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Review Article

Polyethylene plastic production process

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ABSTRACT

Polyethylene has become the most important polyolefin plastic with excellent mechanical properties, processing properties and chemical stability. It is used in the production of film, packaging and pipe. However, the non-polar property and low rigidity limit its application in certain fields. The new progress of chemical and physical modification upon polyethylene are reviewed. The former includes graft modification, chlorination, copolymerization modification, crosslinking modification, chlorosulfonation modification and plasma modification. There are different methods of polyethylene production which include high-, medium- and low-pressure polyethylene. All three methods had their own benefits and shortcomings which coexist in the industry.

KEYWORDS: polyethylene high-pressure production process

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1. Preface

The plastics industry is a new industry. Since the mid-nineteenth century, it began with the introduction of mixture of camphor and nitrocellulose. Since the 20th century, people created a series of synthetic resin that was consistent with properties of natural resin using chemical synthesis technique. Since then, the plastics industry begun to flourish and had become an indispensable material in many aspects of daily life.

At present, the plastics industry is one of the fastest growing industries in the world. The world's plastic production was 1.5 million tons in 1950, 6.9 million tons in 1960, 30 million tons in 1970, and in 1979 it had doubled to 63.44 million tons. It was estimated that, by 1985, the world's total output of plastic would rise up to 100 million tons and to greater than 350 million tons by 2000. In the foreseeable future, the world would massively produce fine plastic with volume and weight greater than steel. The future world will be 'a world of plastic'.

Polyethylene has an excellent low-temperature resistance, a great chemical resistance, an outstanding power insulation, a good pressure resistance and a marvelous radiation resistance. Since polyethylene is composed only of carbon and hydrogen, there is no polar element present hence it comes with good water resistance.

Based on required pressure in production, there are high-, medium-, and low-pressure manufacturing methods. Each has its own advantages and disadvantages. In general, the polyethylene produced by the high-pressure method is called 'low-density polyethylene' and the polyethylene produced by the medium- or low-pressure method is called 'high density polyethylene'. In addition to manufacturing methods, polyethylene can be divided into low-density and high-density polyethylene with respect to their molecular structure. There is low molecular weight polyethylene, ultra-high molecular weight polyethylene, cross-linked polyethylene, chlorinated polyethylene, chlorosulfonated polyethylene, ethylene-ethyl acrylate copolymer and other polyethylene and its copolymer. With the development of various modification technologies and composite technologies, polyethylene is engaging into new applications.

2. Introduction to Polyethylene

2.1. Introduction

Polyethylene products are very common in our daily life. For examples, food and pharmaceutical packaging film, wire and cable insulation and pipe. Therefore, the production of polyethylene is humongous as is one of the most popular used polymer materials in day-to-day life. A large number of products could be manufactured from plastic which include plastic bags, plastic film and milk barrels which are suitable for hollow molding, injection molding and extrusion of various products. For instances, various containers, cable cladding, pipe, profile and sheet.

Polyethylene is among the top five world's largest productions and consumptions of synthetic resin. The main varieties are low-density polyethylene (LDPE), high-density polyethylene (HDPE) and linear low-density polyethylene (LLDPE). In 2002, the production capacity of polyethylene in the world had reached 68,517,000 t/a, of which Western Europe accounted for ~20%, North America accounted for ~30%, and Japan accounted for ~5%. Beside Japan, the Asia-Pacific region accounted for ~24%, Africa/Middle East accounted for 12% whereas Central and South America accounted for ~4%. In 2001, the global operating rate had dropped to less than 80% due to the rise in the prices of global production and raw material as a result of economic slowdown. In 2002, as the recovering of the global economy, the polyethylene operating rate restored ~80%.

Polyethylene is very sensitive to environmental stress (chemical and mechanical) and has poor heat-aging resistance. The properties of polyethylene vary depending on the molecular structure and density. The products of different densities (0.91 to 0.96 g/cm^3) can be obtained by different production methods. Polyethylene can be processed by general thermoplastics molding methods. They are mainly used to manufacture thin films, containers, pipes, monofilament, wire and cable, daily necessities, etc. and is applicable in television, radar and other high-frequency insulation materials. With the development of petrochemical industry, polyethylene production has been developing rapidly, and the output of plastic production accounts for about 1/4. In 1983 the world's total polyethylene production capacity was 24.65 Mt and had a construction capacity of 3.16 Mt.

