Packaged ABS Resin Technology

Science & Technology Management Department

2011

CHINA NATIONAL PETROLEUM CORPORATION

We would like to cooperate with industry peers for the common development and prosperity of ABS!

Contents

China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. As an integrated oil company of cross-regions, cross-industries and cross-countries, it adopts modern enterprise system to realize the integration of upstream and downstream operations, internal and external trade and production and marketing. CNPC has 17 upstream companies, 33 downstream companies and 36 large-scale marketing companies. It is China's largest producer and supplier of oil and gas, and also one of the largest refined oil products and petrochemicals. In 2010 CNPC produced 105 million tons of crude oil and 72.5 billion cubic meters of natural gas, while crude processing volume reached 135 million tons. The total revenue of RMB1, 720 billion with a profit of RMB172.7 billion had been achieved the same year. Its profit is among the highest of the domestic enterprises in China.

CNPC was ranked 10th in Fortune Global 500 in 2010 and 5th among global top 50 oil companies.

CNPC strictly follows by the combined strategies of increasing resource capacity, expanding market shares and consolidating the international role, and persists in regarding technical innovation as a key framework to advance technological progress. To develop its core businesses, focuses will be placed on the solutions of key bottleneck technologies and key proprietary technologies. Thanks to continuously improving of the technical innovation system, optimizing the configuration of technological resources and strengthening the construction of strong talent teams, CNPC's technological creativity has been considerably upgraded. Consequently, a large number of technologies have been developed independently, with its own intellectual property.

The Packaged ABS Resin Technology is one of representatives for major innovations of CNPC.

CLEAN ENERGY SUPPLY FOR BETTER ENVIRONMENT

1 INTRODUCTION

1.1 ABS Resin

ABS resin (Acrylonitrile Butadiene Styrene) is the graft copolymer of three monomers—acrylonitrile, 1,3-butadiene and styrene. As a thermoplastic high molecular material with high strength, high toughness, excellent processability, this copolymer combines the impact resistance of butadiene, rigidity and chemical resistance of acrylonitrile, glossiness and mouldability of styrene.

The Packaged ABS Resin Technology independently developed by CNPC: Emulsion polymerization is adopted to synthesize small particle-sized polybutadiene latex that transforms to large particle-sized polybutadiene latex through chemical agglomeration. Then the large particle-sized polybutadiene latex undergoes the reaction of emulsion graft polymerization with styrene and monomers of acrylonitrile to produce ABS graft latex. Graft latex is made into ABS powder through coagulation, dewatering and drying. ABS powder, SAN particles that are produced by bulk polymerization and various additives are mixed in proportion, extruded and granulated before ABS resin forms.

