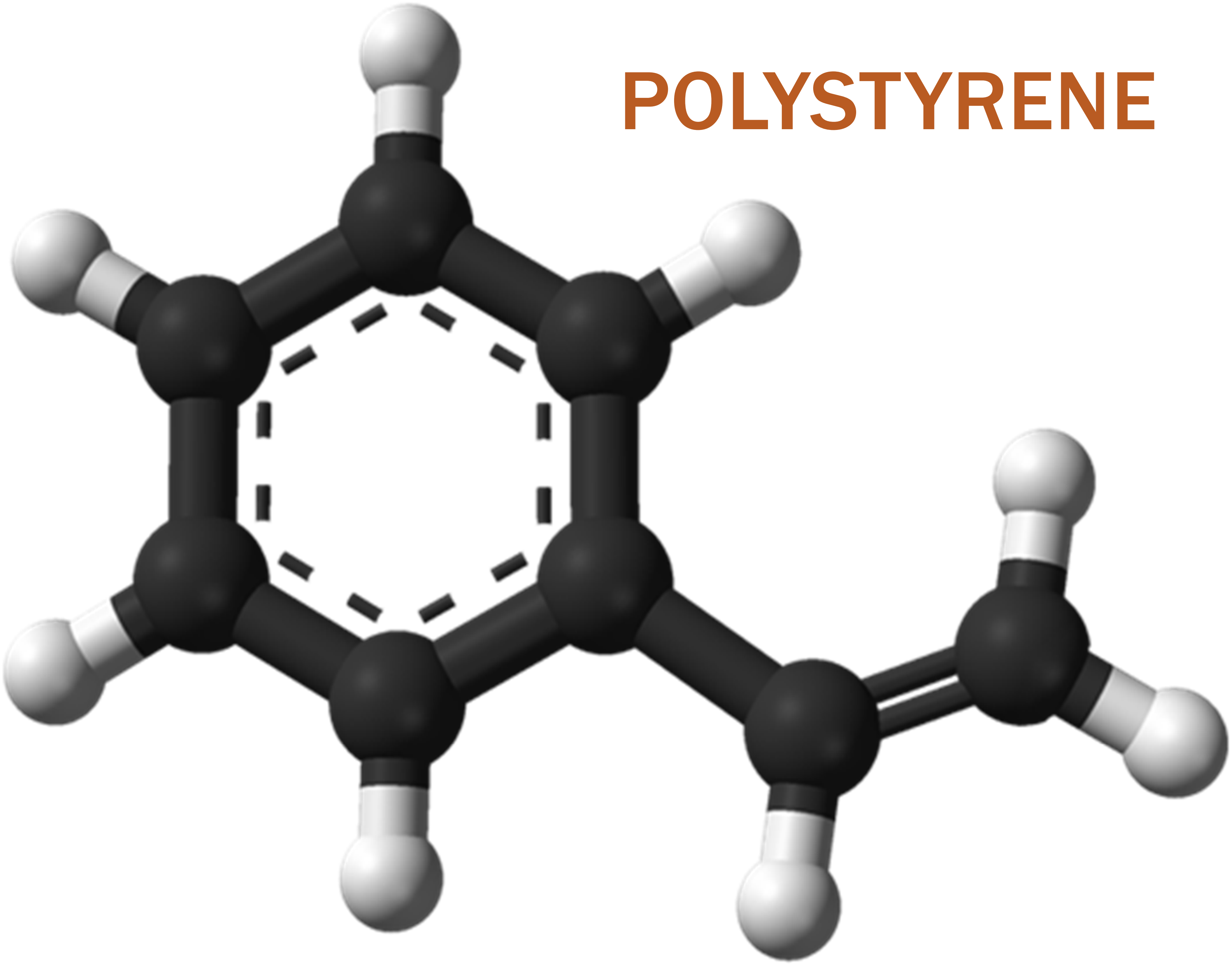
POLYSTYRENE



Why PS?