In recent years, application of polyethylene as a diffusing agent in the field of nuclear physics, astrophysics, reactor operation to measure the amount of neutrons on the nuclear physics was evident.

2.2. Structure of polyethylene

Polyethylene (PE) is a type of plastic. The plastic bags that we get from the supermarket are made of it. Although PE has the simplest structure of the polymer, it is still the most widely used polymer material. PE is synthesized by polymerization of ethylene ($CH_2 = CH_2$). [2]

The performance of PE depends on its polymerization. Ziegler-Natta polymerization was carried out under medium-pressure (15-30 atm), organic compound catalytic conditions for high density polyethylene (HDPE). Under these conditions, the polymerized PE molecules were linear and the molecular chain was very long with a molecular weight up to several hundred thousand. If produced under high-pressure (100-300 MPa), high temperature (190-210 ℃) and in peroxide catalytic conditions free radical polymerization, the end product would be low-density polyethylene (LDPE) which was a branched structure.

2.3. polyethylene in the industry development

PE is the most widely used variety of synthetic resins in China. It is mainly used to make high-frequency insulating materials such as film, container, pipe, monofilament, wire, cable and many other daily necessities. With the development of petrochemical industry, PE production has been in rapid development with a production accounting for ~1/4 of total plastic production. The rapid expansion of China's economy had created a favorable environment for the development of synthetic resin industry. PE industry was expected to grow at a faster rate.

From January to June of 2008, the cumulative production of PE resin was 3,520,250.09 tons which showed an increase of 2.36% over the same period of last year. During this period China imported 2,537,799,893.00 kg of primary polymer which was worthy US $4,085,020,175, and exported 97,449,745.00 kg of primary polymer which earned RMB152,849,306.

Within the period from 2008 to 2011, new projects in the Asia-Pacific region were mainly located in China, India and South Korea. They continued to be a source of power. China was becoming the world's largest exporter of PE films and bags which were exported to North America, Western Europe and Japan in large quantities. In addition to the industry on the film, woven bags, pipe, cable materials, hollow containers, turnover boxes and other products led to a strong demand for PE consumption growth. Hence, China's PE production capacity was expected to grow rapidly than before. At present, China's PE industry production and development had the following major characteristics:

(1) Rapid increase in production capacity and production;

(2) The supply gap is large, the dependence on imported goods has not changed;

(3) Strong consumer demand in conjunction with the rapid development of the future;

(4) Remains a problem as the industry is becoming increasingly competitive

(5) LLDPE gradually finds its way to the LDPE market share

2.4. Polyethylene usage

PE is a promising synthetic material with great physical and chemical properties. It has high degree of mechanical properties and excellent combination of good dielectric properties. In addition, the molding process is good and the price is low. They are particularly important in following aspects:

(1) Electrical insulation

Due to its high stability, moisture resistance and high dielectric properties, it is an excellent material in the making of insulation material in electrical, non-electrical engineering and many other relevant aspects.

(2) Anti-corrosive agents

Can be used for anti-corrosive materials such as pipes, lining and so on.

(3) Packaging

PE sheet has properties of low-density, soft, water impermeable, high tear strength and chemical resistance. These characteristics are necessary for packaging materials hence PE film has a high market value in the packaging industry and is gradually replacing celluloid.

(4) After radiation treatment, PE (i) is hard to deform; (ii) will not produce environmental stress cracking; (iii) has strong elasticity; (iv) has excellent electrical insulation and solvent resistance; (v) has high temperature resistance; (vi) has low power factor. Hence the greater performance after radiation puts it into a wider range of uses. For examples, insulating materials for capacitors and transformers and higher temperature parts in aircraft. However, the cross-linking reaction of PE during radiation results in difficulty to undergo subsequent processing.

