Polystyrene

by

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History

Historical Aspects. Styrene [*100-42-4*] (known as styrax) was first isolated in 1831 by BONASTRE from the resin of the amber tree. In 1839 E. SIMON, who also first described the polymer, gave the monomer its name. He observed that styrene was slowly converted into a viscous solution on standing. Around 1925 the development of an industrial production process for polystyrene began; this work achieved success in the plants of the IG Farbenindustrie in Germany in 1930. In the United States polystyrene was first produced on a commercial scale in 1938 by the Dow Chemical Company.

Styrenics polymers

The terms Styrenics or Styrenic Polymers are used to describe a family of major plastic products that use Styrene as their key building block. Included in this family of products are:

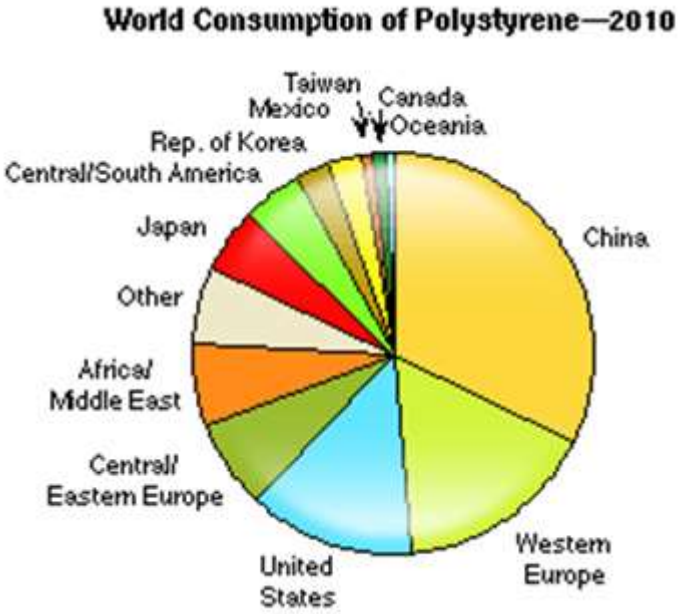
PS / EPS /ABS / SAN /

MABS / ASA / BENDS/ SBC / s-PS /SMA

UPR /SBR / SBS

Global Demand

- 2010 Demand – 15 MMT
- 2020 Demand – 20 MMT projected.
- Growth rate expected is 4.7%



Growth Drivers- PS & EPS

Growth Drivers

- Packaging
- Construction

In 2010

Packaging industry consumption - 41.5% PS

47.9% EPS

Construction industry consumption – 7.7 % PS

47.8% EPS

PS

PS, or Polystyrene: a thermoplastic polymer which softens when heated and can be converted into semi-finished products like films and sheets, as well as a wide range of finished articles.

EPS

EPS, or Expandable Polystyrene: a thermoplastic product that is lightweight, strong, and offers excellent thermal insulation, making it ideal for the packaging and construction industries.

ABS

ABS, or Acrylonitrile Butadiene Styrene Copolymer: an opaque, thermoplastic polymer material made from the monomers Acrylonitrile, 1,3-Butadiene and Styrene. Strong and durable even at low temperatures, it offers good resistance to heat and chemicals and is easy to process.

SAN

SAN - Styrene Acrylonitrile Copolymer: a transparent thermoplastic polymer material with amorphous structure made from the monomers Styrene and Acrylonitrile.

MABS

Methylmethacrylate-acrylonitrile-butadiene-styrene copolymers (MABS): are transparent, ABS-like materials with improved resistance against fats and oils.

ASA

Acrylonitrile-styrene-acrylate copolymer (ASA): is a product similar to ABS, but with excellent weatherability because of the use of butyl acrylate rubber containing no double bonds compared to butadiene rubber. It is widely used for automotive exterior parts (mirror housings, grilles, and so on) and for other outdoor applications in the area of sports/leisure and durable electrical and electronics (E&E) housings.

Blends -Noryl

Blends: polystyrene blends homogeneously with polyphenylene (PPE) ether to yield high temperature resistant, stiff and tough materials (polyphenylene ether (PPE/HIPS). ABS and ASA blend well with polycarbonate (PC) and PA to yield PC/ABS, PC/ASA, PA/ABS and PA/ASA blends combining the excellent thermal properties of the engineering thermoplastics PC and PA with those of ABS and ASA.