06

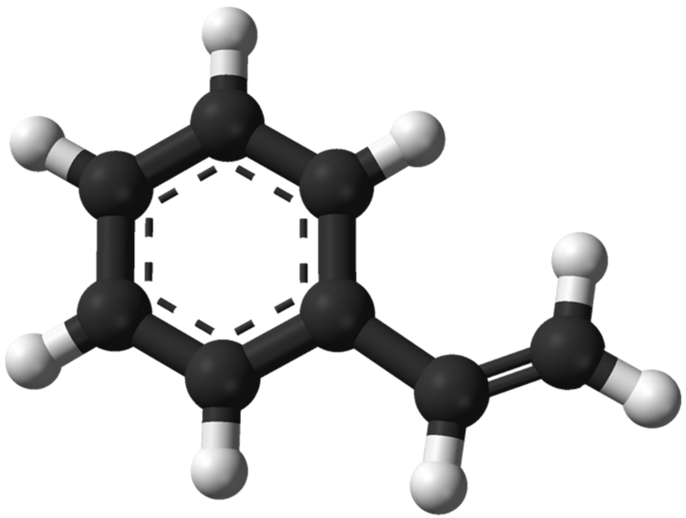
PS

Outline

- **History**
- **Overview of PS**
- **Synthesis:**
  Mechanisms
  Steps
  Tacticity
- **Some reaction to polystyrene**
- **Properties**
  Physical
  Thermal
  Mechanical
- **Polystyrene Products**
- **Polystyrene Recycling**
- **Conclusion**

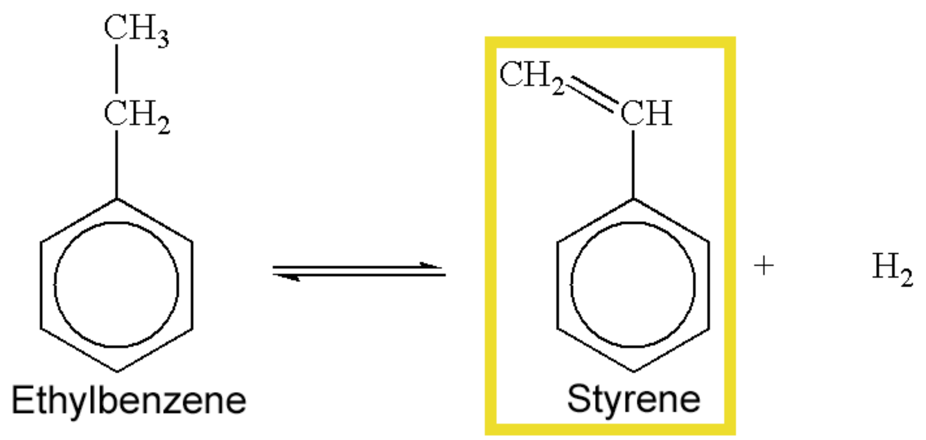
History

Polystyrene (PS), like most polymers, was accidentally discovered in Berlin in 1839 by a pharmacist named Eduard Simon



Overview

- **Monomer(s):** Styrene (reaction below)
- **Contains:** Phenyl rings
- **Mn Range:** 100,000–400,000
- **Key Characteristic:** Thermoplastic



Synthesis

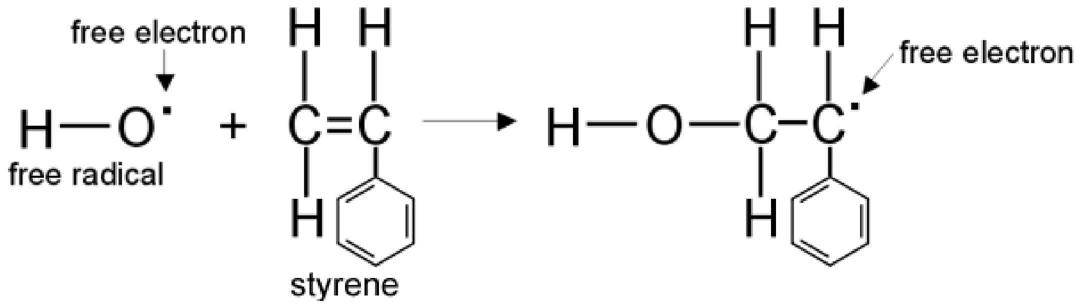
- **Mechanism:**
  Addition
- **This includes:**
  free radicals, cationic, anionic
- **Steps:**
  Initiation, Propagation, Termination

