Sanyo Chemical

It is a translation based on the content of corporate PR magazine "Sanyo Chemical News" issued in early spring 2020 (No.518).

Performance Chemicals

Useful performance chemicals by Sanyo Chemical Industries' Group 142

Antistatic Agents for Polyethylene Film and Sheets

Yasushi Nakamura
Unit Chief, Functional Resin Research Department

Plastic has superiority in various properties, such as moldability, lightness, and electrical insulation, and has been used in a wide range of industrial fields, such as the housing of home appliances/OA equipment, conveying trays and packaging materials for electronic devices, and automotive interior materials.

However, its electrical insulation easily invites static charge build-up on its surface of the material, which causes various problems by static electricity. They include failure of plastic products resulting from contamination with dust or dirt, sticking of plastics to each other, damage to electronic circuit or malfunction of electronics devices due to electrostatic discharge and fire or dust explosion in the event by a spark .

In order to avoid such problems caused by static electricity, the ease of plastic surface charge (surface specific resistance) is controlled appropriately according to the intended use (Table 1).

One of the control methods is the use of antistatic agents. Our company has commercialized polymer-type antistatic agents PELESTAT and PELECTRON products that impart long-lasting antistatic property to compounded resins, and has expanded the product line-up. A historical review of our polymer-type antistatic agents is presented here. Also, PELESTAT LM230 (developed product) that can applied to the polyethylene (PE) resin film for food wrap. Its use is increasing recently.

Antistatic Agents

A common way to make a plastic antistatic is using an antistatic agent to make it conductive to discharge static electricity. Antistatic agents include surfactants, carbon blacks, and polymer type antistatic agents. Among them, polymer type antistatic agents are utilized for a wide range of applications because of the advantages of no humidity dependence of its effect and no bleed out. By combing a conductive polymer with a plastic material and compatibilizing them to make a conductive pathway in the plastic for providing antistatic properties. Since the effects last almost permanently, they are also called "permanent antistatic agents".

Polymer Type Antistatic Agents by Sanyo Chemical Industries

Our company has commercialized polymer-type antistatic agents PELESTAT series since 1994. PELESTAT is a special block polymer with PEO chains. With additives of about 10 mass% of the agent, various plastics materials such as acrylonitrile-butadiene-styrene (ABS) resin, high-impact polystyrene (HIPS) resin, acrylic resin, polyamide resin, and polyolefin resin, will be modified so that they can show antistatic properties permanently.

The mechanism of antistatic properties of PELESTAT is shown in Fig. 1. First of all, PELESTAT itself has a surface resistivity of 10^7 - 10^9 (Ω/□), and it has a moderate

Table 1 Purpose of prevention of static charge on the plastic and the levels

Surface specific resistance (Ω/□)	Charging phenomenon	Purpose of prevention of static charge	Applications
10^{13} ≤	Static electricity is accumulated	(Insulation)	(Insulation material)
10^{12} - 10^{13}	Takes charge but attenuates slowly	Hazard prevention in a static state	Prevention of adhesion of dust/dirt
10^{10} - 10^{12}	Takes charge but attenuates soon	Hazard prevention in a dynamic state	Electric shock prevention (explosion prevention)
10^{8} - 10^{10}	Takes no charge	Electricity accumulation prevention	Protection of electronic components/circuits
10^{7} - 10^{8}	Takes no charge	Provides conductivity	Various semiconductor materials

conductivity. Also, when PELESTAT is effectively distributed in the compounded resin during kneading and shearing, the unit with a moderate conductivity is dispersed in the plastic and form continuous conductive pathway like a streak, leading to the discharge of electric charge and prevention of static charge. In order to let PELESTAT disperse in the plastic like a streak, it is necessary to control the dispersed condition at the time of melt-kneading with resin and to utilize the shear stress at the time of molding. In order to form a streaky conductive pathway in the plastic effectively, it is designed to optimize the compatibility with resin and melt viscosity utilizing the dispersion control technology of our company.

The main advantages of PELESTAT include the followings: (1) It exerts beneficial antistatic effects from immediately after molding and the effects last almost permanently. (2) Since the effects do not depend on the humidity environment, it exerts high antistatic properties even at low humidity. (3) It does not bleed out so that neighboring materials are free of contamination. (4) It excels in thermal stability and does not impair heat resistance of the molded plastics. (5) It excels in dispersibility regardless of the plastic, which means that it can be used effectively with various types of plastic. (6) Arbitrary coloring is available with pigments.