In addition to the above-mentioned purposes, there are other uses such as various medical equipment, spraying metal, wood, fabric and other materials. HDPE can be used as rubber reinforcing agent. [1]

3. Polyethylene Properties

3.1. Polyethylene physical properties

Ethylene is transparent in the film state but is opaque in the presence of massive blocks due to a large number of crystals inside and strong light scattering. The degree of PE crystallization is affected by the number of its branches. The more branches, the more difficult to crystallize. The melting temperature of PE crystal is also affected by the number of branches, distributed in the range from 90 to 130 °C. PE monocrystals can generally be prepared by dissolving HDPE in xylene at 130 °C or higher.

PE is a white waxy translucent material which is soft, tough, lighter than water, non-toxic and has excellent dielectric properties. It is flammable and continued to burn after the fire. Its water permeability is low and the organic vapor transmission rate is larger. The transparency of PE decreases with the increase of crystallinity. Under certain crystallinity, the transparency increases with the increase of molecular weight. HDPE melting point ranges from 132 to 135 ℃, LDPE at ~112 ℃. At room temperature it is not soluble in any known solvent whereas at 70 ℃ or greater it can be dissolved in toluene, amyl acetate, trichlorethylene and other solvents.

PE is odorless, non-toxic, waxy, low-temperature resistant (minimum temperature down to -100 ℃), chemically stable and resistant to most of the acid-base erosions (intolerant of oxidative acids). At room temperature it can be slowly dissolved in some organic solvents due to its linear molecular structures. In addition, PE does not swell and has great electrical insulation performance. However, PE is very sensitive to environmental stress (chemical and mechanical role) and has poor heat resistance. The properties of PE vary depending on the variety which subsequently depends on its molecular structure and density.

3.2. Polyethylene chemical properties

PE has excellent chemical stability. It is resistant to acidic and basic solution such as hydrochloric acid, hydrofluoric acid, phosphoric acid, formic acid, amines, sodium hydroxide and potassium hydroxide at room temperature. However, nitric acid and sulfuric acid have a stronger destructive effect to PE. PE is susceptible to photo-oxidation, thermal oxidation and ozone decomposition. Under the action of ultraviolet light, it is prone to degradation. Carbon on PE has excellent light shielding effect. After irradiation there will be cross-linking, broken chain and formation of unsaturated groups and other reflection. Ethylene is produced by polymerization of a thermoplastic resin. Copolymers of ethylene with a small amount of alpha-olefins are also included in the industry.

3.3. Features of polyethylene

Its corrosion resistance and electrical insulation properties (especially high-frequency insulation) are excellent, but can be easily chlorinated, chemical cross-linked, irradiation cross-linking modified. Glass fiber reinforced with low-pressure polyethylene has lower melting point, great rigidity, hardness and strength, high water absorption, good electrical properties and resistance to radiation. Under higher pressure, it has good flexibility, elongation, impact strength and better permeability. High molecular weight polyethylene impacts strength and fatigue resistance. Ethylene is suitable for making corrosion-resistant parts and insulating parts while high-pressure polyethylene is suitable for making films. Ultra-high molecular weight polyethylene on the other hand is suitable for making shock absorption, wear and transmission parts.

3.4. Molding characteristics

(1) Crystalline material: small moisture absorption, no need to be fully dried, excellent mobility, pressure sensitive, the use of high-pressure in injection molding, temperature uniformity and great filling speed. Note that the choice of gate position is essential to prevent shrinkage and deformation.

(2) Great shrinkage values, prone to deformation warping. Cooling should be slow, a cooling system required.

(3) Heating time should not be too long otherwise it will break down.

(4) Soft plastic parts have a shallow side of the groove, can be of leakage when forced.