Synthesis Steps

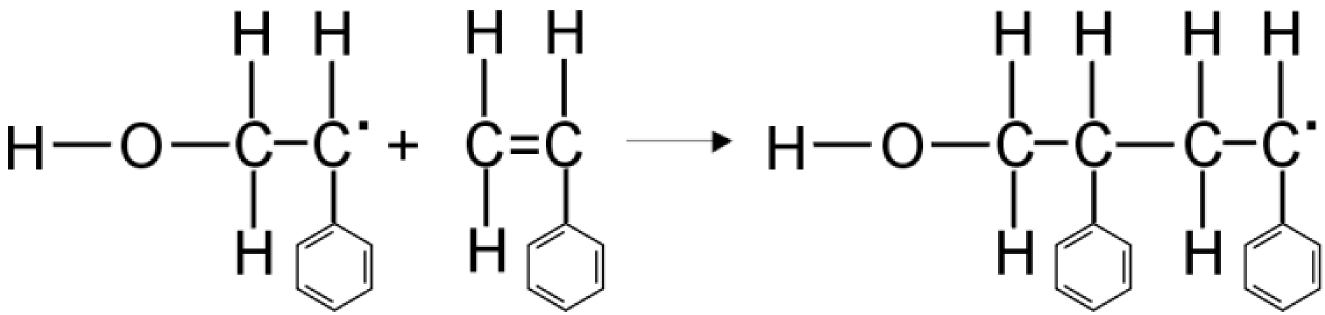
- **Initiation:**

1.

2.



