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Development of Water Based Emulsion for Paper Coating that Achieve Reduction of Plastic Usage

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1. Introduction

The ocean plastic pollution has been highlighted, and the demand for de-plasticization is increasing all over the world. Plastic waste that flows into the world's oceans amounts to 8 million tons per year and is expected to exceed the total weight of fish by 2050. Most of those wastes are food packaging, and since the import of waste plastics has been banned in China and other Asian countries, plastic waste disposal methods have become a common issue worldwide[1]. In order to respond to this situation, measures such as charging for plastic bags, prohibiting the use of plastic straws, and raising the recycling rate have been sent from the government and brand owners and put into practice in each country. In Japan, the use of paper for products, including plastic straws and confectionery bags, has been promoted[2]. In order to replace the huge amount of plastic used, it is desirable to use paper that can be obtained from naturally occurring wood. In addition, paper is an excellent material from the viewpoint of recycling, and the conversion of plastic to paper is positioned as a leading answer for de-plasticization. On the other hand, the superiority of plastics over paper includes resistance to liquids and gases / barrier properties, thinning/adhesiveness, and processability. Therefore, paper products with polyethylene laminate, which is a composite of plastic and paper, are widely used. However, since these laminated papers have an adverse effect on recycling, there is a demand for alternatives from laminates to resin coats, starting with European countries.

In this report, we introduce the development of water/oil resistant emulsions as an alternative to polyethylene laminates as a first step to enable de-plasticization.

2. Role of polyethylene laminate

Polyethylene is an excellent material as a paper laminating agent. By melting at a high temperature and forming a coating film on the base material, it is possible to impart a barrier property to liquids and gases and protect the base material from various components. Further, since it can be melt-bonded in a short time by heat, that is, it can be heat-sealed, it is an excellent material in terms of molding. Furthermore, as can be seen from the fact that it is used for food wrapping paper, paper cups, etc., it is extremely reliable in terms of safety. However, it is difficult to collect laminated paper as used paper in a general paper mill, and the advantage of paper's recyclability cannot be utilized. Therefore, there is a need for an alternative material that performs as well as polyethylene but does not adversely affect the recyclability of paper.

We have accumulated technologies related to water-based emulsions for paper manufacturing, inks, and paints, and are working on the development of water-based emulsion. In this report, we introduce water-based emulsions for paper coating that shows a comparable level of performance to that of polyethylene laminate. Regarding 'performance', we focused on water/oil resistance and heatsealability. Regarding 'safety', we

studied the conformity with the US FDA CFR Title 21.

3. Development of emulsion for water-based coating agent

3-1. Core-shell emulsion "Hiros-XE" series

We have developed core-shell emulsions that are synthesized by emulsion polymerization in an aqueous system using a polymer emulsifier for water-based printing inks, water-based paints, and water-based coating agents, and have accumulated the synthesis technology (Figure 1). By converting a polymer with a carboxyl group into an aqueous solution (varnish) with an organic amine or inorganic metal and introducing a hydrophobic core polymer using this as a shell, a high concentration water-based emulsion can be obtained without using a low molecular weight emulsifier or an organic solvent. Compared with emulsions using low molecular weight emulsifiers, this core-shell emulsion exhibits extremely excellent coating suitability because it has low thixotropic properties despite its high concentration.

The drying speed and leveling property in the drying process in which the coating film is formed immediately after coating can be controlled mainly by the design of the shell part, such as the type of alkali that neutralizes the carboxyl group. The physical characteristics of the coating film in the final product after coating, such as rub resistance and water resistance, combine various factors such as the ratio and affinity of the shell part and the core part, the hydrophilicity / hydrophobicity of the polymer, Tg, and the molecular weight. Therefore, it can be adjusted according to the application and purpose.