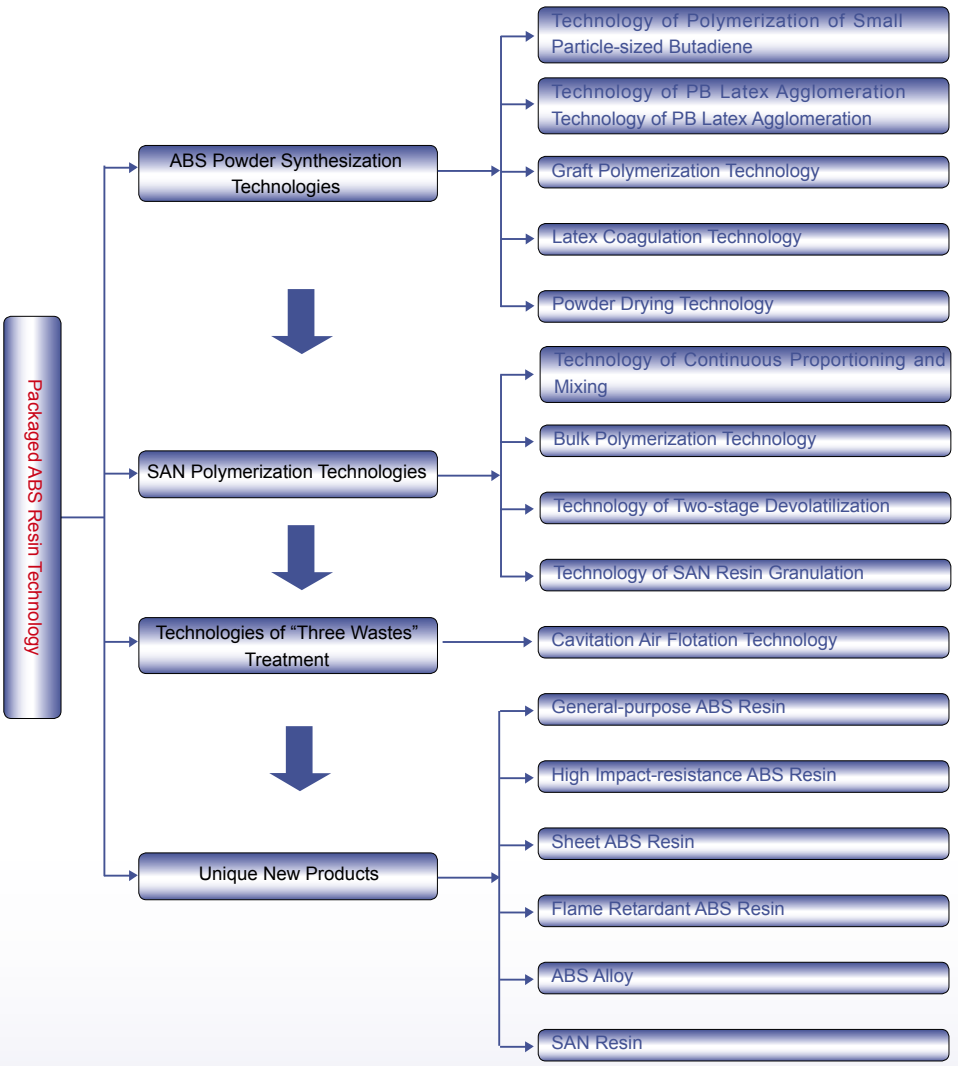
CNPC introduced technology of ABS resin from abroad in early 1960s. CNPC's scientific research personnel have hammered at the production, research and development of ABS resin. With over 40 years of endeavors, CNPC has become an important manufacturer and main driving force in scientific research of ABS resin. It owns the well-equipped resin synthesization laboratories and a national top R&D team consisting of over 100 senior talents in resin development and over 300 specialists for professional services. These talents and specialists have abundant experience in many fields (e.g. ABS resin production technology, new product development) and made substantial achievements. The early 21st century witnessed CNPC's dedication to the production and R&D of ABS resin, and now CNPC has become an indispensable manufacturer and technical service supplier in ABS resin industry.

1.2 Advantages of CNPC ABS Resin Technology

The Emulsion Graft Technology, namely the Packaged Technology of SAN Mixing independently developed by CNPC delivers the combination of the two-stage process for forming large particles latex and high rubber content graft polymerization, which solves the conflict between the rapid polymerization reaction and particle size control, as well as the conflict between the high conversion rate and gel content to improve the production efficiency by 2~3 times compared with similar equipment.

- The Technology of Polymerization of Small Particle-sized Butadiene is featured by short polymerization time, high conversion rate, optimally controlled particle size, low system viscosity, excellent polymerization stability and stable latex with a storage period of over 2 years.

- The chemical agglomeration period is short and the storage period of agglomerated latex with sound stability can reach over 1 year;
- The Graft Polymerization Technology ensures that graft polymerization process takes short time, rubber content may be adjusted between 40%~75%, graft percentage and conversion rate are high and latex can be easily coagulated and dried;
- Coagulant with low cost is used in coagulation process that is carried out under low temperature and the coagulated latex powder in uniform particle size ensures stable operation of the dewaterer with long-time cycle;
- Highly safe Nitrogen Drying Technology sufficiently ensures a safe powder drying process;
- The SAN Synthesization Technology boasts good operation flexibility, high safety factor, high conversion rate, low residue monomer content, few “three wastes” and little pollution to environment;
- The Cavitation Air Flotation (CAF) Technology featured by simple operation and high processing efficiency is introduced in wastewater treatment system;
- Compared with that of the similar units, its consumption of energy and material is relatively low.