(5) May melt and hence not to use with organic solvents to prevent cracking

4. Polyethylene Production Process

4.1. Development of polyethylene preparation methods

In 1933, the British domestic chemical industry found that ethylene could be polymerized under high-pressure to produce PE. This method was industrialized in 1939, commonly known as high-pressure preparation. In 1953, Federal Republic of Germany K. Ziegler found that $TiCl_4$-Al $(C_2H_5)_3$ could be used as a catalyst and hence ethylene could be polymerized at lower pressure. This method was industrialized by the Federal Republic of Germany Hurst company in 1955 and referred to as low-pressure PE. In the early 1950s, Philip Petroleum found the use of chromium oxide-silica gel as a catalyst, ethylene in the pressure could be polymerized to produce HDPE, and in 1957 it achieved industrialization. In 1960, Canada DuPont began to manufacture LDPE with ethylene and α-olefin solution. In 1977, the United States Carbide Corporation and Dow Chemical Company had made low-pressure method of LDPE, known as linear LDPE, which was referred to as the United States Carbide's gas phase method. LLDPE and branched LDPE have similar performance. The combination with low energy consumption in the production gave rise to the rapid development of PE and it became one of the most compelling new synthetic resin.

The core technology of low-pressure is the catalyst. Germany Ziegler invented $TiCl_4$-Al $(C_2H_5)_3$ system as the first generation of polyolefin catalyst. The catalytic efficiency was low, about a few grams per gram of PE. 1963 Belgium Solvay company pioneered the magnesium compound as the carrier of the second generation of catalyst. The catalytic efficiency increased to hundreds of thousands grams per gram PE. The catalyst residue could also be eliminated using the second-generation catalyst. Later on, a gas-phase efficient catalyst was developed. In 1975, an Italian company developed granulated PE and directly produced spherical polyethylene catalyst, known as the third-generation catalyst which was another milestone for HDPE production. [4]

4.2. Production methods

It could be divided into low-, medium- and high-pressure methods. High-pressure method is used to produce LDPE. This method was developed early and its usage accounted for ~2/3 of the total output of PE. However, with the production technology and catalyst development, its growth rate was greatly lagging behind the low-pressure method, which included the slurry-, solution-, gas-phase and improved LDPE methods. The slurry method was divided into a stirred tank slurry process and a loop reactor slurry method, and was mainly for the production of HDPE. The solution- and gas-phase methods could not only produce HDPE, but also add comonomer. The production of LDPE is also known as linear LDPE. In recent years, a variety of low-pressure processes developed rapidly.

The current process of producing LDPE is mainly by autoclave and high-pressure tube method. Organic peroxide is used as initiator and free radical polymer. The LDPE process is the modified version of LDPE equipment production. The pressure will be reduced with the use of Ziegler catalyst production of linear PE. Most of the current LLDPE is produced by gas phase and solution processes, while HDPE is mostly by the slurry method. Traditionally, slurry processes have been used to produce HDPE, but in recent years the application loop reactor in producing LLDPE is also evident.

4.2.1 High-pressure method

High-pressure method uses oxygen or peroxide as the initiator to polymerize ethylene. The ethylene is fed into the reactor by secondary pressure and is polymerized into PE at a pressure of 100 to 300 MPa and at a temperature of 200 to 300 °C under the action of an initiator. The reaction is separated by pressure and the unreacted ethylene is recovered and recycled. PE in the addition of plastic additives creates granulation after extrusion.

The polymerization reactor consists of a tubular reactor (pipe length up to 2000 m) and a kettle reactor. Tube method has a one-way conversion rate of 20-34%, single-line annual production capacity of 100 kt. Kettle process flow of one-way conversion has a rate of 20-25% while single-line annual production capacity is 180 kt.

4.2.2 Low-pressure method

Polymerization by the low-pressure method, liquid phase method (also divided into slurry and solution method) and gas phase requires a pressure of below 2 MPa. General steps are the preparation of the catalyst, ethylene polymerization, polymer separation and granulation. China is mainly using Ziegler catalyst slurry method. The most important gas phase bypasses the need for solvent recovery and polymer drying processes, saving 15% of the investment and 10% of the operating cost. Compared with the traditional high-pressure method, the investment is only 30% and the operating costs is only 1/6. Thus it has been a rapid development. However further improvement should be made for quality and variety in the gas phase.

