Powder Coatings

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Middle East Region

- From Dubai to Kuwait, there's an estimated US$2.4 trillion in construction projects either underway or in development in the world's biggest oil patch.

- Surprisingly, US$1.4 trillion of that total is for projects in civil construction. This means spending on residential and commercial construction projects in the Middle East outweighs construction on oil, gas, power, petrochemical, industrial, and water projects combined.

- Infrastructure development is not only crucial in meeting the region’s social challenge, but has an essential contribution to make towards improving business competitiveness in the Middle East.

GCC Markets

- The promising construction and industrial growth in the region, the GCC is one of the fastest growing markets for the global paints and coatings industry. This paint and coating market was estimated at $2.059 billion in 2010 and expected to reach $3.003 billion by 2017 at a compound annual growth rate (CAGR) of 5.5 per cent.

Markets in Central and Eastern Europe.

- Paint demand across countries in Eastern Europe to the countries of Black Sea region, namely Armenia, Belarus, Estonia, Georgia, Latvia, Lithuania, Moldova, Russia, Turkey and the Ukraine has been estimated at 2.7 million tons, and with average market growth of 5.8 % p.a., this can be expected to reach more than 3.6 million tons by the end of 2016.
- Market for Powder Coating in 2011 was 93,950 MT.

Drivers for growth are

- Growth in construction markets,
- Growth in infrastructure investment
- Rising salaries and greater disposable incomes
- Growing industrial output

Powder Coatings

Global Powder Coatings Market Will Reach USD 10.5 Billion in 2018

……..Transparency Market Research

Worldwide demand for powder coatings has increased over the last few decades, due in part to their lower environmental impact when compared to other coatings.

On a world-wide basis, powder coatings represented approximately 6 % by value of the overall coatings market.

Global Market - Growth

	2011	2018	CARG 2012-18
Quantity ,KT	1,680.00	2,667.00	6.8%
Value, US$	6.5 Billion	10.5 Billion	7.2%

- Developing economies of BRICS members has led to an increasing demand for consumer goods such as appliances, automobiles and furniture.

- In addition, support for the use of powder coatings by authorized environmental agencies such as EPA and REACH is another major factor responsible for the growing demand for powder coatings.

Global Market - Growth

- Appliances were the largest application segment for powder coatings, accounting for over 20% of the consumption in 2011. China is leading the growth.
- Powder coatings demand from automotive is expected to grow at a CAGR of over 7% during the next five years due to the rising demand of automobiles, both in terms of original equipment as well as spare parts across the world.
- Asia Pacific is the largest and fastest growing market for powder coatings, consuming over 700 kilo tons of powder in 2011. Emerging end user industries in economies such as China, Brazil and South Africa are expected to further add to the demand for powder coatings.

Powder Coating - Growth

- Powder coating market will grow faster than the general coatings market. There are several reasons for this optimism.

❖ VOC legislation is believed to impose even more restrictions on conventional liquid coatings in the near future.