SBC

Styrene-butadiene copolymers (SBC): are transparent, stiff and tough polystyrenes manufactured by a specific anionic process. SBC are widely used in food packaging (beakers, multi-layer co-extruded and thermoformed ‘modified atmosphere packaging’ or shrink sleeves). They are different from styrene-butadiene rubber (SB) made by similar technologies, which have rubber-like properties. They also need to be differentiated from (crosslinked) styrene-butadiene latexes, which are used, for example, as paper sizing dispersions.

s-PS

Syndiotactic polystyrene: a material being produced by a specific catalytic polymerisation process to yield a semi-crystalline, high temperature-resistant material.

UPR

UPR, or Unsaturated Polyester Resins: durable, resinous polymers derived from styrene and used mainly the construction, boat building, automotive and electrical industries.

SBR

SBR, or Styrene Butadiene Rubber: a rubber manufactured from styrene.

SBS & SIS

SBS & SIBS (Kraton) Polymers for Commercial Films

Food packaging: Kraton polymer as clarity and/or toughener in olefinics and styrenics or as tough tie layer in films.

Food wrap films Kraton polymer/polyolefins asPVC replacement.

Elastic films: Kraton polymer = source of elasticity

Medical films: Kraton polymer/polyolefins as PVC replacement.

Protective films: Laminations Labels Kraton polymer is extrudable adhesive layer .

SMA

Other copolymers: styrene-maleic anhydride (SMA) copolymers, as well as styrene/*N*-phenyl maleimide copolymers display high heat resistance and are often used as blend components in high heat ABS and high heat ASA

The benefits of styrenic polymers

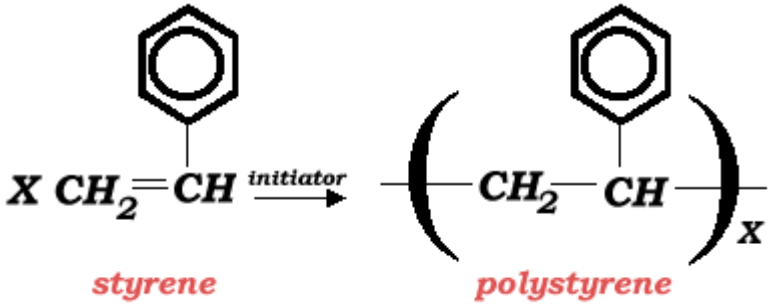
- **lightweight, water resistant and excellent thermal insulator characteristics**
- **in food packaging, they provide high levels of protection against spoilage**
- **Rigid, with a high strength-to-weight ratio that offers energy-savings benefits in transportation and an excellent cost performance**
- **Can be shatterproof and transparent if required**
- **Good electrical insulation**
- **Easy to process and produce in a range of attractive colors**
- **Easy to recycle**

Applications

Manufacturers use styrene-based resins to produce a wide variety of everyday goods ranging from cups and utensils to furniture, bathroom, and kitchen appliances, hospital and school supplies, boats, sports and recreational equipment, consumer electronics, automobile parts, and durable lightweight packaging of all kinds.