The surface specific resistance of the plastic molded articles can be controlled to 10^{10} - 10^{12} (Ω/□) by using PELESTAT. Our company also developed a low-resistance version of polymer-type antistatic agent PELECTRON suitable when making the surface specific resistance lower. PELECTRON was designed so that the PEO chain's ionic conduction could be maximaized by combining our unique technologies, and the surface specific resistance of PELECTRON itself is lowered to 10^{6} (Ω/□). Utilizing these advantages, the application has been widened to the areas where polymer type antistatic agents were not used. For example, it is necessary to control the surface specific resistance of resin to about 10^{7} - 10^{9} (Ω/□) for the protection of electronic devices/circuits. It is because, if the surface specific resistance is too high, the electronic devices/circuits may be damaged by static electricity and if it is too low, by direct discharge. By using PELECTRON, the surface specific resistance can be controlled to 10^{7} - 10^{9} (Ω/□). The relationship between the amount added and antistatic properties (surface specific resistance) when PELECTRON AS is used for ABS resin is shown in Fig. 2.

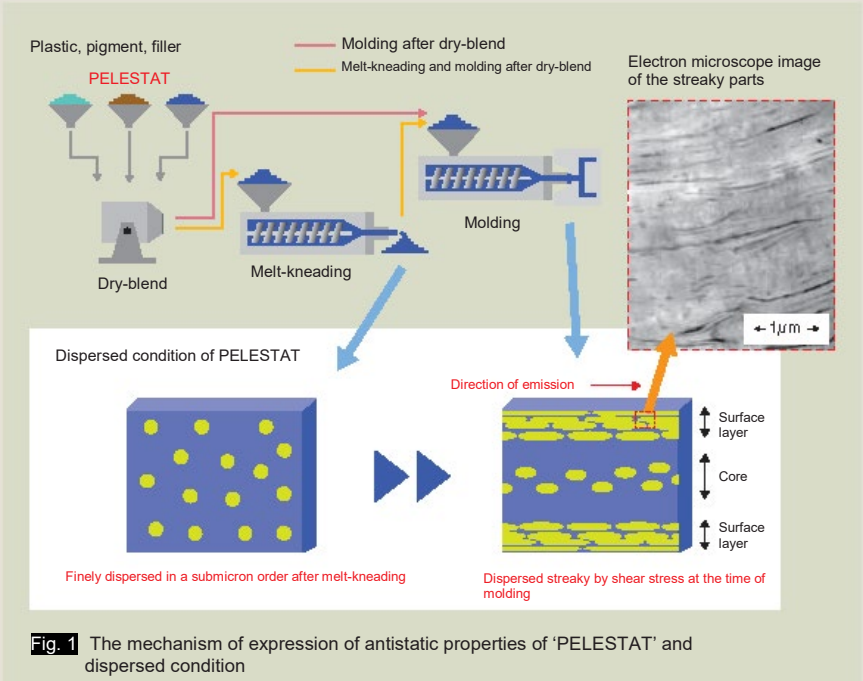


Fig. 1 The mechanism of expression of antistatic properties of 'PELESTAT' and dispersed condition

Polymer Type Antistatic Agents for Molding a Film/Sheet PELESTAT LM230

Polyolefin resin is often used for packaging materials and protection materials by being processed into a film or sheet because of its characteristics, such as moisture-proof properties, gas barrier properties, chemical resistance properties, and heat-sealing properties in addition to its excellent processability. In such applications as well, the need for the prevention of static charge is high.

When it is used for conveying/packaging surface protection films or electronical components, electronical components may have a problem caused by electrostatic hazards. High antistatic properties are required for protecting them from electrostatic hazards as well.

PE resin film is used for the inner bag of the flexible container bag used for storage, transportation, and throwing (preparation) of powders, and explosion/fire due to electrostatic discharge may occur if static electricity is generated by friction between the contents and the inner bag. Therefore, in the inner bag of the flexible container, it is required to control to 10^{10} - 10^{11} (Ω/□) to prevent dust explosion due to static electricity.

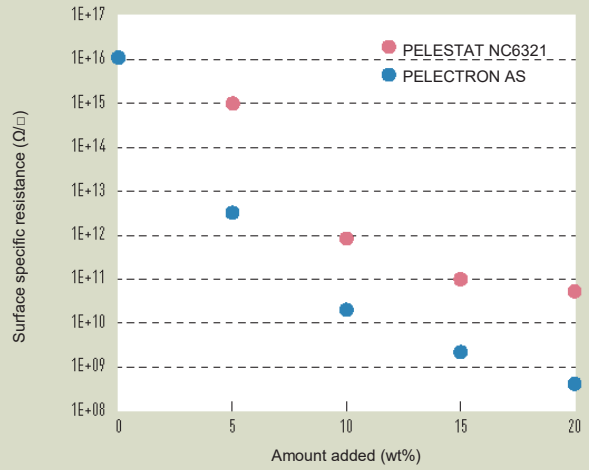
In case of packaging materials whose contents are expensive powders, such as cosmetic ingredients and intermediate of medicine, if the powder adheres and is left inside due to static electricity, it may lead to increase in cost. The antistatic properties are required for reducing loss as well. Thus, in various film/sheet products, the antistatic properties are important.