Packaged ABS Resin Technology
ABS Powder Synthesization Technologies
Technology of Polymerization of Small Particle-sized Butadiene
Technology of PB Latex Agglomeration Technology of PB Latex Agglomeration
Graft Polymerization Technology
Latex Coagulation Technology
Powder Drying Technology
SAN Polymerization Technologies
Technology of Continuous Proportioning and Mixing
Bulk Polymerization Technology
Technology of Two-stage Devolatilization
Technology of SAN Resin Granulation
Technologies of "Three Wastes" Treatment
Cavitation Air Flotation Technology
Unique New Products
General-purpose ABS Resin
High Impact-resistance ABS Resin
Sheet ABS Resin
Flame Retardant ABS Resin
ABS Alloy
SAN Resin

2 UNIQUE TECHNOLOGIES

The “high rubber content by two-stage” ABS Powder Synthesization Technology independently developed by CNPC can solve the conflict between high reaction speed and optimum latex particle size as well as the conflict between high conversion rate and optimum gel content. This technology can also realize the proper combination of rapid polymerization, high conversion rate, high rubber content and optimum particle size, shorten the synthesization time of ABS powder, and optimize the overall performance of ABS resin. As a result, the production efficiency exceeds that of the similar technologies by 60% and the conversion rate of butadiene is higher than 98%. Moreover, fewer monomer recovery units are used, the equipment investment is cut down and the pollution to environment is decreased. Besides, the unit waste water discharge is lessened by 5%~7% and the raw material consumption is reduced. The technology is characterized by mature and simple techniques, stable device operation, long operation cycle as well as safety and eco-friendliness. Meanwhile, this technology can be used to produce ABS powder with rubber content varying from 40% to 75% and can deliver ABS products with high added-value and production techniques to customers with various demands.

2.1 ABS Powder Synthesization Technologies

1) Technology of Polymerization of Small Particle-sized Butadiene

As a main stage of ABS resin production and the most critical technology in the two-stage production of ABS resin, the emulsion polymerization process used for production of small particle-sized PB employs water solvent, butadiene and a small amount of styrene monomers together with compound emulsifier, multifunctional additives, and molecular weight regulator, all of which are dispersed into emulsion by mechanical agitation and react under effect of inorganic peroxide as initiator.

The ABS Resin Butadiene Polymerization Technology independently developed by CNPC solves the conflict between high conversion rate and optimum gel content to allow the proper combination of rapid polymerization, high conversion rate and optimum gel content, which reduces production cost and decrease “three wastes” discharge. Compared with similar technologies, this innovative technology has outstanding characteristics and significant advantages.

Technical Features and Advantages:

(1) With short polymerization time, the same polymerization equipment allows PB latex production to increase by 2~3 times; the polymerization time is shortened by 50%~70% compared with similar technologies;

(2) Conversion rate of polymerization is high and recovery system for butadiene is not needed;

(3) Compound emulsifying system improves the stability of polymerization and agglomeration process;

(4) Multifunctional additives lessen the types and dosage of additives, shorten induction period and improve stability of system;

(5) Unique technology of heat-removing during PB polymerization accelerates heat release during early and later polymerization process while subduces heat release during middle stage to ensure the safety of polymerization;

(6) Without coagulum, polymerization proceeds with high stability and long reactor cleaning interval that can be up to over 2 months;

(7) The gel content may be adjusted between 40%~75% while high conversion rate is ensured.

Application of Technology

The technology is generally used for the production of rubber latex during the production of General-purpose ABS Resin, Special ABS Resin and ABS Alloy, as well as for the production of polybutadiene and styrene butadiene latex.

2) Chemical Agglomeration Technology

Chemical agglomeration which takes small particle-sized PB latex (80~120nm) as base latex is used to produce grafting trunk latex with particle size of 120~400nm. During the agglomeration, anhydride agglomerant is added under certain conditions and agitation while reaction temperature and time are controlled; besides, the particle size, particle size distribution and PH viscosity can be effectively controlled to ensure the stability and practicability of agglomerated latex.

Compared with similar technologies, Chemical Agglomeration Technology independently developed by CNPC may allow agglomerated latex with properties within optimum range required by different types of ABS resins. In addition, little latex is precipitated during the agglomeration process and the concentration of agglomerant is high to enable more stable agglomerated latex and improve the stability of grafting reaction.

Technical Features and Advantages

- Continuous and precise control on latex particle size allows the production of any kind of latex with the particle size between 120nm and 400nm;
- Both agglomeration process and equipment are simple and easy to operate. Particle size is easy to control;

- Rapid agglomeration reaction, agglomeration time < 1h and latex precipitated <0.03%. The agglomeration cycle is 60% shorter and the latex precipitated is 70% less than those of similar technologies;
- Agglomerated particle size is stable (may be stored for over 1 year) and particle size, particle size distribution, PH, and viscosity can be effectively controlled.

Application of Technology

The latex particle size, particle size distribution and additives may be adjusted to produce grafting trunk latex required by different types of ABS resin.