Conditions and Process Description: Ethylene has a purity of 99% or more and is polymerized in the presence of catalyst titanium tetrachloride and monochloride diethylaluminum in gasoline at a pressure of 0.1-0.5 MPa and a temperature of 65-75 °C to obtain a slurry of HDPE. The first step is the destruction of residual catalyst by alcoholysis, then proceeds with neutralization, washing, and the recovery of gasoline and unpolymerized ethylene. The next step is drying to obtain granulation product. Features: corrosion resistance, electrical insulation (especially high-frequency insulation), can be chlorinated. Specific gravity: 0.94-0.96 g/cm^3; Shrinkage: 1.5-3.6%; Molding temperature: 140-220 °C.

PE produced by the Slurry method is insoluble in solvents. Slurry polymerization conditions are mild and easy to operate. The alkyl aluminum is commonly used as activator and hydrogen as a molecular weight regulator for the use of kettle reactor. The polymerizer is passed through a flash kettle, a gas-liquid separator to a dry and granulate the powder. The production process also includes solvent recovery, solvent refining and other steps. Using a different polymerizer in series or in parallel is also available.

The polymerization consists of two types. First is the mixing tank reactor in which you can obtain products of different molecular weight. The second is the slurry method with a ring reactor. The former contains two or more reactors, in series or in parallel. In the slurry process, monomer, comonomer and hydrogen are dissolved in the diluent. The reaction temperature and pressure are both low. Since the polymer does not dissolve in the diluents, it cannot produce low-density products but only HDPE. The LDPE can be produced with lighter isobutane as a diluent (most of which is heavily diluted with other slurries) using Phillipe loop reactor slurry. In recent years manufacturers have used the process to produce LLDPE.

The loop reactor slurry prevails in the United States, while Europe and Japan are mostly using stirred tank reactors. Philips ring reactor slurry uses chromium oxide as catalyst while the mixing reactor slurry method uses Ziegler Chin catalyst. The molecular weight distribution is narrow. As for the production of high molecular weight HDPE by the use of double-kettle series method, it has reduced productivity and its operational control is also more difficult. Slurry industrialization occurs earlier hence its development is more mature and product quality is also better. However, most of the world's HDPE is produced by slurry method. In the United States, HDPE produced by the slurry method accounted for 2/3 of total HDPE production. Similarly, in Western Europe and Japan the slurry process stands predominant.

Solution polymerization -Ethylene and PE are dissolved in solvents. The reaction system is homogeneous. Reaction temperature (≥ 140 ℃) and pressure (4-5 MPa) are higher. It is characterized by short polymerization time, high production intensity, high yield, high density, medium and low-density of polyethylene which can better control the properties of the product. However, the molecular weight of the polymer obtained by the solution method is low, the molecular weight distribution is narrow while the content is low.

4.2.3 Medium-pressure method

The medium-pressure process uses a chromium catalyst supported on silica gel to polymerize ethylene under medium-pressure in a loop reactor to produce HDPE. The Dutch DsM stamicarbo craft Dow Process and DuPont process in Canada are relatively important. The first two pressures are lower while the latter is higher. It is also known as medium-pressure solution method. The current solution method is at the medium-pressure, in which the solution process, the monomer and the resulting polymer are soluble in the solvent so the higher the temperature required, the higher pressure. When the polymer molecular weight is high, the solution viscosity, stirring difficulties and production capacity is limited. Subsequently, the production of high molecular weight products becomes more difficult due to the reaction pressure, temperature and polymerization rate.

Ethylene stays for a short time in the reactor, usually for a few minutes. Switching grade transition time is short and transition material is less. For instance, Canada DuPont pressure solution method stays for Zmin, can be switched between 3 to 4 grades in 24 hours. When the new grade is put into the material, the granulation lasts only 20 min. The resin produced by the solution method is of good quality, the molecular weight distribution can be very narrow and the melt index can be high. Solution method uses evaporation of solvent recovery method of polymer as energy consumption so that the solvent recovery process is more complex.