In recent years, the needs for the prevention of static charge for the inner bag of the flexible container for food powder and packaging materials for intermediate of medicine are increasing particularly in the Western markets, and when antistatic agents are used for these purposes, it is necessary to obtain certification of food wrapper from the European Food Safety Authority (EFSA) or the Food and Drug Administration (FDA). Among antistatic agents of our company, PELESTAT 230 has obtained certification.

However, the molding temperature of PE resin film used mainly for the inner bag of the flexible container and packaging materials for intermediate of medicine is relatively low, and when PELESTAT 230 with a slightly high melting point (melting point: approx. 165°C) was used, it was difficult to have enough antistatic effect and film features. This is because PELESTAT 230 does not melt enough at a low molding temperature, and because it is difficult to form a conductive pathway on the surface layer of film or sheet molded plastics. Therefore, our company developed PELESTAT LM230 with a low melting point. The melting point of the developed product is approx. 115°C. We succeeded in lowered the melting point by approx. 50°C compared with the conventional product PELESTAT 230 and also in improving the compatibility with PE resin. The relationship between the amount added and antistatic properties (surface specific resistance) when PELESTAT LM230 is used for low-density polyethylene (LDPE) resin used for a film/sheet is shown in Fig. 3. Also, since the developed product excels in compatibility with LDPE resin, it does not negatively affect the appearance and resin properties of a film. In addition, the heat-sealing properties, a characteristic required for a film, could also be greatly improved compared with the conventional product PELESTAT 230 by lowering the melting point (Fig. 4).

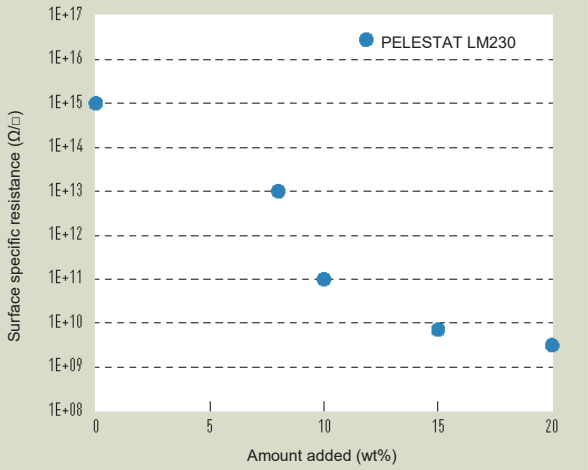
Prospects

The examples of properties of PELESTAT and PELECTRON series and target resins are shown in Table 2. Since PELESTAT and PELECTRON series can provide antistatic properties tailored to the needs for a wide variety of resins



Surface specific resistance was measured in conformity to ASTM D257.

Fig. 2 Antistatic effect of 'PELECTRON AS' (ABS resin, injection molding)



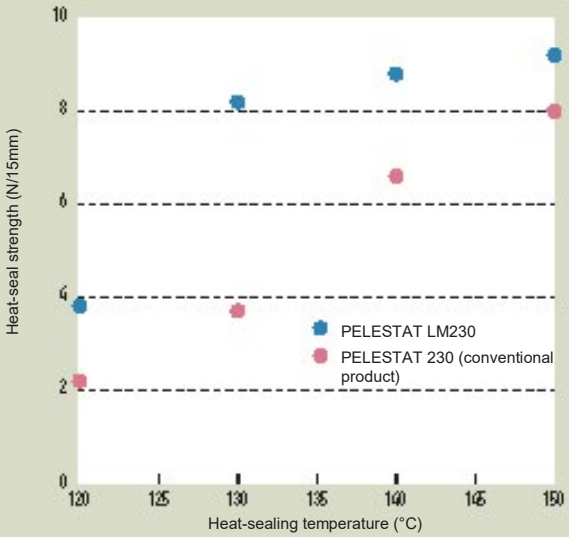
Surface specific resistance was measured in conformity to ASTM D257.

