Metallized films for capacitors and metallized film capacitors

1 Introduction of Anhui Safe Electronics Co., Ltd.

Anhui Safe Electronics Co., Ltd. was established in February 2007, specializing in the production of metallized films for capacitors and metallized film capacitors. The company is located in Tongling City, Anhui Province, the People's Republic of China.

Anhui Safe Electronics Co., Ltd. now has 3 high-vacuum coating machines and 14 high-speed film slitting machines. The capacitor production line has multiple automatic winding machines, metal spraying machines, testing machines and welding and pouring equipment. The company can provide metalized film for finished products and semi-finished products, AC motor capacitors, photovoltaic wind energy capacitors, welder capacitors, pulse capacitors, DC -LINK capacitors, etc.

Anhui Safe Electronics Co., Ltd. has ISO9000 quality system certification, ISO14000 environmental system certification, ISO18000 occupational health system certification, products comply with EU RoHS and REACH regulations, and capacitor products have obtained China CQC, Germany TUV Rheinland, and American Underwriters Laboratories UL certification.

2 Characteristics of Anhui Safe Electronics Co., Ltd. organic dielectric film

The metallized film for capacitors that can be supplied by Anhui Safe Electronics Co., Ltd. belongs to high polymer materials. Currently available products are: polypropylene film and polyester film. The former is mostly used to manufacture AC capacitors and large DC capacitors. Mostly used to make small DC capacitors.

The metallized film for capacitors produced by Anhui Safe Electronics Co., Ltd. is an organic dielectric film. Its characteristics are as follows:

1) Improved film purity

Organic dielectric film is a high molecular polymer. The degree of polymerization and molecular configuration of the molecule are greatly affected by the catalyst, stabilizer and polymerization process. It has been ensured that the degree of molecular polymerization is appropriate and the molecular weight dispersion is small. The monomers are connected

end to end, forming isotactic or syndiotactic, the molecular end groups conform to the monomer end groups, and there are few heterogeneous molecules. In addition, it contains few impurity molecules. In this way, the purity and uniformity of the electrical film are guaranteed from the molecular level.

2) Improvement of film structure

Organic dielectric film are largely formed by the aggregation of isotactic molecules. Due to the large secondary valence bonding force between the molecules, the molecules tend to be densely packed, resulting in higher crystallinity of the organic film. In order to meet the electrical properties of the film, the crystalline and amorphous regions in the film must be oriented in a certain direction.

The smooth film used by Anhui Safe Electronics Co., Ltd. uses a biaxial stretching method. Its surface morphology is somewhat similar to the network structure of orange peel. The joints of the network are deformed spherical particles, which are composed of oriented crystal regions Structure, and each crystalline region is connected to a relatively oriented amorphous region.

After orientation of the film, its uniformity is improved, its crystallinity is increased, its melting point is increased, and the thermal motion of the molecular segments (especially in the amorphous region) is restricted. Therefore, by orienting the film, the compressive strength can be increased, the loss can be reduced, and the resistivity can be improved.

3) reduction of film thickness

An important development direction of the capacitor film is: under the premise of ensuring the uniformity and consistency of the film structure (molecular aggregation and orientation), its minimum thickness has been greatly reduced. The minimum thickness of polypropylene film that Anhui Safe Electronics Co., Ltd. can provide in batches has reached 2.0μm, and the thickness of polyester film has reached 1.9μm, and there is also a trend of thinning.

At the same time, with the improvement of film performance, the thickness of the dielectric film used in the capacitor also decreases, which reduces the volume of the capacitor.

4) Film surface treatment

The surface of the film is processed according to the application of the film. Anhui Safe Electronics Co., Ltd. can provide two kinds of polypropylene electrical film- smooth film and roughened film. The base film of the metallized polypropylene film for a capacitor is a smooth film. For power capacitors with a withstand voltage of several KV to several tens of KV, a method using a roughened film and aluminum foil is used. The roughened film can improve the impregnation ability of the capacitor core, increase the capacitance, and increase stability.

3 Determination of the working field strength of Anhui Safe Electronics Co., Ltd. metallized film capacitor

Metallized film capacitor with excellent manufacturing performance and controllable cost are mainly determined by the thickness, temperature resistance, and material, thickness, and type of the metallized film base film selected.