Gas phase -Ethylene in the gaseous polymerization uses fluidized bed reactor. The catalyst has two kinds of chromium and titanium. First it takes from the tank and added to the bed with high-speed ethylene cycle to maintain the bed fluidization. Finally it is eliminated by heat polymerization. The resulting polyethylene is discharged from the bottom of the reactor. The reactor pressure is about 2 MPa and the temperature is 85-100 °C.

4.3. Production process

Presently, there are many companies specializing in PE technology in the world: 7 enterprises LDPE technology, 10 with LLDPE and full density technology, and 12 with HDPE technology. From the technical development point of view, high-pressure production of LDPE resin production technology is the most mature. Kettle and tube process technology is also mature and currently coexists. Foreign companies generally use low temperature and high activity catalyst-initiated polymerization system which can reduce the reaction temperature and pressure.

High-pressure production of LDPE will be large-scale and tube-oriented direction. Low-pressure production of HDPE and LLDPE use mainly titanium and network catalyst. Europe and Japan use mainly titanium catalyst whereas United States uses network catalyst.

Catalyst technology: catalyst is a key part of PE technology. In 1991, metallocene catalyst achieved industrialization in the United States which leads to development of PE production technology. At present, the world's main applications of PE production technology shared 11 species, and China has 8 of them:

(1) High-pressure tube and kettle reaction process

(2) Mitsui chemical low-pressure silt method CX process

(3) BP gas phase Innovene production process

(4) Chevron - Phillips company double loop reactor LPE process

(5) Nordic Chemical North Star (Bastar) Shuangfeng process

(6) Low-pressure gas phase Unipol process

(7) Basel Polyolefin Company Hostalen Crafts

(8) Sclartech solution production process

5. Chapter IV Polyethylene modified varieties

Modified PE varieties are mainly chlorinated PE, chlorosulfonated PE, cross-linked PE and blended modified varieties.

5.1. Chlorinated polyethylene

A chlorine atom can be obtained by partially replacing the hydrogen atom in the PE with a chlorine moiety. Chlorination is carried out under the action of light or peroxide and is mainly produced by industrial suspension in the industry. Due to (i) the molecular weight of the raw material PE and its distribution, (ii) the degree of branching and chlorination, (iii) the distribution of chlorine atoms and (iv) the residual crystallinity, it is possible to obtain chlorinated PE of consistency varying from rubbery to hard plastic. The main purpose is to make polyvinyl chloride modifier to improve the impact resistance of PVC. Chlorinated PE itself can also be used as electrical insulation materials and ground materials.

5.2. Chlorosulfonated polyethylene

When PE reacts with chlorine containing sulfur dioxide, some of the hydrogen atoms in the molecule are replaced by chlorine and a small amount of sulfonyl chloride ($-SO_2Cl$) groups to give chlorosulfonated PE. The main industrial system is the suspension method. Chlorosulfonated PE is resistant to ozone, chemical corrosion, oil, heat, light, abrasion and tensile strength. It is a kind of elastomer with good performance and can be used to make contact parts of food.

5.3. Crosslinked polyethylene

X-ray, electron beam, ultraviolet radiation or chemical method (peroxide or silicone cross-linking) is employed to make linear PE mesh or body type of cross-linked PE. Silicone cross-linking method is simple, low operating costs and cross-linking can be carried out step by step. Blow molding and injection molding should be adopted. Cross-linked PE is resistant to heat, environmental stress cracking and has better mechanical properties than PE. This makes it suitable for large-scale pipe, cable and rotary molding products.

5.4. Blending modified varieties

The LLDPE and LDPE after blending can be used for processing films and other products. PE and ethylene-propylene rubber blends can be used to produce a wide range of thermoplastic elastomers.

5.5. Metallocene polyethylene

Metallocene PE is a novel thermoplastic which resembled the 90's polyolefin industry's most important technological progress following the LLDPE production. Since it uses metallocene as polymerization catalyst to produce PE, the performance of the traditional Ziegler-Natta catalyst polymerization in production of PE is therefore significantly different. metallocene catalyst in the synthesis of metallocene PE is unique and has excellent performance and application. This had aroused widespread concern in the market and many of the world's leading petrochemical companies had invested huge manpower, material resources competing development and research.