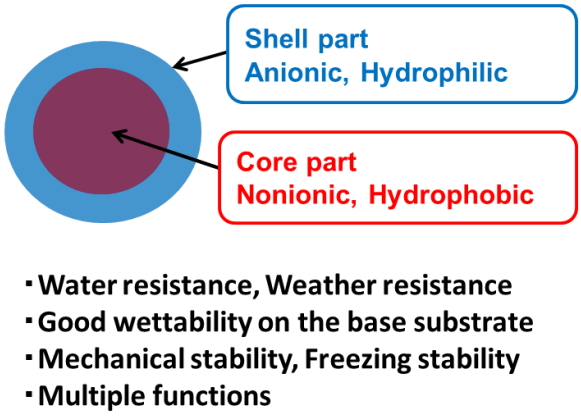

Figure 1. Core-shell emulsion

3-2. Hiros-X / NE-2260

Using this core-shell emulsion technology, it was decided to substitute the laminate by developing the level of water resistance and oil resistance obtained by polyethylene laminating with an emulsion coating film, that is, a resin coating. In addition, assuming paper that comes into contact with food, we decided to develop products with a composition corresponding to FDA21CFR §176.170 and §176.180. In order to comply with FDA21CFR §176.170 and FDA21CFR §176.180, there is a limit to the amount of styrene, which is the most versatile monomer in the industry. developed.

NE-2260 exhibits high oil resistance as well as water repellency level without using wax, silicone or fluorine compound (Figure 2, 3). It is believed that this effect is due to the fact that the composition of the core and shell has a chemical / physical gap, which causes a fine distribution in the coating film formed by the emulsion. It also has heat-sealing properties, which are important for processability, and can be sealed at about 150 °C (Figure 3).

NE-2260 exhibits high water resistance and oil resistance, and is an aqueous emulsion conforming to FDA21CFR §176.170 (limited use: cannot be used for liquid containers, etc.), §176.180, and it is a high-performance emulsion that can be widely used for purposes other than food because it is compatible with the inventory of each country such as the China, Taiwan, South Korea, Philippine, etc.

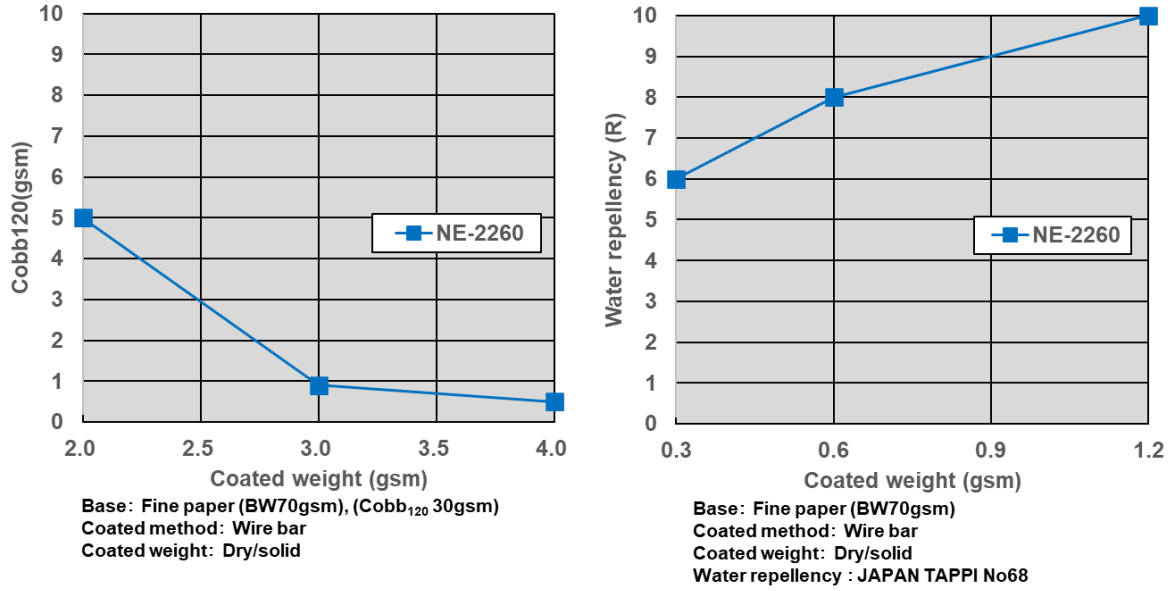

Figure 2. NE-2260 water resistance (left) and water repellency (right)