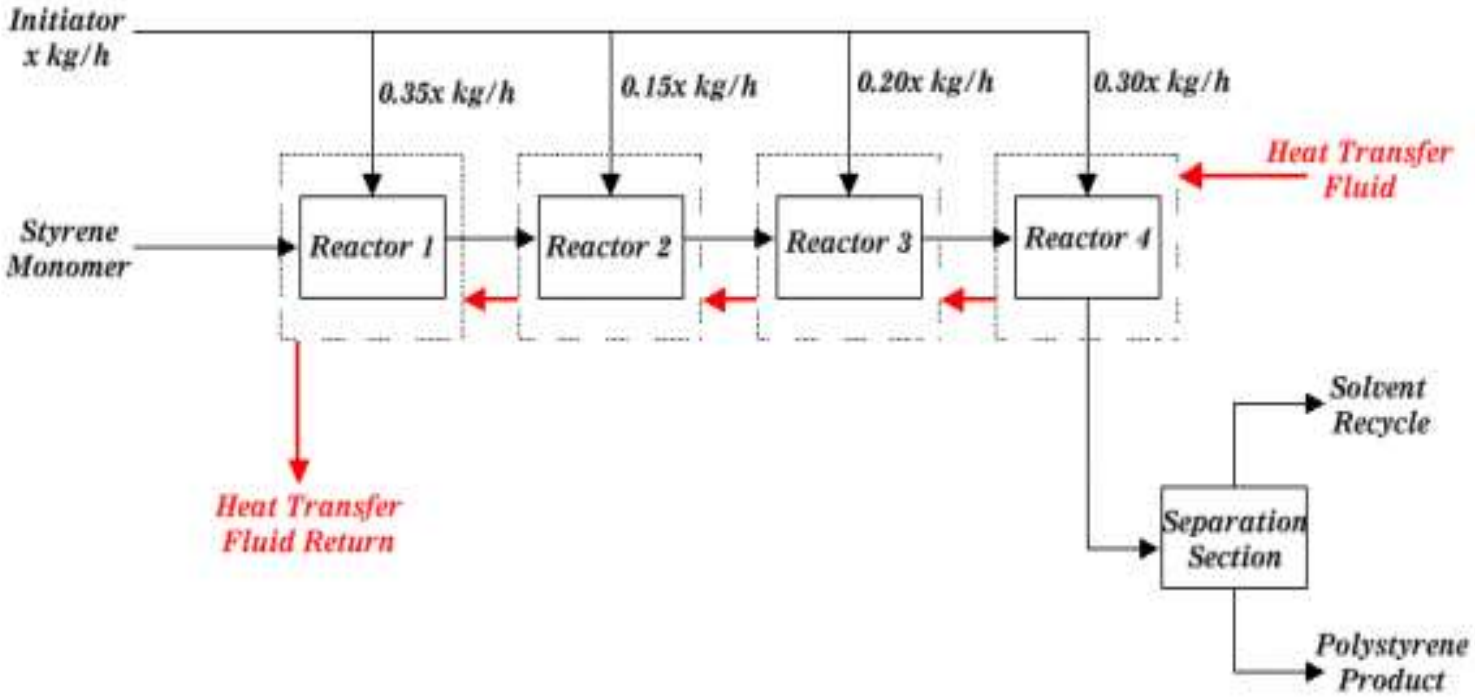
Polystyrene

- Polystyrene is an odorless, tasteless, rigid thermoplastic.
- Pure Polystyrene has following structure



Manufacturing Process

Most commonly used process – Continuous Bulk polymerization



Crystal Polystyrene & HIPS

- The homopolymers of styrene are also referred to as general purpose, or crystal, polystyrene. Because of the brittleness of crystal polystyrene, styrene is frequently polymerized in the presence of dissolved polybutadiene rubber to improve the strength of the polymer. Such modified polystyrene is called high-impact, or rubber-modified, polystyrene.
- The styrene content of high-impact polystyrene varies from about 88 to 97 percent. Where a blowing (or expanding) agent is added to the polystyrene, the product is referred to as an expandable polystyrene.

Crystallinity in Polymers

- **Most people are familiar with crystals only because of salt and perhaps growing crystals aspart of a school science project. Therefore, talking about crystals and plastics together is a new concept to many people. In reality, polymers are not like salt, which is totally crystalline, but are semi-crystalline. Unlike crystals like salt, polymers have only short-range order and a much looser organization.**