Metallocene catalyst for ethylene polymerization can only be obtained from the molecular weight of 2 to 3 million of the wax and catalytic activity is not high enough. There was no practical significance and therefore did not attract a wild attention. Until 1980, Professor Kaminsky of the University of Hamburg in Germany found that ethylene polymerization could be carried out in toluene solution with a co-catalyst combined with zirconocene chloride zirconium dichloride (CP_2ZrCl_2) and methylaluminoxane (MAO) with a catalyst activity of up to 10^6 g-PE/g-Zr. MAO is a high-homogeneous polymethyl-aluminoxane synthesized by dimethylaluminum and water under conditions other than the polymerization system. Professor Kaminsky's discovery has bestowed vitality into metallocene catalyst research, attracting many companies to involve. In 1991, Exxon achieved the metallocene catalyst for polyolefin industrial production to produce the first batch of metallocene PE (MPE). Its trade name is 'Exact'.

The main varieties are LLDPE and very low-density polyethylene (VLDPE). MPE has two series, the packaging field is the main goal of the film grade and the other is octene-1 for the comonomer plastic, known as POP (Polyolefine Plastmer). MPE film grades have a lower melting point and a significant melting zone. Its toughness, transparency, hot viscosity, heat sealing temperature and low odor are significantly better than traditional PE so that it can be used to produce heavy bags, metal trash lined, food packaging and stretch film.

6. Polyethylene Processing and Application

6.1. Processing and Application

PE can be used in blow molding, extrusion, injection molding and other methods of processing, as well as in the manufacture of thin films, hollow products, fiber and daily sundry goods. In the actual production, in order to improve the oxidative stability of PE, a small amount of plastic additives are required. Common UV absorbers are o-hydroxy-benzophenone or its alkoxy derivatives, for example, carbon black. In addition, the addition of antioxidants, lubricants and colorants has expanded its application.

6.1.1 Film

LDPE produced by blowing accounted for more than half of the film production. This film has good transparency and a certain degree of tensile strength, and is widely used in a variety of food, clothing, medicine, fertilizer, industrial packaging and agricultural filming. It can also be processed into a composite film for packaging heavy objects. Since 1975, HDPE film was developed. It had good strength, printability, machinability, and stability against low temperature and moisture. LLDPE was also used to make thin film, whose had better strength and toughness than LDPE film. Its puncture resistance and rigidity were also good. Although it has poor transparency, it is still slightly better than that of HDPE. In addition, it can also be processed into paper, aluminum foil or other plastic film coating.

6.1.2 Hollow products

HDPE of high strength is suitable for hollow products. It can be made by blow molding bottles, barrels, cans, tanks and other containers or by casting method into the tank and other large containers.

6.1.3 Tube-sheet

Extrusion can produce PE tubing. HDPE pipe strength is greater and is suitable for underground laying. The extruded sheet can be subjected to secondary processing. HDPE can also be made into foam and building materials.

6.1.4 Fiber

China referred to fiber as the ethylene fiber. Generally it uses low-pressure PE as raw materials which is being spun into synthetic fibers. Ethylene is mainly used for the production of fishing nets and ropes or spun into short fibers for use as flakes. It can also be used for industrial acid and alkali fabric. At present, ultra-high strength PE fiber (strength up to 3 - 4 GPa) has been developed and applied to bulletproof vest, automobile and off-shore operation.

6.1.5 Sundry goods

Sundry products produced by injection molding include daily groceries, artificial flowers, turnover boxes, small containers, bicycles and tractor parts.

7. Conclusions

The plastics industry is one of the fastest growing industrial sectors in the world and is one of the largest and most versatile thermoplastic general materials. Polyethylene has excellent resistance to low temperature, great chemical resistance, outstanding power insulation, good resistance to high-pressure and marvelous resistance to radiation. It is therefore, becoming the most predominating material covering every aspects of our life.

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