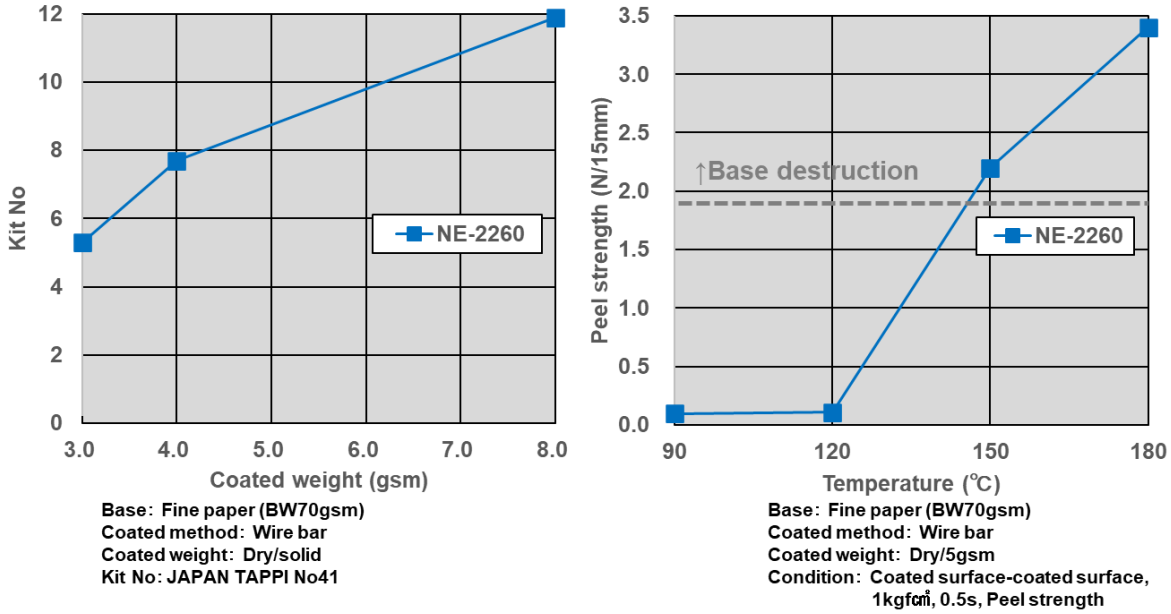

Figure 3. NE-2260 oil resistance (left) and heat sealability (right)

3-3. Hiros-X / PE-2273

So far, we have introduced NE-2260, which is a styrene acrylic emulsion, but a styrene-free aqueous emulsion is required as a product with even better safety. In addition, NE-2260 cannot be used for liquid containers such as a paper cup to the limited use of FDA21CFR §176.170. Therefore, we have developed Hiros-X / PE-2273, which is an aqueous emulsion that solves these problems and further expands the scope of application.

PE-2273 is an all-acrylic type emulsion that is styrene-free, but shows almost the same water