Anhui Safe Electronics Co., Ltd. uses the following principles to determine the thickness of the dielectric when designing capacitors:

1)Under the short-term (1 second to 1 minute) overvoltage, the capacitor should not be subject to electrical breakdown;

2)Under the working voltage, the capacitor cannot break down during its reliable working period;

3)There is no possibility of thermal breakdown of the capacitor, and the internal temperature of the capacitor must be lower than the maximum temperature allowed by the medium.

Because the electric field strength and the area of the dielectric between the plates are much larger than other insulating layers, reasonable determination or selection of the working field strength of the dielectric is the core issue of capacitor design.

The field strength is usually determined after comprehensive analysis based on factors such as the performance and quality of dielectric materials, the level of production technology of capacitors, test data of rapid aging (ie accelerated life) of trial products, and practical experience.

From the perspective of reliability, the larger the strength of the selected workplace,

the better. However, considering the economic indicators, the selected working field strength can only meet the design requirements of the capacitor.

4 Material and structure of metallization layer

4.1金属化电极材质

4.1 Metallized electrode material

A major advance in the manufacturing process of metallized film capacitors is electrode metallization. The metallized electrode makes the capacitor self-healing, improves reliability, reduces the volume and weight of the capacitor, prevents failure of the capacitor under low voltage, facilitates the use of capacitors in series, and reduces the difficulty of manufacturing capacitors.

Metallized film capacitors have a self-healing function. When the capacitor is partially broken down, the performance of the capacitor can be quickly restored through the self-healing of the metallized layer, which improves the reliability of the capacitor. Self-healing can be divided into two types: discharge self-healing and electrochemical self-healing.

There are usually defects on metallized films (metallization defects, semiconductor defects, poor insulation defects or pores). When the voltage applied to the capacitor reaches a certain level, the Joule thermal energy generated in the area close to the defect point melts the metallized layer in the area, causing arcing between the electrodes here. The arc quickly evaporates and throws away the molten metal in this area, forming a metal-free insulation isolation zone. The arc is extinguished to achieve self-healing of the discharge. It should be ensured that the discharge self-healing time is short, the self-healing energy is small, the defect is isolated well, and the medium is not damaged. If this is not possible, excessive self-healing will occur, and the lighter will greatly reduce the capacitance, and severely make the capacitor fail.

If the metallized film is easy to form an oxide insulating layer (such as an aluminum metallized film), the capacitors produced by it will undergo electrochemical self-healing at a lower voltage. What is formed around the defect is the oxidation of the metal. Thing. The electrochemical self-healing lasts for a long time, which will cause the capacitor to fail the capacitance in advance at a lower voltage.

Anhui Safe Electronics Co., Ltd. can provide aluminum metallized films and zinc-aluminum composite metallized films in batches.

After oxidation, aluminum can form a denser and uniform oxide film and prevent further oxidation of aluminum. Therefore, the aluminum metallized film has a long shelf life and does not require special packaging. This allows aluminum films to be used in large quantities when producing capacitors. However, during the use of capacitors made of aluminum metallized film, the edges and the inside of the aluminum layer will be converted into non-conductive alumina, which will reduce the capacitance and the effect of electrochemical self-healing. Capacitance loss will be exceeded when the voltage is too high.

Zinc-aluminum composite film has the advantages of zinc film and aluminum film, and to a large extent solves the disadvantages of the two. Zinc-aluminum composite film has two forms of layered composite and alloying. Considering the potential difference between zinc and aluminum, the alloying form is better. The zinc-aluminum film is mainly zinc, and the surface layer of the metallized film has a large aluminum content (but still less than zinc). It can form a dense aluminum oxide film, protect the metallized layer, and prevent further oxidation. The aluminum content in the middle of the metal layer is small, and the aluminum content in the contact layer with the base film is increased, which can prevent low boiling point zinc from re-evaporating from the film and enhance the adhesion of the metallized layer.