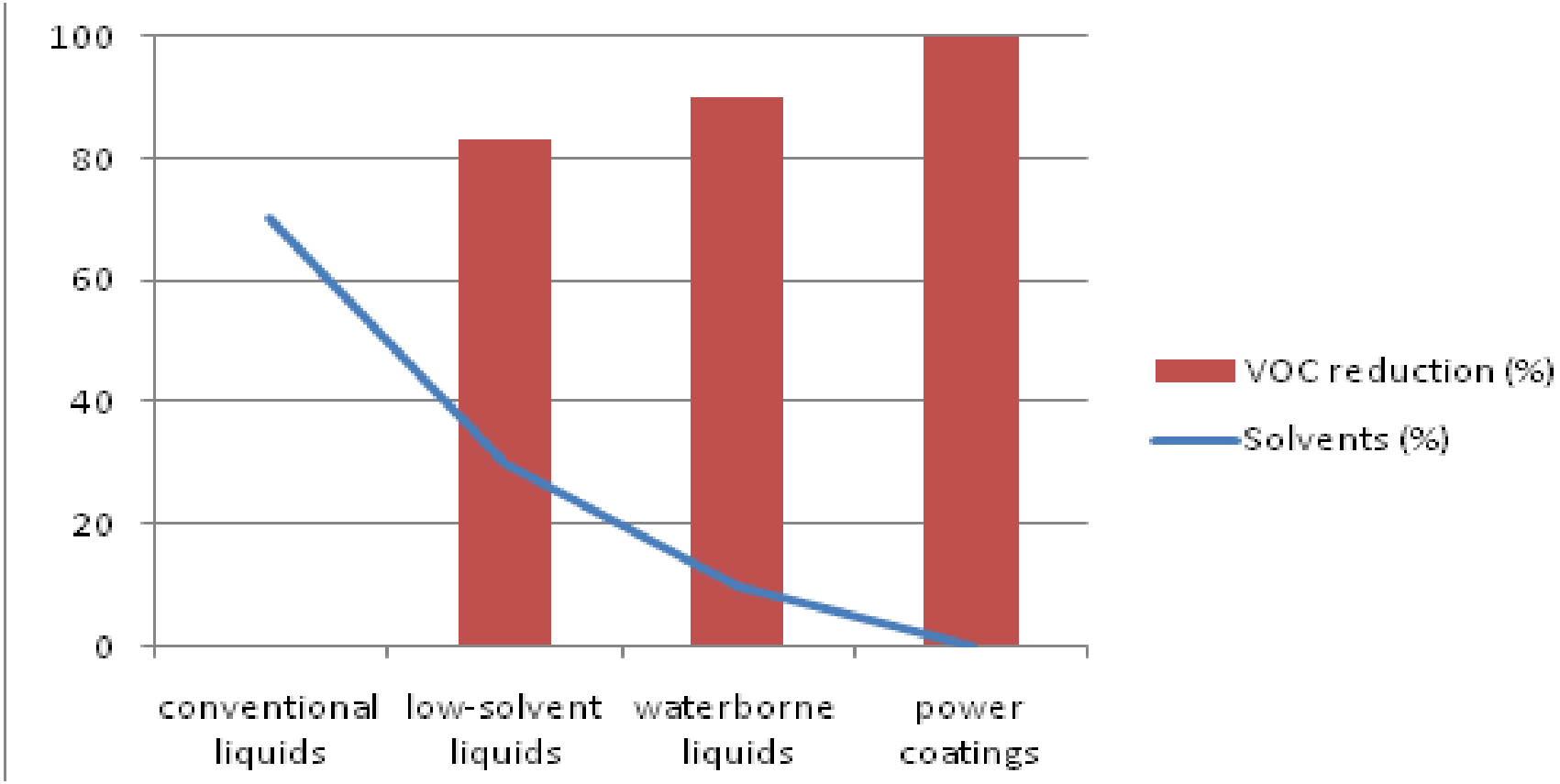
❖ The trend toward efficiency and productivity will increase giving preference to any coating system that benefits the end-user's bottom line.

❖ Continuous development work has contributed to ongoing improvements in the properties and performance of the powder coating materials.

- However, for future success it will be very important to open new application fields. This is being done through the development of new material and powder coating equipment.

VOC REDUCTION AND PERCENT

PETROLEUM SOLVENTS, BY COATING TYPE



CHINA & The World Market

- In 2012, China produced about 1.1 million metric tons of powder coatings, an increase of seven percent year-over-year.
- Akzo Nobel Powder Coatings (~60,000 MT, 5 factories)
- Dupont Huajia Chemicals (~20,000 MT, 4 factories)
- Nippon Paint Co. (~20,000 MT from 3 factories)

- Key participants in the powder coatings world market include Akzo Nobel, PPG Industries, Sherwin – Williams, DuPont, BASF and Valspar among others.