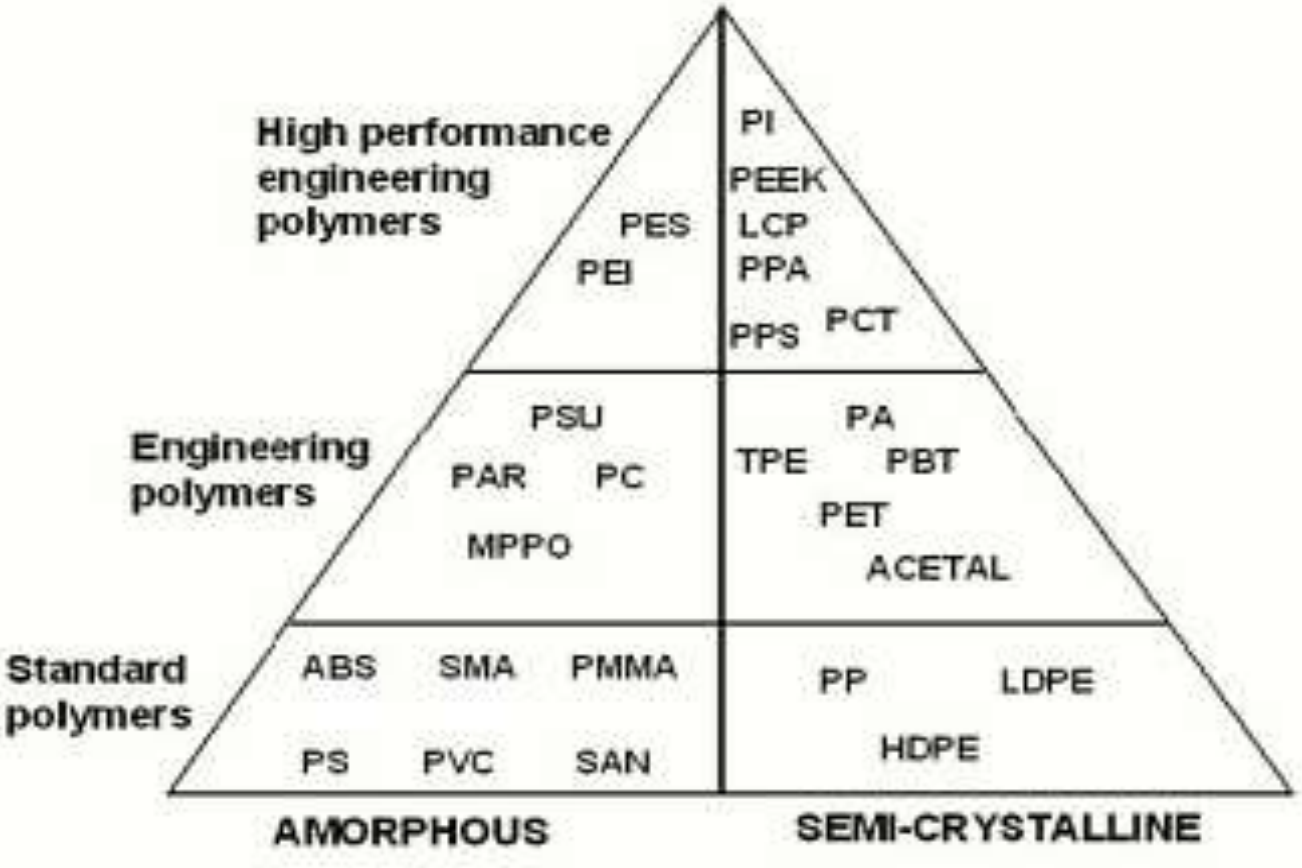
Crystallinity in Polymers

- **Crystallinity is one of the great divisions of the complete family of plastics. Amorphous polymers (those with no significant degree of crystallization) behave very differently than crystalline polymers (those with a significant degree of crystallization). Understanding crystallization and the effect it has on the properties of polymers can make understanding the behavior of polymer families much easier.**

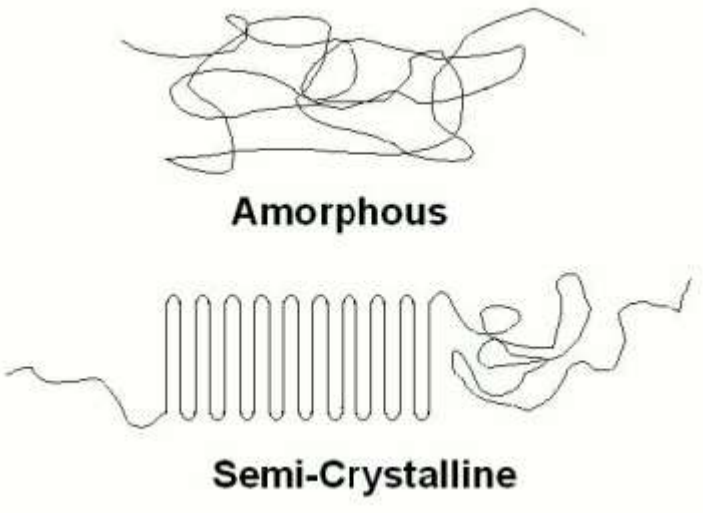
Amorphous polymers

- Amorphous polymers are those where the polymer chains have no well-defined order in either the solid or liquid states. The model that is most often associated with this characterization is a bowl of cooked spaghetti, where the long strands of spaghetti are both flexible and slide over one another.