3) Graft Polymerization Technology

As for the graft polymerization, main latex PB, styrene and acrylonitrile monomers are taken into emulsion graft polymerization reaction under the function of additives such as emulsifier and initiator while the free styrene-acrylonitrile copolymer is produced.

CNPC has innovated to combine the compound emulsifying system and the highly efficient oxidation-reduction system for high gel graft polymerization. Compared with similar technologies, this technology features short reaction time, high rubber content, less coagulum, high conversion rate, safety and environment friendliness, stable heat release and simple reaction operation. Meanwhile, high added-value ABS resin products may be produced based on this technology.

Technical Features and Advantages

- Innovative compound emulsifying system;
- Short graft polymerization reaction time (<6h) and production capacity of grafting unit improved by 34.6%;
- High conversion rate (>98%) and low pollution to environment; high rubber content (>60%), production cost for ABS resin reduced, overall performance of ABS resin improved and production capacity of ABS resin production equipment increased;
- Subsequent coagulation and drying processes can be ensured to proceed smoothly;
- Ensure ABS products to have pleasant appearance.

Application of Technology

The technology is generally used for the production of graft latex specially used for the General-purpose ABS Resin, Special ABS Resin and ABS Alloy. Different technical support and technical follow-up service may be provided according to the requirements by customers.

4) Coagrulation Technology

CNCP developed unique continuous three-reactor coagulation process innovatively. The coagulation process mainly includes two stages, namely, coagulation and maturation. After coagulation and maturation, the graft latex is put in a dryer for dewatering. Latex coagulation is one of the indispensable processes of emulsion polymerization. The latex coagulation conditions are critical for subsequent processes.

Different from similar technologies, this process uses sulfate as coagulant, which generates low cost and has less corrosion effect on equipment. In addition, the operation temperature is low, maturation duration is short and the coagulated particle size is uniform. Tripping times of dewaterer are reduced, and operation cycle is prolonged while coagulation

cost is cut down, “three wastes” discharge decreased and water content and debris in the dewatered and washed powder reduced.

Technical Features and Advantages

(1) Simple process, easy operation and continuous coagulation process;

(2) Coagulant with low cost, little corrosion and little dosage is used to effectively reduce production cost and decrease pollution to environment;

(3) Optimum agitation speed under low temperature is used to produce uniform coagulated particles with stable structure, and water content in the dewatered wet powder is low;

(4) Deflocculation method with excellent coagulation effect is used, which enables rapid particle formation, even particle size distribution, rigid particles, easy washing, and environment friendliness. This method eliminates the effect by coagulant dripping speed in deflocculation method to particle sizes and distribution;

(5) Long cleaning interval for coagulation reactor;

(6) Little corrosion by coagulant to equipment prolongs service life of the equipment;

(7) Product quality is improved with little debris content in dewatered and washed powder.

Application of Technology

Generally used to the flocculation of graft latex and relative emulsion.

5) Powder Drying Technology

Drying Technology with nitrogen circulating fluidized bed used to dry ABS powder takes nitrogen as the drying medium. Nitrogen heated by heater enters the dryer and takes away moisture in the powder. Moisture and heat contained in nitrogen are washed away by water. Split range control is used to maintain system pressure as well as supplement and refresh nitrogen timely.

Nitrogen Recycling Drying Technology is used for ABS Powder Drying Technology developed by CNPC where the nitrogen which can dry the powder by successively taking away moisture and other volatiles in the powder through direct-contact type sieve plate tower. Compared with similar technologies, this technology can be used to increase drying temperature, shorten drying time, reduce moisture contained in powder and accumulated powder in the drying tower, improve safety factor during drying process to ensure safe and stable drying operation and prolong the operation cycle of the dryer. In addition, this technology can be used for drying other flammable and explosive powders.

Technical Features and Advantages

(1) The technology of recycling nitrogen in the drying process is used to reduce consumption of nitrogen and improve safety by eliminating the hazard of detonation of air drying system;

(2) Prolonged cleaning interval for the dryer;

(3) The dryer operation temperature raised, high drying rate and moisture contained in powder less than 1%.

Application of Technology

This technology can be generally used for drying different types of powders, especially flammable and explosive materials, to ensure safe production process.

2.2 SAN Polymerization Technologies

SAN Polymerization Technologies cover the mature Technology of Continuous Monomer Proportioning and Mixing, Bulk Polymerization Technology, Technology of Two-stage Devolatilization and Technology of SAN Resin Granulation.