Chinese Market

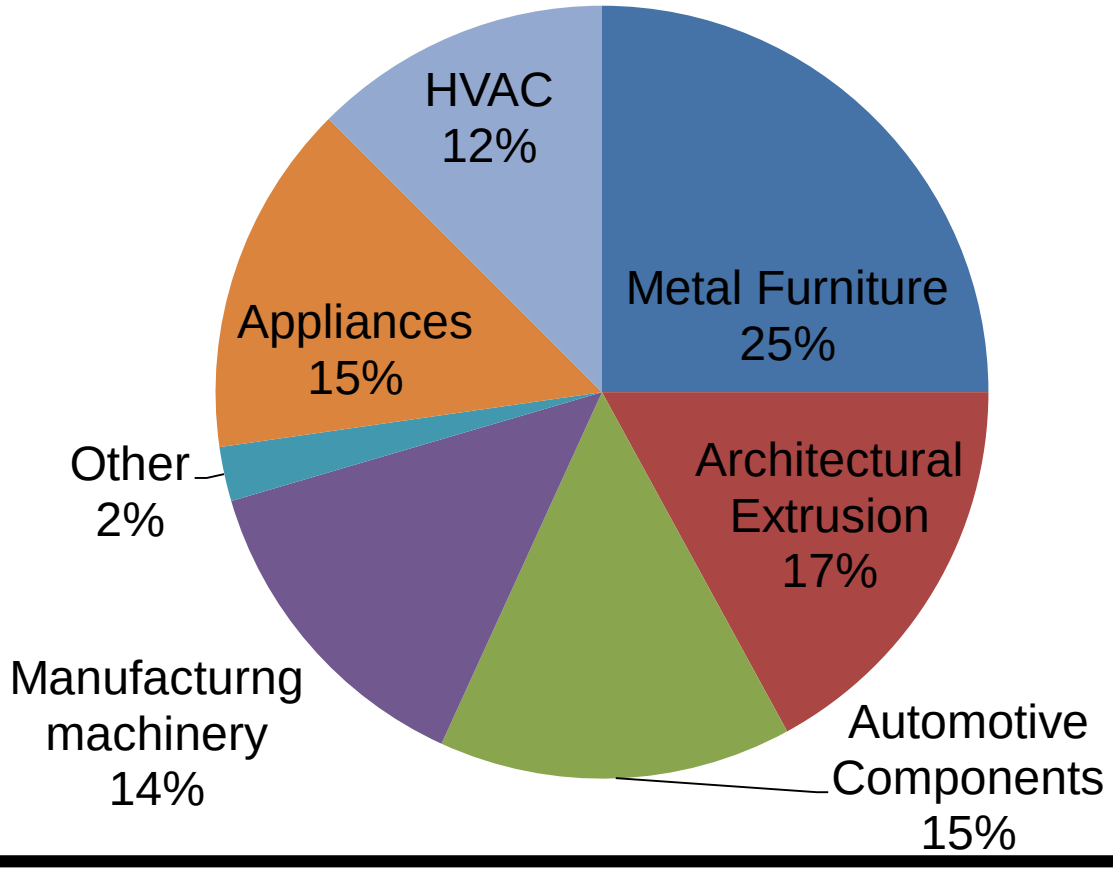
- Over 2,000 powder coating manufacturers exist in China, and as of 2006.
- 98 % of them are SMEs with production levels under 1,000 MT per year.
- Only 40 companies in China produce more than 1,000 MT per year. Ten large foreign firms produce
- 20 % (142,000 MT) of Chinese powder coatings, with the largest three producing 100,000 metric tons per year.

They are:

- AkzoNobel Powder Coatings (~60,000 MT, 5 factories)
- Dupont Huajia Chemicals (~20,000 MT, 4 factories)
- Nippon Paint Co. (~20,000 MT from 3 factories)

- Other foreign-owned powder coatings firms sharing 42,000 MT of annual production are: Valspar, PPG, Orica, BASF, Jotun, Rohm Haas, Tiger Werke, and 3M.
- Foreign firms have also increased their Chinese market share through mergers and acquisitions. Nippon Paint and Dow Chemical are recent examples of this M&A activity