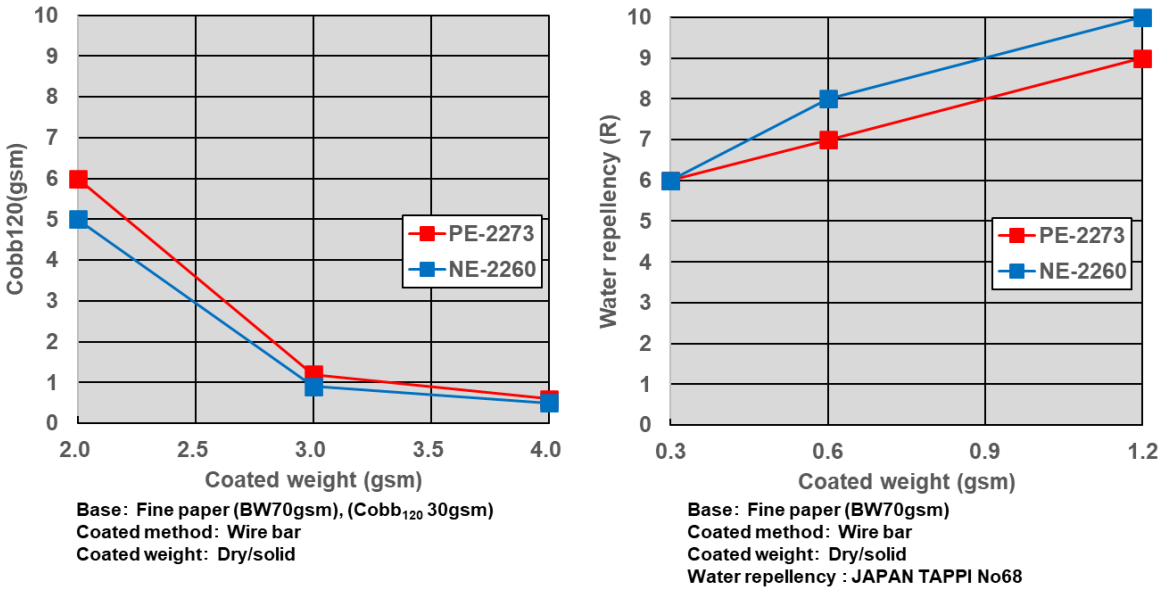

Figure 4. Water resistance (left) and water repellency (right) of PE-2273

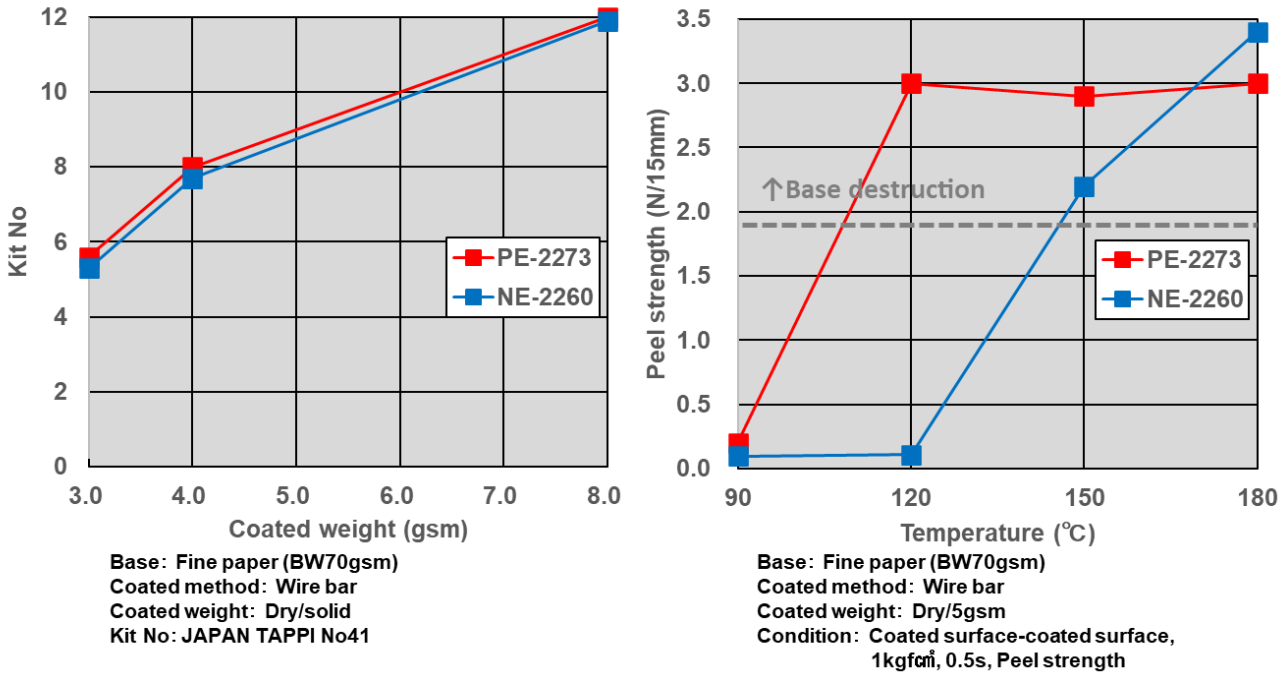

Figure 5. PE-2273 oil resistance (left) and heat sealability (right)

resistance and oil resistance as NE-2260 (Figure 4, 5), and is complying with FDA21CFR §176.170 and §176.180 without using restrictions. Furthermore, since heat sealing is possible at a temperature of about 120 °C, which is lower than NE-2260 (Figure 5), it is possible to process under conditions closer to polyethylene laminate.