1) Technology of Continuous Proportioning and Mixing

As for the continuous proportioning and mixing process, two monomers with preset flow rate controlled by the regulating valve and flow gauge realize the cascade and split range control through flow ratio control system. The monomers are mixed by pipe static mixer while onsite chemical analysis and timely adjustment are performed to ensure uniform monomer mixture with stable proportion.

Technical Features and Advantages

- Continuous proportioning, short surge time;
- Low liquid mixture temperature to facilitate heat-removing from reactor;
- Precise control with narrow proportion fluctuation range;
- Stable operation, the proportion may be timely adjusted according to production load;
- Easy maintenance.

Application of Technology

This technology is applicable to the production with continuous proportioning and strict components requirements.

2) Bulk Polymerization Technology

During SAN resin polymerization process, monomers of styrene and acrylonitrile are thermally initiated to continuous polymerization reaction and molecular weight regulator is continuously added. The reacted mixture will be sent to devolatilization system by a discharge pump when solid content in the reactor gets up to 55%~65%, and conversion rate up to 70%.

Technical Features and Advantages

- Polymerization in reactor;
- Easy control and flexible operation;
- Heat remove from gas phase to allow stable temperature;
- Short process flow and high production capacity;
- Stable product quality;
- Little “three wastes” discharge, safe and eco-friendly;
- Long operation cycle.

Application of Technology

Applicable to the continuous SAN resin production.

3) Technology of Two-stage Devolatilization

During the two-stage SAN resin devolatilization, unreacted styrene and acrylonitrile monomers of the polymer as well as the ethylbenzene solvent are removed from the devolatilizers in different operation conditions to obtain SAN resin. The removed monomers are condensed, and return back to polymerization system for repeated reaction.

Compared with similar technologies, this technology boasts better devolatilization result, less monomers left in product, lower product yellowness, higher SAN heat resistance, safer performance and more eco-friendliness.

Technical Features and Advantages

- Two-stage devolatilization to allow reuse of condensed liquid and lower down material consumption;
- Acrylonitrile is removed at a relatively low temperature from the first devolatilizer to yield low-yellowness product;
- Styrene is removed from the second devolatilizer at a relatively high temperature and vacuum.

Application of Technology

It is applicable to remove unreacted monomers of

polymer with high viscosity.

4) Technology of SAN Resin Granulation

Underwater Granulation Technology and Centrifugal Drying Technology are used to produce SAN resin particles which are delivered by fans. Logic programs are made according to requirements of process and switching of end product tanks is sequentially controlled by DCS.

During SAN granulation process, the melted polymer is boosted by high viscosity gear pump and extruded into strip bundle through die plate. After passing the guide plate, polymer strips are cooled down by spray water, and then cut into SAN particles by granulator. The speeds of pressure roller and slitter can be regulated to control particle size.

Technical Features and Advantages

- Spray water may be recycled to allow low material consumption;
- Underwater granulation emits little dust and gives little pollution to environment;
- The particle is uniform with smooth appearance;
- Effective dryness delivers low moisture content in particles.

Application of Technology

This technology is applicable to granulation and delivery of all types of melted resin.

2.3 Technologies of "Three Wastes" Treatment

Cavitation Air Flotation Technology is used by CNPC to treat "three wastes" with treated water satisfying emission requirements of Grade I GB 8968-1996.

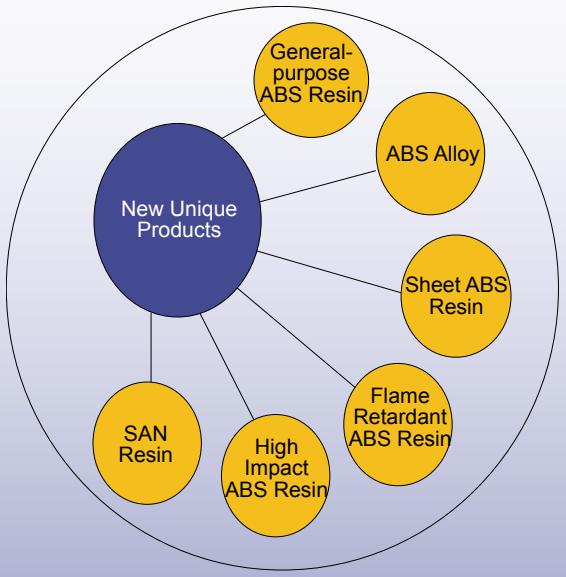
1) Technology of "Three Wastes" Treatment by Cavitation Air Flotation

Waste water from ABS unit is treated by processes of flocculation, air flotation, and scum dewatering and the treated water satisfies requirements of drainage. Features of this technology include high treatment efficiency, integrated equipment (rational structure and easy maintenance) and low energy consumption.