The zinc-aluminum composite film has excellent self-healing performance. The square resistance of the zinc-aluminum composite film is about 7.5Ω / □, the square resistance of the aluminum film is about 3.0Ω / □, and the thickness of the metallized layer of the zinc-aluminum composite film is about half smaller than that of the aluminum film. Therefore, the zinc-aluminum film has a shorter self-healing time and requires much less energy than the aluminum film. The self-healing is also faster, and the possibility of excessive self-healing is less. Because electrochemical self-healing does not occur, the zinc-aluminum composite film has less capacitance loss and longer life during use. The zinc-aluminum composite film currently used generally adopts a thickened edge type, which can reduce the contact

resistance between the core end face and the gold spray layer, improve the capacitor's ability to withstand pulse current, and the capacitor loss is small. The field strength of zinc-aluminum film is usually higher than that of aluminum film.

The following is the composition analysis result of the zinc-aluminum film. The first is an electronic image of the film:

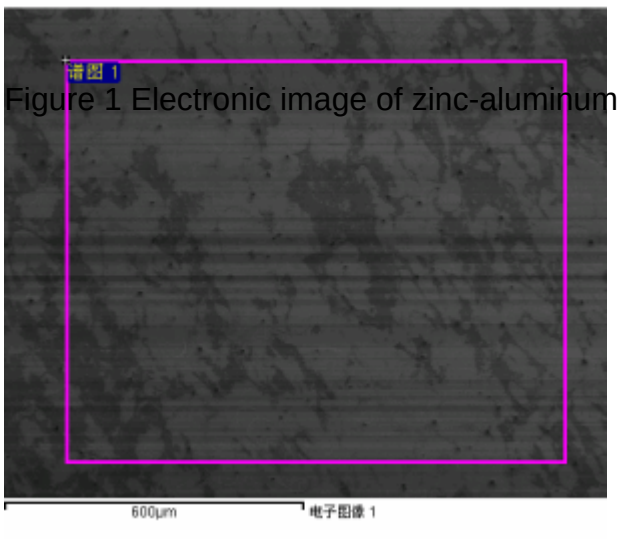
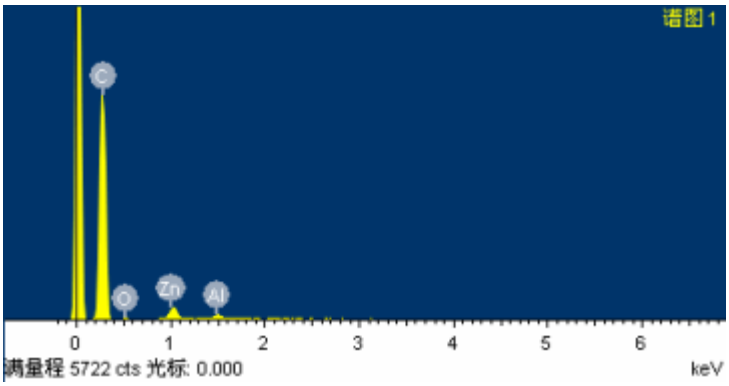


Figure 1 Electronic image of zinc-aluminum film

The second is



The analysis data of the elements contained in the film are shown in the following table. Because the polypropylene-based film has more content than the metal layer, the more elemental content is carbon and oxygen. It can be seen in the metalized layer material that the zinc content is more than aluminum.

Table 1 Composition of zinc and aluminum film

element	Weight percent	Atomic percentage
C	102.47%	96.91%
O	2.77%	1.97%
Al	0.67%	0.28%
Zn	4.82%	0.84%
Total	110.73%	100%

4.2 Metallized electrode structure

4.2.1 Metallization layer thickness

The metallized polypropylene film is formed by vapor-depositing a thin metallized electrode on a polypropylene-based film. The thickness of the metallized electrode is tens of nm. In actual use, a square resistance (square resistance, unit is Ω / □) to indicate electrode thickness. The larger the square resistance, the smaller the thickness of the metallization layer.

After years of development, the electrode structure of the zinc-aluminum composite film has been improved and tried many times. The thickness of the metallized electrode of the zinc-aluminum composite film is not equal. The common value of the square resistance in the middle active region is 6 ~ 12Ω / □, while the thickness of the metal layer in the edge zone increases, and the square resistance becomes smaller, about 2 ~ 4 / □or so. The thickened edge layer can effectively increase the contact strength between the gold sprayed layer and the metallized film, and reduce the rate of defective wear.