3-4. Hiros-X / QE-2128

PE-2273 is an emulsion with excellent water resistance, oil resistance, and heat sealability without any restrictions on FDA applications, but there are cases where the take-up rolls after coating are placed under high temperature, high humidity, and high pressure. Therefore, assuming various usages, it is necessary to

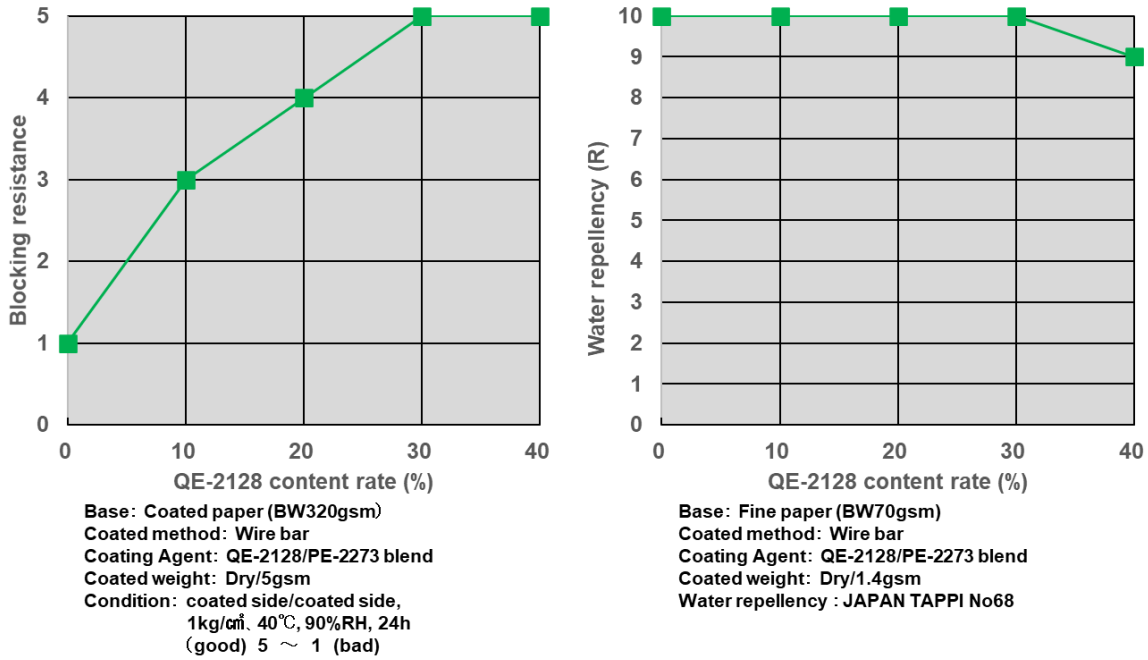

Figure 6. Relationship between QE-2128 compounding ratio and blocking resistance (left) and water repellency (right)