Amorphous & Crystalline Polymers



Molecular Arrangement



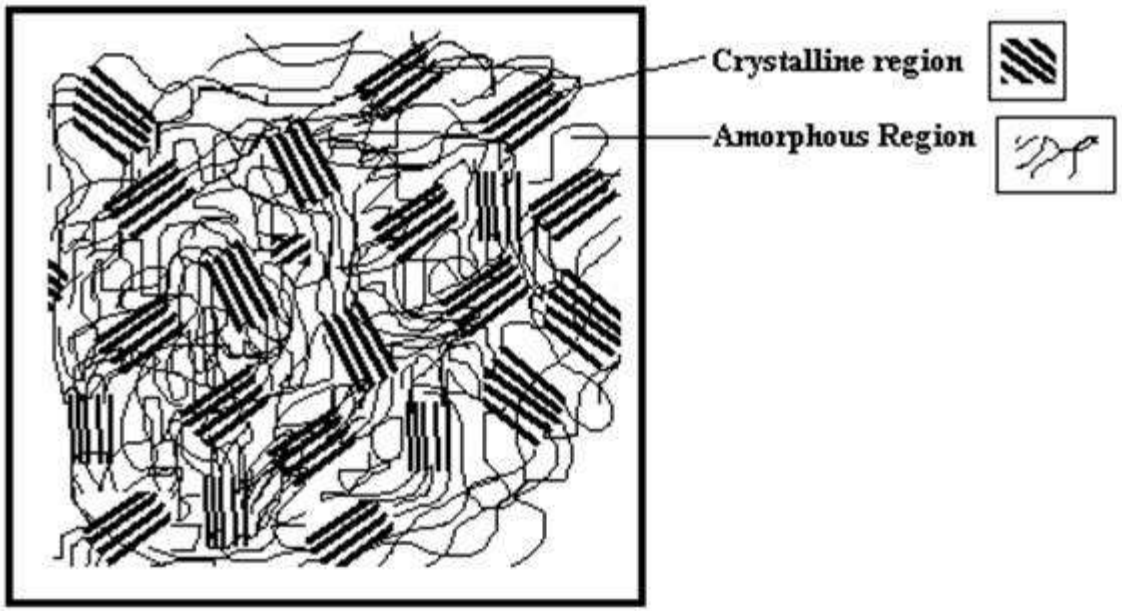


Fig 1. Mixed Amorphous Crystalline Macromolecular Polymer Structure

Transparent Plastics

Examples of amorphous polymer are PMMA, PS, PVC and ABS. As a rule, any polymer that can be produced in a transparent form is an amorphous polymer.

Order of Performance

PS> SAN> PMMA> PET> PC

PS Consumption

- PS consumption has been affected by inter-polymer competition and changes in consumer behaviour
- The media closures sector has been hit by the increasing preference for digital music download sales, which have been growing at over 20 percent per year. The increase of digital music has severely impacted CD sales, and with it the use of polystyrene media enclosures
- In developed markets, the packaging sector is the largest application area for polystyrene, in such products as disposable cutlery, vending cups, egg trayS etc.