The metallized film has self-healing properties, and the self-healing performance of the metallized film is appropriately improved, When the capacitor is partially broken down, the performance degradation can be prevented by self-healing, and the life of the capacitor will be increased.

4.2.2 Isolation security film

In order to pursue higher safety, some capacitors are equipped with explosion-proof devices, which can cut off the power supply of the capacitor (or isolate the excessive self-healing area) before the capacitor may burst due to excessive self-healing, thereby ensuring the safety of the capacitor. Capacitors manufactured by Anhui Safe Electronics Co., Ltd. have safety devices: CBB65 capacitors with mechanical explosion-proof devices,

lamp capacitors with thermal fuses, CBB60 and CBB61 capacitors with isolation safety films.

Because the mechanical explosion-proof structure is applied to small-capacity capacitors, the disadvantages of larger capacitors and higher costs will occur. Capacitors made using isolation safety films have appeared. It replaces a single mechanical explosion-proof device with many miniature fuses evenly distributed in the area of the film metallized electrode. Oil-shielding technology is used in the manufacture of metallized films, The metallized layer is divided into many small areas connected by micro-fuse. When excessive self-healing occurs in a small area, the micro-fuse in this area is automatically disconnected to cut off the connection with the other parts of the capacitor, ensuring the safety of the capacitor itself and playing an explosion-proof role. Common types of security membranes are grid-like structure, T-shaped structure, hexagonal structure, reinforced fuse structure, etc. They have different structures, but the principle is the same and the effect is similar. The following figure is a diagram of the most common security film with a grid structure.

Figure 3 Diagram of the grid-shaped security film



When the isolation safety film capacitor is applied to a small capacity capacitor, it has considerable advantages. Compared with capacitors with mechanical explosion-proof devices, they have the characteristics of small size and low cost. The process of

manufacturing capacitors (epoxy potting) of CBB60 and CBB61 capacitors can be used to manufacture capacitors, which is less difficult to manufacture and the production threshold is reduced. The CBB60 and CBB61 capacitors without the explosion-proof function can be explosion-proof, which can improve their safety performance.

However, the disadvantages of isolated safety film capacitors are also very obvious. From the principle point of view, the safety film capacitor is used to isolate the self-healing area to ensure safety. After long-term use, the capacity attenuation of the capacitor is greater than that of general metallized film capacitors.

4.2.3 Metal shielding method during evaporation

The metallization on the polypropylene-based film does not cover all areas of the surface of the base film. The margin areas on the film and the pattern of the isolation security film are metal-free.

There are two shielding methods to prevent evaporation of metal in these areas: one is steel tape shielding, which uses steel tape to cover areas that should not be evaporated; the other is oil shielding, which is coated with a pattern before evaporation. In this way, the metal in the oil area cannot be paid. Steel strip shields may have burrs on the edges of the shield, and have more self-healing points, which affect the performance of the capacitor. The metallized film produced by Anhui Safe Electronics Co., Ltd. is an oil shield.

5 Anhui Safe Electronics Co., Ltd. capacitor temperature resistance

5.1 Special requirements for capacitor temperature resistance

Capacitors are operated at temperatures exceeding their maximum operating temperature, and capacitor life is reduced. The maximum operating temperature of the motor capacitor is generally 70 ° C. This is because the maximum summer temperature in most parts of China is generally about 40 ° C. Although capacitors are passive components, there are still some losses, and some heat is generated by themselves. The temperature of the case when the capacitor is working is generally higher than the working environment temperature. A few degrees to a dozen degrees Celsius, and the inside of the capacitor core is a few degrees to a dozen degrees higher than the case. In this way, the maximum operating temperature of the capacitor is set to 70 ° C.

However, according to the market experience of Anhui Safe Electronics Co., Ltd. for many years, in the Middle East, Southeast Asia, Africa and other places, AC motor capacitor failure rates are significantly higher than China, Europe and North America. After analysis, these areas are located in the desert Gobi or tropical areas. The maximum working environment for capacitors installed outdoors may exceed 50 ° C. If you continue to use capacitors with a maximum operating temperature of 70 ° C, life performance cannot be reliably guaranteed. In these areas, capacitors with higher temperature resistance should be used, such as capacitors with a temperature resistance of 85 ° C.