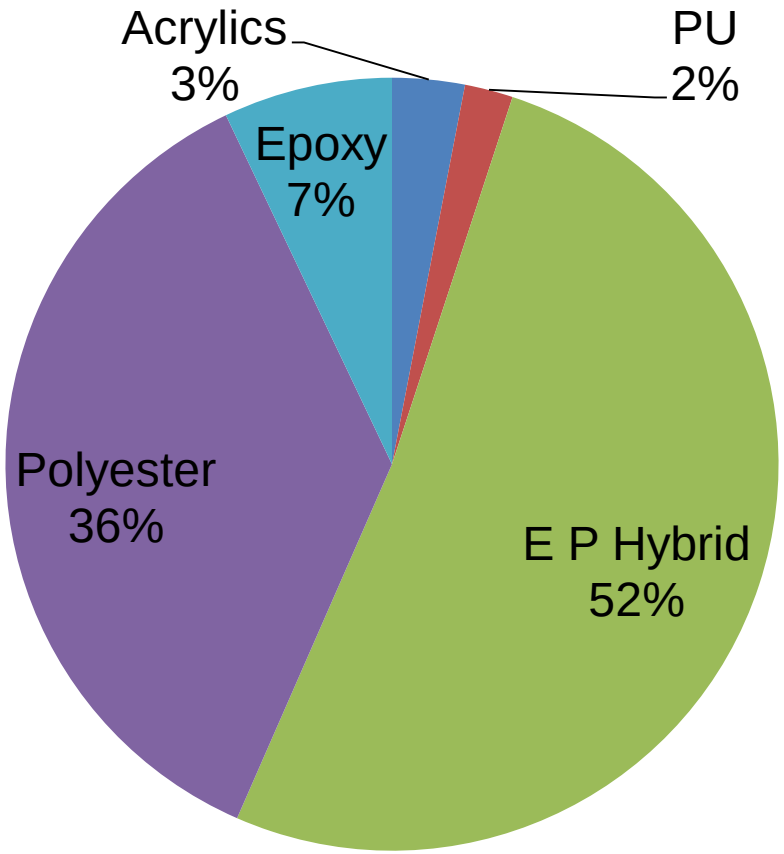
Powder Coatings Market Segmentation



Global Market - Issues

- However, powder coatings have a few application and design difficulties such as application of very thin coats, thin films inside corners and uneven thickness of coating at edges.
- In addition, pigmented powders cannot be blended to form different colors.
- These factors are expected to hamper the growth of the powder coatings market.

Global Technology Segmentation



Five main families of powder Coatings

- **Epoxy** powder coatings exhibit inherent toughness, corrosion resistance, chemical resistance, flexibility, adhesion, and abrasion resistance. Epoxy powder is normally used where a tough durable film is required and the product will not be exposed to direct sunlight for long periods of time. An epoxy coating will form a chalk like appearance on the surface with lengthy exposure to sunlight. Epoxies make up approximately 7% of world powder production.

- **Categories**

❖ Epoxy resin and imidazoline or phenolic or dicyandiamide hardner reaction.

❖ Epoxy Polyester (hybrid) carboxylated polyester resin and epoxy resin reaction.

Epoxy – Performance Properties
(Typical)

Property	**Range**
Hardness (pencil)	HB–7H
Impact Resistance (in.-lbs)	60–160
Gloss (60 deg. meter)	3–100+
Color	All colors, clear and textures
Salt Spray	1,000 hrs.
Condensing Humidity	1,000 hrs.
• Cure range	25 min at 250 °F (121 °C)

(Typ. 2 mil (0.05mm) film 3 min at 450 °F (232 °C) to
– time at Metal temp.)

Five main families of powder Coatings

- **Epoxy-polyester hybrid** powder coatings are epoxy powders with a high percentage of polyester resins (some-times approaching or exceeding 50%). These powders are similar to epoxies with improved resistance to yellowing in sunlight and weatherability. Hybrid powders are considered the backbone of the powder coatings industry and make up 51% of world powder production.