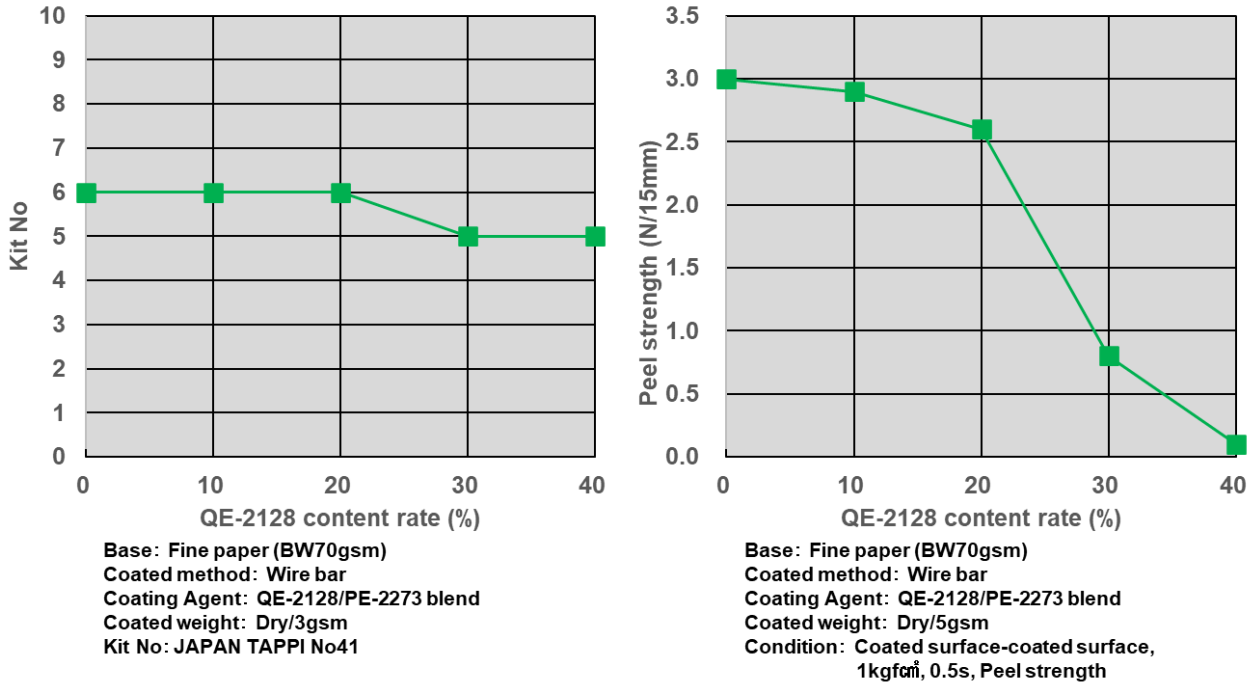

Figure 7. Relationship between QE-2128 compounding ratio and oil resistance (left) and heat sealability (right)

prepare a method to solve the blocking resistance. As measures against blocking resistance, we considered increasing the Tg of PE-2273 and combining it with an inorganic filler, but as a more versatile method, we decided two-liquid mixing type of PE-2273 and an emulsion specializing in blocking resistance. By changing the ratio of the two liquids, it is possible to respond to various conditions and target levels. The

emulsion developed here that specializes in blocking resistance is Hiros-X / QE-2128.

Like PE-2273, QE-2128 is an all-acrylic type emulsion that is comply with FDA21CF §176.170 and 76.180 without limitation. It is a design in which a high Tg polymer site is arranged without adversely affecting the water resistance, oil resistance, and heat sealability of PE-2273. Due to the influence of Tg, the minimum film forming temperature is high, but this can be easily formed by using the combination with an emulsion with a low minimum film forming temperature such as PE-2273.

It is possible to improve the blocking resistance by increasing the compounding ratio of QE-2128, and if the compounding ratio is up to about 30%, high water resistance, oil resistance, and heat sealability can be maintained (Figure 6, 7). It is considered that various performances can be obtained in a well-balanced manner by controlling the compounding ratio according to the target level. QE-2128 can be used not only with PE-2273 but also with NE-2260 and other emulsions to improve the blocking resistance of the coating film.

4. Conclusion

Based on the above results, Table 1 shows a summary of the physical characteristics, performance, and legal regulations of NE-2260, PE-2273, and QE-2128. NE-2260, a styrene acrylic type that conforms to the FDA and has a wide range of applications for overseas inventory, PE-2273, an all-acrylic type that has no restrictions on the use of FDA and is characterized by heat sealability, and the same type as PE-2273, we have developed QE-2128, which improves blocking resistance. By combining these products as needed, coated paper can achieve the same level of water resistance, oil resistance, and heat sealability as polyethylene laminated paper.

In the future, when replacing polyethylene laminate, various laws and regulations and restrictions on use are expected, so we will continue development.

＜References＞

1) Harada S, Review of Environmental Economics and Policy studies, Vol.13, No1, 2020.3, 12-16.

2) Otsuka N, Material cycles and Waste Management Research, Vol.30, No2, 2019, 115-122.

Table 1. Properties of NE-2260, PE-2273, QE-2128

Product	NE-2260	PE-2273	QE-2128
Non-volatile (%) Vis(mPa･s) pH MFT (℃)	49 600 8.0 5>	40 800 8.0 5>	36 600 8.0 49
Acid value (mgKOH/g) Tg (℃) Ionic	53 -10 Anion	38 -11 Anion	38 63 Anion
Component	Styrene-Acrylic	All Acrylic	All Acrylic
Water resistance Oil resistance Heat sealability	◎ ◎ ○	◎ ◎ ○	- - -
FDA 21CFR § 176.170 § 176.180	Application limited Confirm	Confirm Confirm	Confirm Confirm
Food Sanitation Act PL※	Listed	Listed	Listed

※Positive list of food utensils, containers and packaging under the Food Sanitation Act in Japan.

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