When used in luminaires, capacitors are installed near the luminaire, and the working environment has a higher temperature environment. Depending on the specific use environment, capacitors with a temperature resistance of 85 ° C or 105 ° C need to be used.

When the metallized film is used in safety capacitors or circuit boards, the capacitors need to be wave soldered or reflow soldered to the circuit board. The capacitors have a high temperature resistance and need a capacitor with a temperature resistance of 105 ° C or higher.

The temperature resistance of polypropylene itself is not very good. According to Anhui Safe Electronics Co., Ltd.'s many years of experience in manufacturing metallized films and capacitors, the long-term maximum operating temperature of conventional electrical polypropylene films is about 70 ° C. To obtain a polypropylene film for capacitors with better temperature resistance, the properties of polypropylene must be modified. In order to explore how to improve the temperature resistance of capacitors, we analyze from polypropylene structure, raw materials for biaxially oriented polypropylene films, and film manufacturing processes.

5.2 Three-dimensional structure of polypropylene

According to the three-dimensional structure of the polymer chain, polypropylene has three varieties: isotactic polypropylene (IPP, isotactic), syndiotactic polypropylene (SPP, syntactic), and atactic polypropylene (APP).

Atactic polypropylene (APP) has the characteristics of low melting point, low crystallinity, good solubility, good moisture resistance and chemical resistance. Its main uses are: as hot-melt adhesives and effective components of some coatings; as polymer processing aids, compatibilizers, etc .; and as composite materials for manufacturing construction, such as modified cement, modified asphalt Waterproof membrane.

Syndiotactic polypropylene (SPP) is a low-crystalline material with a crystallinity of about half that of IPP. Although its rigidity and hardness are only half that of IPP, its impact strength is twice that of IPP. SPP's heat resistance is not as good as IPP's, but SPP's texture is soft, low density, low temperature heat sealability, transparency, air permeability, and gloss. Its main uses are: injection sheet, film, hollow blow molding, etc.

Compared with SPP, isotactic polypropylene (IPP) has good rigidity, high hardness, high strength, and good heat resistance. It can be used at a temperature of about 1100 ° C for a long time. Compared with polyethylene, it is tough, wear-resistant, and heat-resistant. Dielectric properties and chemical inertness. It becomes brittle at low temperatures. Its main applications are: pipes, plates; monofilaments, flat filaments, strapping ropes; films, packaging bags; fibers, etc.

The crystallization properties of isotactic polypropylene are as follows:

α crystal form: It belongs to monoclinic system, and it is produced at about 138 ℃. It is the most stable structure with a melting point of 180 ℃.

β crystal form: It belongs to the hexagonal crystal system and is produced below 128 ° C. The melting point is 145 ~ 150 ° C. When it is processed above the melting point, it will be converted into α crystal form;

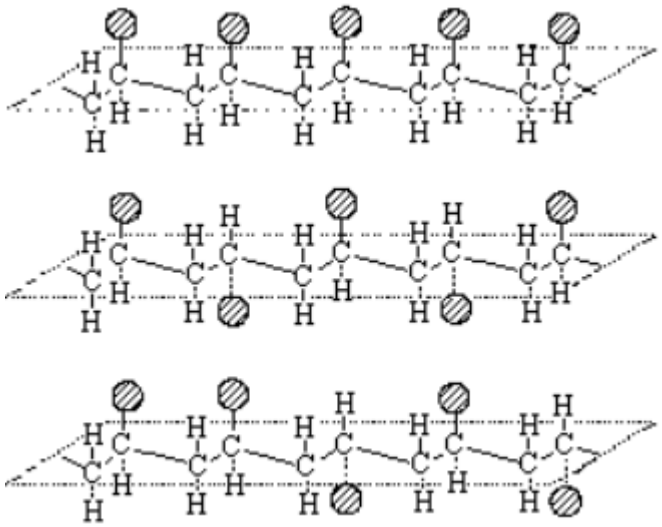
γ crystal form: belongs to the triclinic crystal system, the melting point is 170 ℃, which can only be seen when the molecular weight is low;

d crystal form: this crystal form can be seen in samples containing more amorphous components;

The pseudo-hexagonal crystal form is also called a sub-crystalline structure. After isotactic polypropylene is melted, it is rapidly cooled to below 70 ° C, or cold-drawn at a temperature below 70 ° C to generate a pseudo-hexagonal crystal form. This crystal form is unstable, and heat treatment above 70 ° C transforms into an α crystal form.