Five main families of powder Coatings

- **Polyester** powder coatings feature characteristics of long-term exterior durability, high performance mechanical properties and heat resistance. Polyester powder is widely used for decorative components where good resistance to the ultraviolet rays from sunlight is important. Many auto-motive trim components and other exterior components are coated with polyester powders. Most coatings used on buildings use TGIC-polyester powders which raise environmental and health concerns. TGIC-free polyester powders are available. Polyesters make up approximately 36% of world powder production.

Polyester Categories

- **Polyester TGIC**,

Carboxylated polyester resin and TGIC reaction

- **Polyester B-hydroxyalkylamide**,

carboxylated polyester resin and b- hydroxyalkylamide reaction.

- **Polyester glycidyl ester,**

Carboxylated polyester resin and glycidyl ester reaction

Polyester TGIC Performance Properties

Typical

Property	**Range**
Hardness (pencil)	HB–4H
Impact Resistance (in.-lbs)	60–160
Gloss (60 deg. meter)	20–90
Color	All colors, clear and textures
Salt Spray	1,000 hrs. minimum
Condensing Humidity	1,000 hrs. minimum
Cure range	30 min at 300 °F (149 °C)

(Typ. 2 mil (0.05mm) film 10 min at 400 °F (204 °C) to time at Metal temp.)

Safer Crosslinkers

- The crosslinkers or hardeners in powder coatings remain an environmental concern. Since the seventies, the crosslinker triglycidyl isocyanurate (TGIC) has been the standard for highly weather resistant polyester powders for architectural, automotive and general industrial applications.

Safer Crosslinkers

- Some years ago, toxicological studies showed it had some evidence of mutagenic potential. Therefore the EU decided that the symbol T (toxic, symbolized by a skull), accompanied by the relevant risk phrase, was to be used for TGIC labeling from May 1998 onwards. In Europe especially, this labeling led raw material producers to develop safer alternatives to TGIC.

- Over the last two decades, two main market products have become established in Europe:

Safer Crosslinker-Araldite PT930

- Di- or tri-glycidyl esters of terephthalic and isophthalic acid, tetrahydrophthalic acid and trimellitic acid (“Araldite PT 910” from Huntsman);

The crosslinking reaction of the first is a poly-addition with carboxyl functions of the polyester resin similar to TGIC. Although this product is one of the best technical alternatives, powder products with this hardener have to be labeled in the EU with Xi and risk phrases R36/38 and R43 (irritation to eyes and skin, may cause sensitisation by skin contact).

Safer Crosslinker -Primid XL-552

- b-hydroxyalkylamide (“Primid XL-552” from EMS Chemie)

Alternatives based on the second technology crosslink via esterification with the carboxyl functions of the polyester resin. Water is a cleavage product, which may lead to pinholes at higher film builds above 80 µm. On the other hand, due to their comparatively high performance in terms of appearance, outdoor stability, mechanical and anti-corrosion properties, both crosslinking technologies have, in spite of some specific disadvantages, gained significant market acceptance.

Five main families of powder Coatings

- **Polyurethane** powder coatings have excellent gloss retention and long-term resistance to humidity and corrosion in thin film applications. They provide good all around physical and chemical properties and have a good exterior durability. Polyurethanes make up less than 2% of world powder production.

- **Categories**

Hydroxylated polyester resin and isocyanate reaction

Urethane polyester Properties-
Typical

Property	**Range**
Hardness (pencil)	HB–4H
Impact Resistance (in.-lbs)	60–160
Gloss (60 deg. meter)	15–95
Color	All colors, clear and textures
Salt Spray	1,000 hrs.
Condensing Humidity	1,000 hrs.
Cure range	25 min at 320 °F (160 °C)

(Typ. 2 mil (0.05mm) film 10 min at 400 °F (204 °C)
To time at Metal temperature)

Five main families of powder Coatings

- **Acrylic** powder coating is specified where the decorative requirements and resistance to ultraviolet rays from sun-light for a longer period of time is critical. They have good gloss and color retention on exterior exposure and have heat and alkali resistance. Acrylics make up approximately 3% of world powder production

- **Categories**

GMA(glycidyl methacrylate) acrylic resin and dicarboxylic acid reaction.