- Aerator produces highly efficient bubbles in waste water without blockage.
- Easy operation and high treatment efficiency.
- Integrated equipment with rational structure and easy maintenance.
- Low energy consumption and high efficiency.

2.4 Unique New Products

CNPC is armed with an R&D team for development and technological innovation of new ABS products. With independently developed Packaged Technology of Emulsion Graft –SAN Mixing, a series of new ABS products are further developed and marketed nationwide.



1) General-purpose ABS Resin

The General-purpose ABS resin independently developed by CNPC has outstanding overall performance with high impact strength, excellent mechanical property, chemical resistance, mouldability, space stability and dyeing property.

Application

- Electronic and electrical components
- Automobile parts
- Toys
- Cameras
- Pipes

Performance Indexes of General-purpose ABS Resin

Indexes	Grades and Index Values			Test Method
	750A	750	750SW	
Izod impact strength J/m ≥	200	200	200	ASTM D256-2006
Tensile strength MPa ≥	42	45	40	ASTM D638-2003
Rockwell hardness (R scale)	100	98	95	ASTM D785-2003
Melt mass-flow rate (MFR) g/10min	25～36	36～50	45～60	GB/T 3682-2000
Heat distortion temperature ℃ ≥	78	80	80	ASTM D648-2006
Bending strength MPa	60	60	60	ASTM D790-2003
Modulus of elasticity in bending MPa	1900	1900	1900	ASTM D790-2003

2) High Impact ABS Resin

High Impact ABS Resin independently developed by CNPC has high impact strength with excellent rigidity, processability, dyeing property and chemical resistance.

Application

- Electrical machinery enclosures
- Toys
- Motorcycle parts
- Bicycles
- Helmets

Performance Indexes of High Impact ABS Resin

Indexes	Grades and Index Values	Test Method
	740A	
Izod impact strength J/m ≥	280	ASTM D256-2006
Tensile strength MPa ≥	40	ASTM D638-2003
Rockwell hardness(R scale)	95	ASTM D785-2003
Melt mass-flow rate (MFR) g/10min	15～27	GB/T 3682-2000
Heat distortion temperature ℃ ≥	80	ASTM D648-2006
Bending strength MPa ≥	63	ASTM D790-2003
Modulus of elasticity in bending MPA	2000	ASTM D790-2003

3) Sheet ABS Resin

The Sheet ABS Resin independently developed by CNPC has outstanding overall performance with high melt index. It is a kind of resin products with high added-value used for refrigerator inner face with advantageous properties in energy conservation and environment protection as an indispensable special sheet ABS resin for refrigerator. This synthesization technology fills the national technical gap and delivers state-level key new products.

Application

- Household appliance
- Home appliance
- Automobile instrument panel

Performance Indexes of Sheet ABS Resin

Indexes	Grades and Index Values	Test Method
	770	
Izod impact strength J/m ≥	260	ASTM D256-2006
Tensile strength MPa ≥	50	ASTM D638-2003
Rockwell hardness(R scale)	98	ASTM D785-2003
Melt mass-flow rate (MFR) g/10min	12～20	GB/T 3682-2000
Heat distortion temperature ℃	85	ASTM D648-2006
Bending strength MPa ≥	65	ASTM D790-2003
Modulus of elasticity in bending MPa ≥	2200	ASTM D790-2003

4) Flame Retardant ABS Product

Flame Retardant ABS Resin independently developed by CNPC has high fluidity, excellent mouldability, stability, exudation resistance, heat resistance, no corrosion to moulds and equipment and other features. Its flame retardant property satisfies the highest international standard of V-0 grade (UL94-96). It is a safe and eco-friendly product.

Application

- Electrical appliance
- Electronic component
- Heat resistant insulator
- Enclosure for electrical appliance
- Fan blade
- Electrical/electronic machinery
- Interior decoration

5) ABS Alloy

ABS/PC Alloy independently developed by CNPC has excellent compatibility, boiling water resistance, aging resistance, weather resistance and pleasant colors. It is widely used for mobile phone housing, notebook PC shell, automobile parts such as glove box, door handle, handrail, panel, ventilation cover and fender, airplane, interior trim of high speed train, etc.