Fig. 3 Antistatic effect of 'PELESTAT LM230' (LDPE film)

and various shapes, they are used for a wide range of applications as shown in Fig. 5. We would like to improve the products, obtain various certifications, and expand the applications in order to respond to the increasingly diversifying needs for preventing static charge.

References
1) "Design and Usage of Antistatic Materials", Science & Technology (2008)
2) "Technology & Market of Polymer Additives" Chapter 1, 4.4, CMC Publishing Co., Ltd. (2018)
3) SENDA Eiichi, TOKUNAGA Hironobu, Journal of Japan Society of Colour Material, Vol.90, No.11 (2017)
4) Edited by FUJIMOTO Takehiko, 'Introduction to Polymer Drugs', Sanyo Chemical Industries, Ltd. (1992)

[Contact (about the product)]
In Japan
Electronic Materials, Resins & Coloring Materials Division, Sales & Marketing Dept. of Resins Industry
http://www.sanyo-chemical.co.jp/eng/
In U.S.A
SANAM Corporation
State Highway 837 P. O. Box 567
West Elizabeth, PA 15088-0567
http://www.sanamcorp.com/



Dry-blended LDPE resin/metallocene plastomer/antistatic agent = 65/20/15 (mass ratio) was molded using an inflation testing machine and made into a sample. (Die temperature: 170°C, blow ratio: 2.0, film thickness: approx. 50 μm) [Evaluation method] Both sides of the obtained film were heat-sealed under the following conditions: temperature: 120 - 150°C, time: 1 s, pressure: 98 kPa, the 15-mm-wide heat-sealed part was peeled at a peel rate of 100 mm/min, and the heat-seal strength was measured.

Fig. 4 Heat-seal strength of the film using 'PELESTAT LM230'

Fig. 5 Applications of polymer type antistatic agents of our company

Table 2 Main products of 'PELESTAT' and 'PELECTRON' series

	PELESTAT 300	PELESTAT 230	PELESTAT LM230 (developed product)	PELECTRON PVL	PELESTAT NC6321	PELESTAT 6500	PELESTAT 6200	PELECTRON AS
Appearance	Light yellow pellet	Light yellow pellet	Light yellow pellet	Light yellow pellet	Light yellow pellet	Light yellow pellet	Light yellow pellet	Light yellow pellet
Melting point (°C)	Approx. 135	Approx. 163	Approx. 115	Approx. 135	Approx. 203	Approx. 191	Approx. 193	Approx. 195
MFR (g/10 min)	Approx. 30 [190°C, 21.18 N]	Approx. 10 [190°C, 21.18 N]	Approx. 15 [190°C, 21.18 N]	Approx. 15 [190°C, 21.18 N]	Approx. 20 [215°C, 21.18 N]	Approx. 20 [215°C, 21.18 N]	Approx. 30 [215°C, 21.18 N]	Approx. 30 [215°C, 21.18 N]
Refractive index	1.495	1.495	1.495	1.495	1.515	1.515	1.510	1.510
Thermal decomposition onset temperature *1 (°C)	Approx. 240	Approx. 250	Approx. 250	Approx. 250	Approx. 285	Approx. 285	Approx. 285	Approx. 285
Surface specific resistance *2 (Ω/□)	Approx. 1×10^8	Approx. 5×10^7	Approx. 5×10^7	Approx. 3×10^6	Approx. 1×10^9	Approx. 1×10^8	Approx. 1×10^8	Approx. 4×10^6
Target resin	PP, PE (Injection molding)	PP, PE (Extrusion molding)	PP, PE (Extrusion molding)	PP, PE (Extrusion molding)	ABS, t-ABS*3 PC/ABS PBT	ABS, t-ABS*3 PC/ABS PBT	ABS PC/ABS PBT	ABS PC/ABS PBT
Characteristics			Low melting point	Low resistance	Low ionic contamination		Low ionic contamination	Low resistance
Surface specific resistance controllable by the molded articles containing the product (Ω/□)	10^{10} - 10^{12}	10^{10} - 10^{12}	10^{10} - 10^{12}	10^8 - 10^{12}	10^{11} - 10^{12}	10^{10} - 10^{12}	10^{10} - 10^{12}	10^8 - 10^{12}

*1 TG-DTA, in air
*2 After molding 'PELESTAT' and 'PELECTRON' separately, and controlling humidity at 23°C and 50 %R.H. for 24 hours, the surface specific resistance was measured by a super insulation meter.
*3 Transparent ABS
Please contact our sales office if you wish to distribute the products Be sure to read the "Safety Data Sheet" (SDS) in advance.
It is the responsibility of the user to determine the suitability and safety of the product in intended application.