Acrylics Properties
Typical

Property	Range
Hardness (pencil)	H–4H
Impact Resistance (in.-lbs)	Excellent, 40–100
Gloss (60 deg. meter)	10–90
Color	All colors, clear and textures
Salt Spray	1,000 hrs. minimum
Condensing Humidity	1,000 hrs. minimum
Cure range	25 min at 350 °F (177 °C)

(Typ. 2 mil (0.05mm) film 10 min at 400 °F (204 °C)
To time at Metal temp.)

Summary of the key properties

Epoxy:

Tough

Chemically resistant

Poor exterior durability (chalking)

Hybrid: Polyester TGIC:

Exterior durable

Good edge coverage

Thicker films are no problem

Acrylic:

Excellent weatherability

Excellent appearance

Good-fair impact resistance

Hybrid

Decorative film performance similar to epoxies

Some UV and overbake advantages

Not exterior durable

Polyester Urethane:

Exterior durable

Thin film powder coating

Powder Coatings
Application Technology

- Over the past decade, worldwide popularity of powder coating technology has enjoyed steady, double-digit growth. One of the forces driving this tremendous success has been continuous improvements in application equipment used in the powder coating process.
- Since the early days of powder coating, powder coaters and application equipment manufacturers have faced several challenges, including: maximization of first-pass transfer efficiency; effective coating of Faraday-cage areas; better finish quality and uniformity; and recoating of rejected parts.
- Recent technological developments, however, have allowed leading equipment manufacturers to offer users new equipment features that more closely meet these challenges. Modern equipment is more and more sophisticated to offer more capabilities previously unavailable.

Formulation

As with any coating, formulation variables are critical to the processing and performance characteristics. The powder coating formulation is much like a liquid coating formulation except that most of the components are in solid, melt processable form. The main raw material components used in powder coatings are as below.

- **Resins** are the key component of powder coatings; the range of resins used is increasing steadily in an attempt to meet the more demanding needs of new market sectors.
- **Curing agents** are used according to the type of resin system employed and the final properties required of the coating.
- **Accelerators** are used to increase the cure reaction rate.

Formulation

- **Pigments**
- **Fillers** are used to reduce the cost of the coating formulation and / or to improve specific properties such as flow, surface texture, lubricity, etc. Common fillers are barytes, calcite, mica, talc, whiting, and wollastonite.
- **Extenders**, such as aluminum silicate, are used to provide opacity and act as a filler.
- **Degassing agents** are particularly important in low-bake systems. They are used to eliminate / dissipate gas bubbles that may cause film porosity and embrittlement or poor finish.
- **Dry Flow agents** improve the free flow of powders within the production delivery systems.
- **Flow agents** enhance film properties and minimize / eliminate surface defects by improving the flow of the molten coating. Examples of flow agents include polyacrylates, silicones, surfactants, and fluorinated alkyl esters.

Formulation

- **Matting agents** are used to reduce the gloss of the cured film.
- **Texturing agents** are used to control / enhance the gloss level of cured films.
- **Rheological additives** provide viscosity control to molten coatings for improved edge coverage or for textured surface effects.
- **Waxes** are added to the formulation to provide slip, hardness, scratch and mar resistance, and to act as free flow powders and anti-bridging agents in processing.

Powder Coatings Non-Metal Products

- **The development of powder that can be applied and cured at low temperatures, the market has opened to heat sensitive substrates such as plastics and wood.**
- **Curing of powder on heat sensitive substrates by reducing the curing temperature to below 121°C. Ongoing development has been devoted to formulating powders that can cure at temperatures below 100°C without compromising durability or quality.**
- **Powder coating on wood is growing significantly. Wood manufacturers and their customers are now able to powder coat a wide range of wood products. Manufacturers of home-office furniture, kitchen cabinets, children's furniture, and outdoor grill tables are discovering that powder coating makes these "hard-use" products retain their new look much longer.**
- **One of the biggest breakthrough in the wood market is the use of engineered wood materials such as medium density fiberboard (MDF). MDF is very suitable for powder coating because of its low porosity and homogeneous surface. Curing of powder on MDF can be accomplished by infrared, or UV light in conjunction with infrared or convection ovens.**