The three-dimensional structure of the three polypropylenes is as follows:

Figure 4 Three-dimensional structure of polypropylene



5.3 Raw materials and requirements for biaxially oriented polypropylene (BOPP) film for capacitors

The advantages of BOPP film are: it can be miniaturized, so that the capacitor can be miniaturized and lightened; it can be roughened and made into high-capacity oil-immersed power capacitors, which is a direction of capacitor development today; dielectric Small loss, which is the main factor for long-term stable operation; the dielectric constant does not change with frequency, which is the main factor that plays a major role in AC capacitors; excellent moisture resistance, no water absorption; cheaper price.

5.3.1 Isotacticity

Isotacticity is the percentage of polypropylene in the middle stereotactic polypropylene portion. The isotactic part has a greater effect on the molecular crystallization, while the atactic part plays an internal lubricating role, which is good for orientation. If the isotacticity is too high, the mechanical properties of the film will be improved, and the hand feels strong, but the thickness uniformity is not easy to control, and the number of film breaks during the transverse stretching will increase; if the isotacticity is too low, the film will be transparent It is improved, but it will make the film soft and not stiff. In addition, the finished film is prone to mucous membranes during storage after winding. The experience of Anhui Safe Electronics Co., Ltd. shows that the isotacticity of the raw material particles is most effective between 95% and 97%.

5.3.2 Ash

The effect of ash on the performance of electrical films is critical. The ash content should be less than 50 ppm.

5.3.3 Volatile content

If the volatile content of the polypropylene raw material is too high, it will be released by heat during processing, which seriously pollutes the environment and equipment, and indirectly pollutes the film, causing a mucosal phenomenon after the film is wound.

5.3.4 Melt Index (MFI)

It is required that the fluctuation range of the MFI of the raw material is preferably controlled within 0.2g / 10min, which is conducive to process control and can also improve film formation stability.

5.3.5 Molecular weight distribution

The wider the molecular weight distribution, the lower the crystallinity of the polymer and the higher the ductility of the resin, which is beneficial for high-speed processing. The molecular weight distribution of electrical film raw materials is required to be 4 to 5.

5.4 Production of biaxially oriented polypropylene film

5.4.1 Production Process

There are two methods for producing polypropylene electrical film: flat film method and tube film method. The flat film method has high production speed and can produce wide-format film. The film has good flatness and large thickness controllable range. The tubular membrane method is just the opposite. Currently dominating the polypropylene film for capacitors is the flat film biaxial stretching process. The following is the process flow:

Polypropylene resin → plasticization extrusion → metering extrusion → filtration → sheet extrusion molding → sheet cooling setting → longitudinal stretching → transverse stretching → heat setting → cooling setting → β-line thickness measurement → corona treatment → collection Roll → Standing → Slit → Inspection → Finished product

5.4.1.1 Extrusion

The thickness uniformity of the material is controlled by the number of revolutions of the metering pump, the number of revolutions of the cooling roller, and the size of the gap

of the mouth film of the machine head. The internal crystallinity of the sheet is controlled by temperature and pressure. To produce a roughened film, the β crystal content in the sheet must be increased.

5.4.1.2 Longitudinal stretching

If the stretching ratio is too small, it will cause uneven thickness in the longitudinal direction; if the stretching ratio is too large, the corner tearing strength will be low, and the film will be broken during transverse stretching, and normal production cannot be achieved. The stretching ratio is usually controlled between 4.5 and 5.0. Sheets should be preheated evenly.

5.4.1.3 Transverse stretching

Processes such as transverse stretching, heat setting, and cooling setting are often collectively referred to as transverse stretching. In the case of ensuring the stable stretching of the film, the stretching temperature should be as low as possible to reduce the thickness tolerance of the film. The speed of the heating wind of the horizontal drawing box is controlled uniformly in the same cross section. Generally, the error cannot be greater than 10%. The upper and lower wind pressures should be the same. The wider the horizontal drawing width, the smaller the wind pressure error. The heat setting process section should form a highest crystallization rate, and perfect the crystallization at the fastest speed, in order to reduce the internal stress of the molecular chain segment during the subsequent production and storage of the product. The maximum crystallization temperature of polypropylene is 120 ~ 150 ℃.

