary microplastic category described in the previous section[11)]. The size is approximately 1–100 nm, which is not visible to the naked eye (mainly nano plastics considering the size)[8)]. These small beads are added as scrubbing materials to items such as facial cleansers, body washes, and toothpaste to remove dirt and dead skin cells[2)]. Previously, fruit seeds including natural apricots and walnuts were used as scrubbing materials, but there were concerns about the stable availability and unification of sizes; therefore, they were replaced with synthetic plastic beads approximately ten years ago. Plastic (polyethylene), which is mainly used for microbeads, has a density of ≤ 1 g/cm^{3}and floats on water; therefore, it easily flows into rivers through drains after use. Microbeads are too small to be removed by wastewater treatment facilities, such as sewage treatment plants, and flow directly into the sea through rivers[8)]. It is now believed that oceans around the world are contaminated with these plastic microbeads. It is estimated that millions of tons of nano plastics flow into rivers, lakes, and the sea annually from consumer washrooms and bathrooms through sewage treatment facilities. This indicates that they are more likely to be directly released into the environment than microplastics, and since the quantities are large, damage to the environment is likely to occur more quickly from these nanoparticles than shredded plastic products after use. Microbeads are not completely dissolved, but only suspended in water; however, they have large surface areas and are more susceptible to exposure to ultraviolet rays because they have been previously fragmented, in contrast to plastic products or microplastic pieces. Solubilization of the microbeads can

occur, and since the surface area is large, harmful substances can be adsorbed, which may increase the probability of ingestion by an organism.

CONCLUSION

In Japan, nano plastics are still contained in many household items, but other countries have started taking measures to ban their use[7]. Some European Union (EU) countries have restricted or banned the use of microplastics. For example, the Netherlands banned the sale of cosmetics containing microplastics at the end of 2016, and France followed in 2018 (think of it as a regulation of nano plastics). Similar sales bans were implemented in Denmark, Ireland, Italy, and Sweden. The UK, which is now outside the EU, banned the production of nano plastic products in January 2018 and the sale of these items in June of the same year.

In this study, we show the definition and toxicity of microplastics and provide examples of household items that contain nano plastics. These plastic fragments are environmentally toxic, particularly nano plastics because they are smaller in size and readily transferred to the environment and the human body. Although regulations are being devised in Europe, these compounds should also be monitored in Japan and other countries. However, no conclusive reports have been produced on the toxicity of these nano plastics. Furthermore, the question of the level of detection of these small pieces remains unanswered. Since these may be factors that slow decision-making on whether regulation is required, there is an urgent need to investigate the toxicity and location of these particles. In addition, the majority of consumers are not aware that polyethylene and polypropylene are included in some of their household products. Therefore, efforts should be made to ensure appropriate knowledge at the individual level, as well as to make consumers aware by including the term "plastic" in the product label.

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Table 1 Impact of microplastics and nanoplastics

Name	Overview	Contribution to impact	
		Microplastic	Nanoplastic
Impact on marine fish and seabirds	Fish and shellfish were not able to grow sufficiently due to accidental ingestion, which affected reproduction. Seabirds may be affected by particles becoming lodged in the trachea through accidental swallowing, or the chemical substances may have caused endocrine disruption as a result of dissolving in body fluids after entering the body.	○	△ (Chemical effect (Latter half) only)
Invasion from fish and shellfish into the human body	Particles have been found in fish and shellfish worldwide, and humans may ingest more than 50,000 per person per year through their diet. The maximum intake of Japanese people is estimated to reach 130,000 pieces per person per year, and if this is accurate, this situation can be considered serious.	○	○
Impact on humans	Previously, ingestion was considered unproblematic since the particles were excreted if they entered the human body, but actually, serious effects could occur. These materials contain additives such as flame retardants and they can carry harmful substances into the human body, similar to a Trojan horse.	△ (There is almost no effect before miniaturization)	○
Environmental impact of nanoplastics, *etc*.	In recent years, it has become clear that small pieces dislodge directly from plastic products. They can also be found in river water. Excretion from the human body is difficult, and the particles are absorbed and enter the body through the bloodstream. They may be also taken up by cells outside the placenta, making it difficult for nutrients and hormones to reach a fetus.	×	○
Microplastics floating in the air	When melting and filtering rime on trees in the highlands of ≧1000 m, 5000-10,000 pieces/L of microplastics have been detected. Humans are inhaling microplastics and nanoplastics. It is not yet clear how microplastics taken up by the lungs affect the human body.	△	○

Although microplastics contain nano plastics, this table shows the contributions when considered separately.

Based on reference 2).

Table 2 Examples of cosmetics containing polyethylene

Classification	Types of cosmetics included	Reason for including microbeads (nanoplastics)
Facial cleanser	Soap, face wash foam, face wash powder, other facial cleansers	○ (Increased cleaning effect)
Cleansing agent	Oil cleanser, gel cleanser, cream cleanser, point remover, and other cleansing agents	○ (Increased cleaning effect)
Skin care products	Essence, milky lotion, face cream, face oil balm, lip care	△ (Addition of moisturizing ingredients, etc.)
Special care products	Facial packs / masks, sheet packs / masks, gommage peels, massage products, eye care products, eyelash serum	△ (Increased cleaning effect)
Hair care products	Shampoo, conditioner, hair pack / treatment, non-rinse treatment, scalp care products	△ (Enhancement and sustainability of effect)
Body care products	Body cleansers, body lotions / milks, body creams / oils, body scrubs, bust / hip care products, leg / foot care products, hand care products, and other body care products	△ (Persistence of effect)

Polyethylene is often used to improve the feel, similar to wax.

Microbeads act as abrasives and are used for sustained aroma and moisturization by including the active agent in the beads.

Based on references 8), 11), and 12).

Table 3 Example of the ingredient list of toothpaste

Type	Specific example
Cleaning agent	Erythritol
Base material	Sorbitol solution, purified water
Wetting agent	Concentrated glycerin, PEG-12
Cleaner	Silicic acid anhydride, powdered cellulose
Viscosity modifier	Powdered silicic acid
Foaming agent	Lauryl sulfate
Cleaning assistant	Polyethylene powder, anhydrous sodium pyrophosphate, silylated silicic acid anhydride
Fragrance	Fragrance (white mint type), saccharin sodium
Brightener	Phytic acid solution
Coolant	Menthol
Caking agent	CMC sodium, xanthan gum
Medicated ingredient	Tocopherol acetate, triclosan
Coloring agents	Titanium oxide
pH regulator	Sodium hydroxide solution

The shaded part is the subject plastic, and the underlined part is similar to the plastic (liquid).

As you can see from the notation, plastic is not mentioned as such, and consumers cannot tell whether it is beaded.

According to regulations in Japan, it is not necessary to indicate whether nano plastics in the shape of beads or capsules are included for product ingredient labeling.

Based on reference 8).