Performance Indexes of Flame Retardant ABS Resin

Indexes	Grades and Index Values			Test Method
	HFA-70	HFA-72	HFA-75	
Izod impact strength J/m ≥	98	120	155	ASTM D256-2006
Tensile strength MPa ≥	38	40	40	ASTM D638-2003
Rockwell hardness (R scale)	95	95	95	ASTM D785-2003
Melt mass-flow rate (MFR) g/10min	130～170	40～60	35～55	GB/T 3682-2000
Heatdistortion temperature ℃ ≥	68	75	75	ASTM D648-2006
Flame retardance Grade	FV-0	FV-0	FV-0	GB/T 2408-1996
Bending strength MPa	55	55	55	ASTM D790-2003
Modulus of elasticity in bending MPa ≥	1800	1900	1900	ASTM D790-2003

ABS/PA Alloy independently developed by CNPC has high impact strength, excellent thermal stability, chemical resistance, favorable shock absorption and sound absorption and is mainly used for sport equipment such as roller skate wheel and axle, ski baseboard, tool box, electric tool cover, car instrument housing, and car fan shock absorber, etc.

PA/ABS Alloy Application

PC/ABS Alloy Application

Performance Indexes of ABS Alloy

Indexes	Grades and Index Values		Test Method
	ABS/PA	ABS/PC	
Izod impact strength J/m ≥	860	747	ASTM D256-2006
Tensile strength MPa	46	55	ASTM D638-2003
Melt mass-flow rate (MFR) g/10min	1.5	1.0～2.0	GB/T 3682-2000
Heat distortion temperature ℃ ≥	92	128	ASTM D648-2006

6) New Series Products of SAN Resin

For its excellent rigidity, chemical resistance, and high stiffness, SAN Resin is widely used for electric appliance, cosmetic container, automobile parts, etc. In addition, SAN resin products are highly stable, transparent, and has excellent processability. It can be as both intermediate product of ABS resin and material for final products. SAN resin products such as SAN-300, SAN-325, SAN-327, SAN-350 are mainly used to mix to produce ABS resin. For its high liquidity, SAN-326 is primarily used to manufacture products requiring high transparency, such as cosmetic containers, food container, etc. Compared with SAN-325, better strength and mechanical properties of SAN-327 enable it to be used for automobile parts, pen barrels, lampshades, etc.

- No appearance change
- Slightly misty appearance
- Significant appearance change
- Softened or solved
- Dipping conditions: 23°C±1°C for 7 days

Performance Indexes of SAN Resin

Indexes	Grades and Index Values				
	SAN300	SAN325	SAN326	SAN327	SAN350
Melt index g/10min	22～35	20～30	8～12	12～16	10～20
Yellowness index	10	10	-	8	10
Residue monomer mg/kg	1250	1250	1250	1150	1250
Vicat softening point ℃	104	99	105	99	100
Rockwell hardness R	-	-	80	-	-
Impact strength J/m	-	-	-	17	-
Tensile strength MPa	56	54	65	64	54

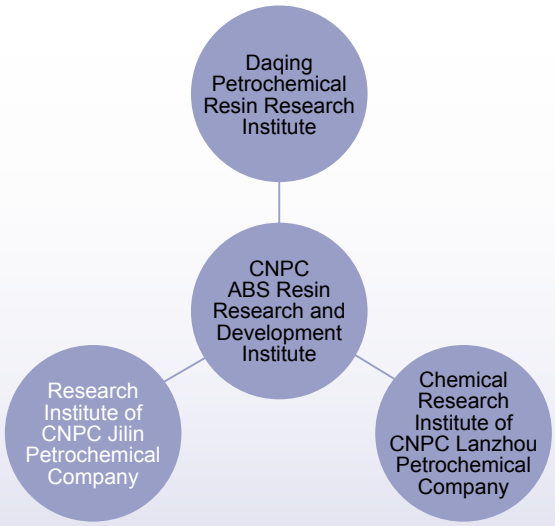
3 TYPICAL CASES

"Packaged ABS Resin Technology" independently developed by CNPC was applied in ABS unit at CNPC Daqing Petrochemical Company. This packaged technology is used to technically upgrade the existing ABS resin unit and improve production output from 50,000 tons per year to 100,000 tons per year. Upgraded PB polymerization time is controlled within 11 hours, high gel graft polymerization within 6 hours with rubber content over 60%. Production cost as well as energy and material consumption are significantly reduced while production efficiency is improved. Waste discharge from 2006 to 2009 was reduced by 5%~7% with waste gas and waste water discharge satisfying the lowest international standard. The equipment operation process completely complies with HSE system while the production stays in stable status with long operation cycle and satisfies environment protection requirements.