5.4.2 Production conditions of polypropylene film

The production conditions of propylene electrical membranes are required to be performed under constant temperature and humidity, and the purification conditions in the plant area are relatively high. General areas require 100,000-level purification, and ordinary BOPP workshops cannot produce electrical membranes. If the ambient temperature and humidity are too high, the surface resistance of the film is reduced, which is conducive to the leakage and elimination of static electricity. However, due to the high temperature and humidity of the film after winding, the product is prone to mucous membrane after long-term storage. Ambient temperature is 25 ~ 29 ℃, humidity is better between 50 ~ 60%.

5.4.3 Orientation during polypropylene stretching

In order to obtain an ideal reinforced film, it is very important to control the process parameters such as temperature, stretching ratio, and stretching speed during the stretching orientation process. BOPP biaxial stretching is usually carried out between the glass transition temperature Tg to the melting temperature Tm. Under a given stretching ratio and stretching speed, if the stretching temperature is appropriately reduced, the molecular stretching deformation will increase and the viscous deformation will decrease. Small, it helps to improve the degree of orientation; but too low temperature will reduce the mobility of molecular segments, which is not conducive to orientation; while hot stretching orientation, there is also a tendency to de-orientation, so it should be reduced quickly after stretching Temperature to maintain the degree of orientation of the polymer chain. In general, at normal production temperature, the degree of orientation increases with the increase of the stretching ratio, and with the increase of the stretching speed, the time for which the tensile stress acts is shortened, thereby affecting the effect of the orientation.

5.4.4 Crystallization during polypropylene stretching

Polypropylene crystallization runs through the entire BOPP production process from melt extrusion to aging treatment. In order to improve film-forming properties, quenched cast slabs are used when polypropylene is extruded to control the formation of crystals and reduce the crystallinity; slower crystallization is required in biaxial stretching to facilitate stretching orientation, and earlier and faster Both crystallization and larger crystalline particles may cause film breakage; in the heat treatment setting stage after transverse drawing, in order to improve rigidity and strength, it is required to generate and accelerate crystallization.

5.4.5 Relationship between orientation and crystallization during polypropylene stretching

The crystals in the biaxial stretching process have the particularity of the polymer aggregate structure, and there is a phenomenon of orientation and crystal intergrowth, that is, orientation leads to crystallization, and there is orientation in the crystal. The stretching orientation causes the wafer to tilt, slip, and stretch. The original wafer is stretched and

refined, rearranged into an oriented state, an oriented folded chain wafer is formed, and straight chain crystals or spherulites are transformed into microfibrous structures. Therefore, the overall performance of the film is further strengthened. For example, studies have shown that tensile orientation leads to regular arrangement of molecular chains, generates homogeneous crystal nuclei, induces tensile crystallization, and forms a string-like interlocking structure, which can greatly improve the mechanical properties of polypropylene in the orientation direction; biaxial stretching can also make polypropylene Larger crystals that may be produced in the medium are broken, thereby reducing the crystal size, increasing light transmittance, and reducing haze. For example, after biaxial stretching of polypropylene, the haze decreases by 50%.

5.4.6 Effects of Orientation and Crystallization on BOPP Properties

The crystallinity and crystal size of polypropylene in the film have important effects on the mechanical properties and optical properties of BOPP films. High crystallinity has high strength and poor toughness; small and uniform crystal size is conducive to improving the mechanical strength, abrasion resistance and heat resistance of the film, and improving the transparency and surface gloss of the film.

From the perspective of crystallization, to produce high-quality BOPP films, the size of polypropylene crystals should be minimized. Generally, two aspects can be considered. One is the process adjustment, such as the cooling rate, temperature, and stretching of each stage. Ratio, stretching speed, etc .; the second is the formulation, such as the choice of the main polypropylene, the use of nucleating agents and so on.

In terms of high-performance engineering and transparency modification of polypropylene, how to make polypropylene crystals finer and homogenized is also one of the important modification approaches.