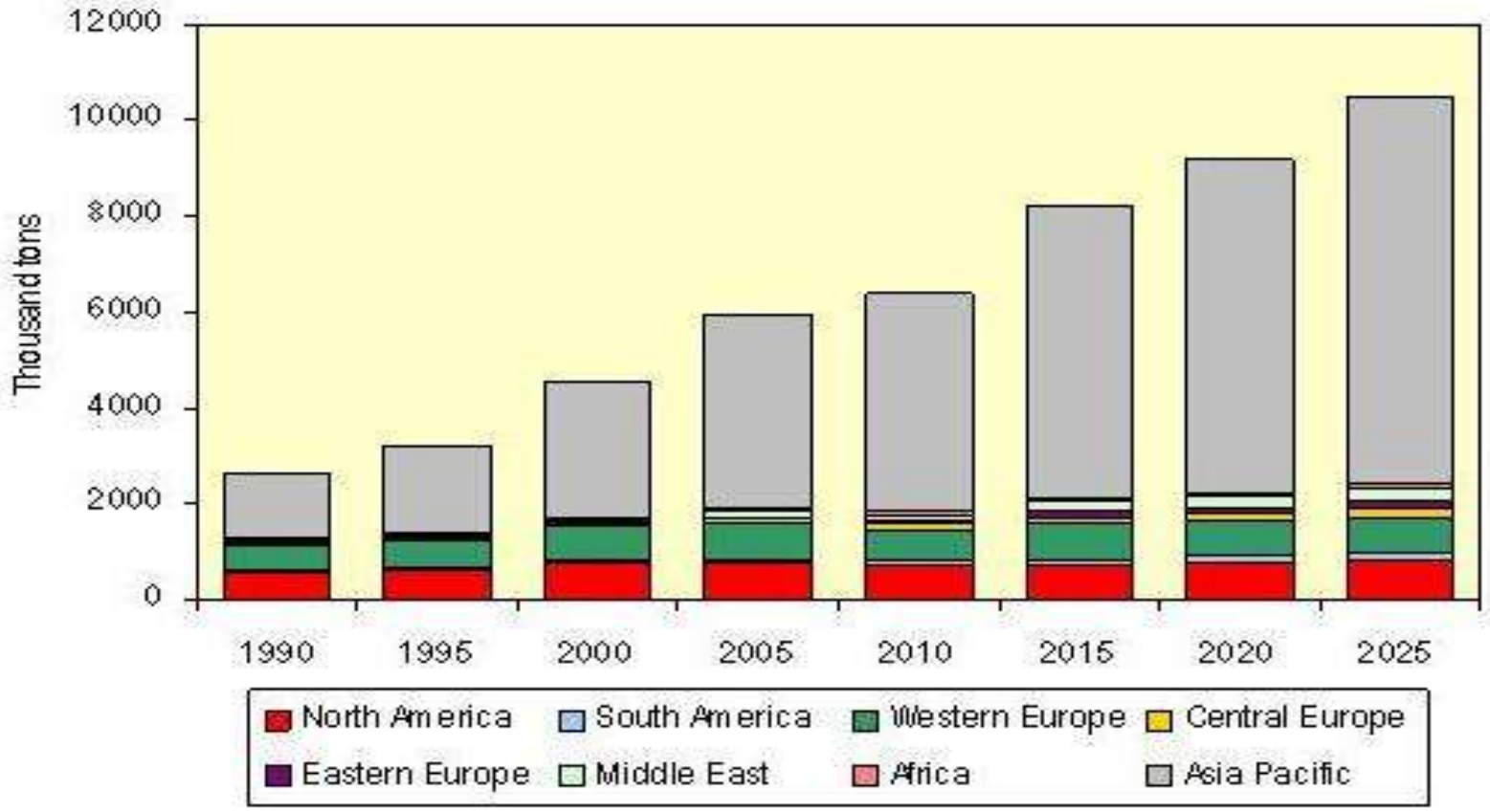
PS Growth

There remain several GPPS applications with a strong growth outlook, for example in packaging and disposable cutlery. GPPS is also used to produce foamed polystyrene, EPS and extruded polystyrene (XPS). This is a good heat insulation material for floors, walls and roofs as, having a closed cellular structure, it does not absorb water.

ABS

- The addition of butadiene rubber as a third monomer to styrene-acrylonitrile resulted in development of a new range of widely used thermoplastics called ABS
- Because the three-monomer system could be tailored to yield different balances of properties, ABS grew to become the largest-volume engineering thermoplastic. ABS served as a bridge between commodity plastics such as PE and PS and higher performance materials such as polycarbonate and nylon.
- Global ABS demand has been under pressure from inter-polymer competition, especially from polypropylene

ABS
Regional Consumption



ABS Growth

Although ABS consumption is forecast to grow at slower rates over 2009-2018 after the recent economic downturn, it will be one of the key drivers for styrene market growth during the recovery of the economy, with long term sustainable growth supported by the electrical appliance and automotive sectors. Asia Pacific, particularly China will remain the largest consuming region with an increasing proportion of the global consumption. Central Europe is expected to grow to balance the slowdown in the Western Europe.

Thank You