ABS750A Resin produced by "Packaged ABS Resin Technology" at Daqing ABS unit has excellent overall performance with high safety, low price and fine processability. It has won good reputation from customers and been granted with titles of "State Satisfactory Product", "Famous Brand in Heilongjiang Province", and "China High-quality Petroleum Product" for consecutive years. Meanwhile, the company is granted with the honorary title of " 'Ankang Cup' Winning Enterprise" and listed as one of China Top 500.

4 R&D EQUIPMENT

CNPC is armed with over 100 senior resin development talents, laboratories with advanced equipment and professional service team consisting of over 300 specialists. Research entity combining scientific research and development, technical service, production and business has been established as professional ABS resin research base and research institute to undertake the technical research of refining and chemical industry for CNPC.



4.1 ABS Powder Research Laboratory

The ABS Powder Research Laboratory comprises PB polymerization laboratory, graft polymerization laboratory, coagulation laboratory, drying laboratory, mixing laboratory, extrusion granulation laboratory, all of which are used for experimental study of emulsion polymerization in atmospheric pressure and pressurized conditions.

4.2 SAN Resin Research Laboratory

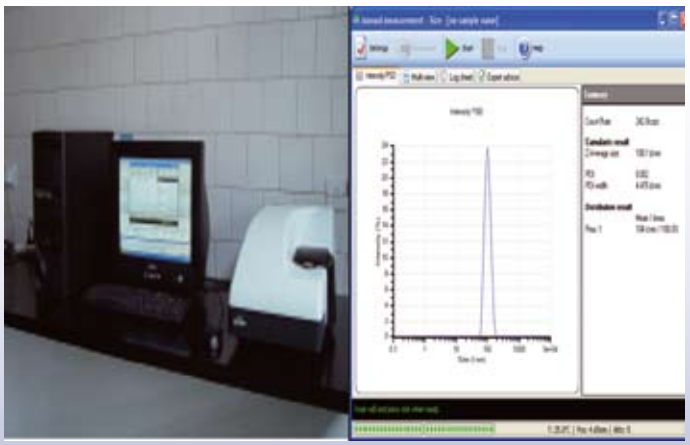
The ABS Powder Research Laboratory is equipped with experimental facilities for SAN emulsion polymerization, experimental facilities for SAN suspension polymerization, experimental facilities for SAN polymerization, including equipment such as emulsion/suspension polymerization reactor, bulk polymerization reactor, single screw extruder, double-screw extruder for bulk polymerization research.

4.3 “Three Wastes” Treatment

The physical treatment laboratory, microbiological treatment laboratory and instrument room are provided for research on different treatment types of waste water.

4.4 Analytical Instrument

The laboratory is equipped with laser particle size analyzer, rheometer, Fourier infrared microscope, scanning probe microscopy, gas/liquid chromatograph and ABS performance analyzer to analyze experiment process and results and provide strong support for research.



5 QUALIFICATION AND STANDARD

CNPC possesses 6 patent certificates for ABS resin quality, 5 of which are for invention and 1 of which is for utility model.

6 EXPERT TEAM

Huang Liben: Professor and senior engineer. He has 40-year experience in research and field operation of engineering plastics and has taken charge of 10 research projects relating to ABS resin. He published over 20 academic papers and 1 monograph.

Phone: 0459-6707206

Li Yizhang: Senior engineer. He has 30-year experience in research and production management of engineering plastics. He has made 12 scientific achievements. He published over 10 academic papers and was granted with 3 state patents for invention.

Phone: 13303695696

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Wang Jingxing: Senior engineer and operation management expert. He has 28-year experience in research and production management of engineering plastics and has made 15 scientific achievements. He published over 10 academic papers and was granted with 2 state patents for invention.

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Li Yongtian: Senior engineer. He has 20-year experience in research and production management of engineering plastics and has made 12 scientific achievements. He published over 10 academic papers and was granted with 5 state patents for invention.

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Lou Yuliang: Senior engineer. He has 20-year experience in research and production management of engineering plastics and made 9 scientific achievements. He published over 10 academic papers and was granted with 1 state patent for invention.

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Zhao Wanchen: Senior engineer and petrochemical expert. He has 21-year experience in ABS resin research and production management. He has taken charge of 10 research projects relating to ABS resin, special material, rubber and SAN resin synthesization. He was granted with 1 state patent for invention.

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