Future Trends

- New resin systems allow powder to meet the end-user's specification for almost any product. Many of these coatings can be cured at temperatures as low as 121°C. The advent of low curing temperature systems, such as IR cured powders, has significantly opened up the market to heat sensitive substrates such as wood, plastics, and assembled components with heat sensitive details. The coating of metal substrates also benefits from this technology, with lower energy and investment costs, shorter curing times, and higher lines speeds.

Future Trends

- Powder coatings are also being developed for high temperature applications. Silicone-based powder coatings are often used on products that must retain their appearance, adhesion, and surface protection even after prolonged exposures to high heat (up to 538°C). Some of these products include gas and charcoal grills, fireplace inserts, engine exhaust components, and light fixtures.

Future Trends

- Significant advancements are also being made in the weatherability of powders for use in automotive and architectural applications. Polyester TGIC based powders, for example, have been used on outdoor stadium seating and other exterior applications that were previously susceptible to degradation from UV. The use of TGIC, which has been labeled as toxic in certain regions, is now being replaced by other binders. Clear, corrosion resistant, and durable powder coatings are used for a wide range of applications including automotive parts. Auto manufacturers such as BMW and Volvo are using powder clear coats over automotive exterior basecoats.

Future Trends

- Equipment development will also contribute to the future advancement of powder coatings. Powder utilization rates of 95% or higher are common. This compares with a 30-80% utilization rate for most other spray coating processes. Advances in infrared and ultraviolet curing technologies are allowing increased production speed in powder coating facilities. IR ovens can sometimes cure a part in as little as 30 secs, and UV curing can be accomplished in a matter of seconds.

Future Trends

- Thin films, 1-3 mils (25-75 µm), can be applied in a wide range of colors, glosses, and textures and ultra thin film, 0.8-1.2 mils (20 - 30 µm) powders are currently being developed. These powders offer better penetration into recesses, more film thickness control, and more effective first pass transfer efficiency.
- Color and surface texture variety is almost limitless with new powder coating formulations. Properly designed powder systems can now change colors in minutes. High production powder systems apply over 20 different colors, with several color changes per day.

Future Trends

- Coil coating applications for powder are also being developed. Coil coating is the process of coating one or both sides of flat metal sheets or strips on a continuous production line. Most powder coating facilities are laid-out in a vertical configuration. However, newly designed horizontal powder coating booths are enabling powder to compete more effectively in the extrusion and pultrusion finishing markets.

Future Trends

- Radically different methods of application are also likely to open future markets. In-mold powder coating processes have been developed in which the powder coating material is sprayed onto a heated mold cavity before the molding cycle begins. During the molding operation, the powder coating chemically bonds to the molding compound and produces a product with a coating that is chip and impact proof. Processes have been developed for applying thermoplastic powder in the field, provided that the substrate is clean and can be preheated properly. Bridge support columns and steel sidewalks have been coated successfully. Also, pipe joints that are originally coated in the factory but must be welded in the field can be recoated with powder, thereby providing a continuous, corrosion resistant coating.

Future Trends

Characteristic	Need / Result
Weatherability	Light fastness, 5+ years exposure with little or no fade
Thinner films	10-20 µm and smooth
Low temperature cure	Below 121°C with no performance loss
High speed cure	IR, NIR, UV, and other energy sources with decorative and performance properties similar to standard cure coatings
Processability	Rapid extrusion, grinding enhancement, premixed pigmentation
Corrosion Resistance	Adhesion without conversion coating pretreatment
Appearance	1. Mid / low gloss polyesters, 2. Smooth, thin film 3.Smooth, low temperature / fast cure 4.Metallic colorant equal to liquid, 5 Clarity with performance

Table lists several material development challenges that remain for the powder coating industry. Solutions to these challenges would further open new finishing areas to powder coating economics.

Thank You