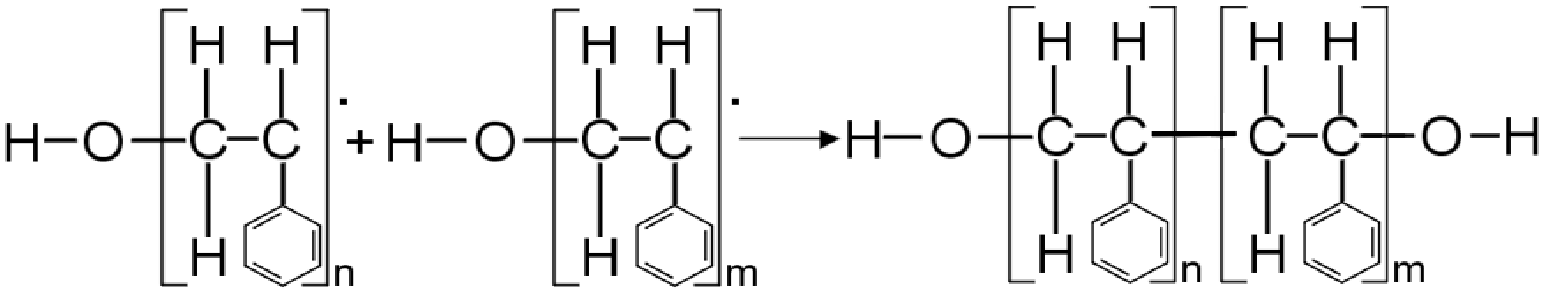
- **Propagation:**



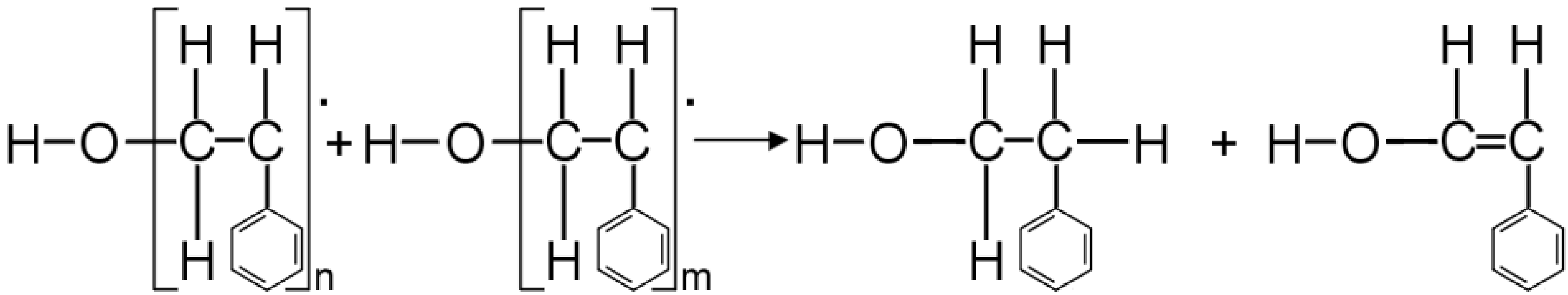
Synthesis Steps

- **Termination:**

1. Combination

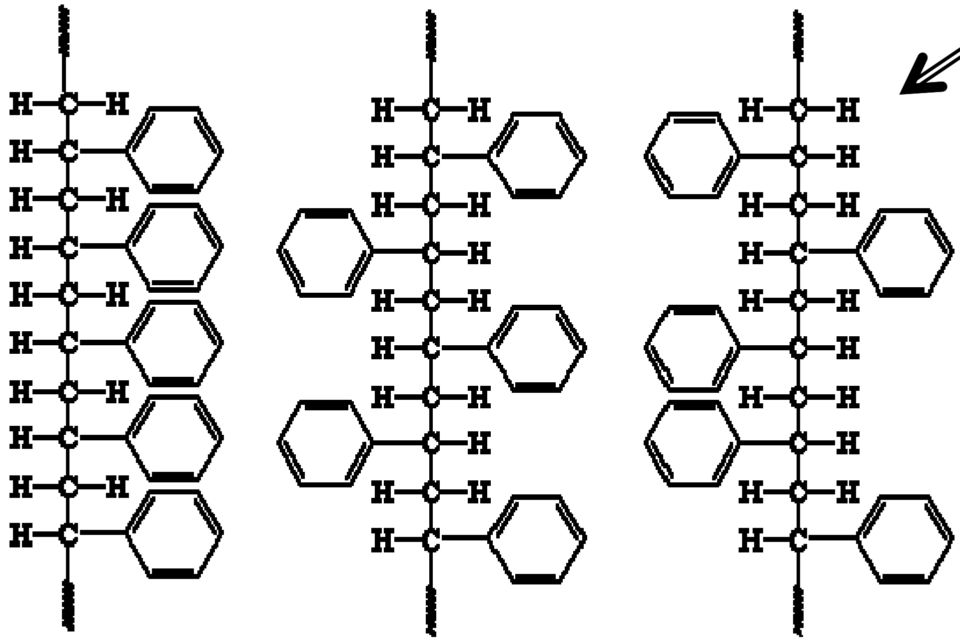


2. Disproportionation



Tacticity and Crystallinity

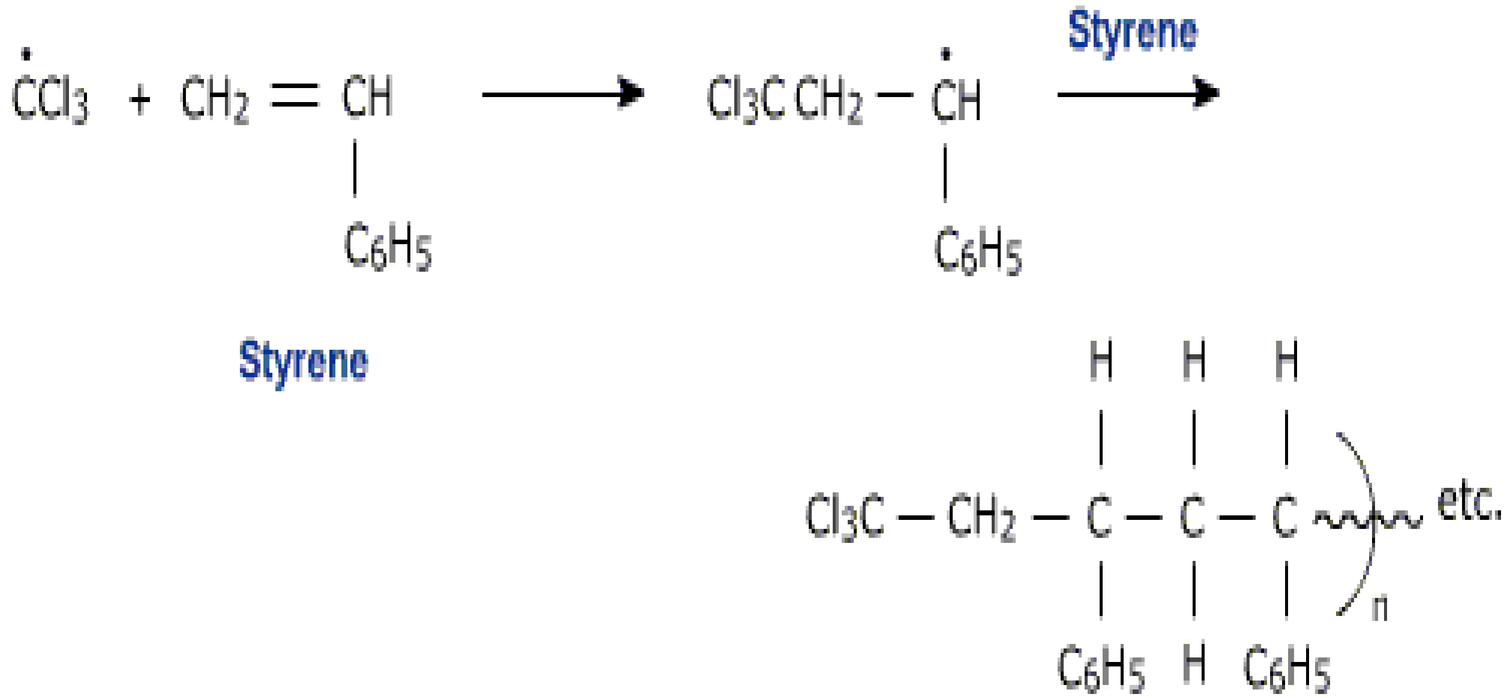
Commercial
Mostly amorphous



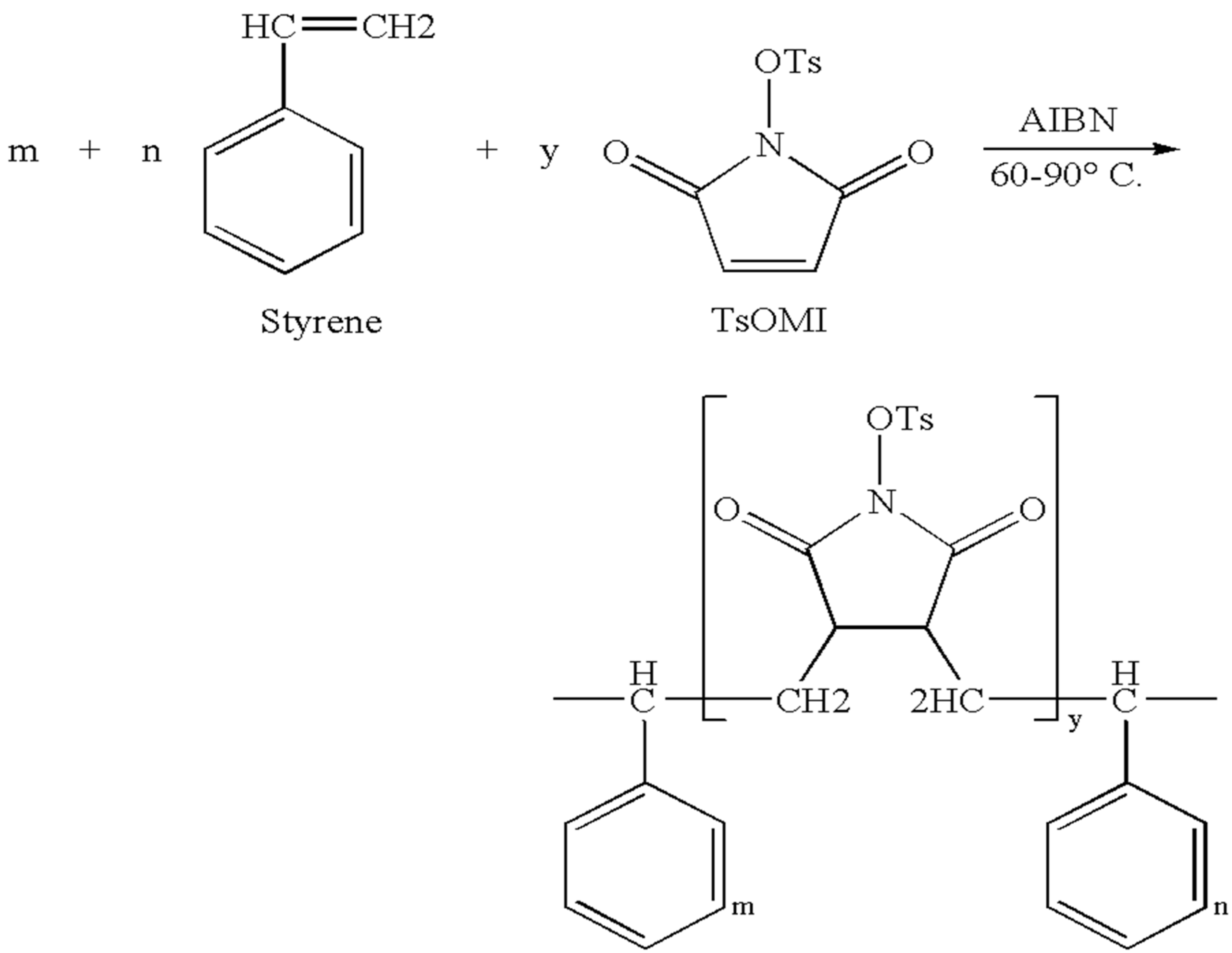
Isotactic Syndiotactic Atactic

Increase crystallinity

Commercial


Styrene
Styrene
etc.

Scheme II:



Poly(styrene-co-[N-(tosyloxy)maleimide])

Forms of PS

General Purpose PS (GPPS)	High Impact PS (HIPS)	Expanded PS (EPS)
		

Forms of PS

	General Purpose PS (GPPS)	High Impact PS (HIPS)	Expanded PS (EPS)
Characteristics	Clear, hard, brittle	Tough, hard	Tough, lightweight, rigid-foam
Cost index ($/lbs)		≤ 0.9	
Embodied energy (MJ/kg)	86.40	87.40	88.60
Trade names	Dylene (Arco)	Bextrene	Styropor (BASF), Styrofoam

Physical Properties

<table>
<tr><th></th><th>General Purpose PS (GPPS)</th><th>High Impact PS (HIPS)</th><th>Expanded PS (EPS)</th><th>Rubber bands (natural)</th><th>Legos (ABS)</th></tr>
<tr><td>Density (g/cm3)</td><td>1.05</td><td>1.04</td><td>0.008-1.10</td><td>0.9-1.0</td><td>1.06</td></tr>
<tr><td>Glass Transition T (°C)</td><td colspan="3">100</td><td>-70</td><td>100</td></tr>
</table>

Thermal Properties

	General Purpose PS (GPPS)	High Impact PS (HIPS)	Expanded PS (EPS)	Rubber bands (natural)	Legos (ABS)
Thermal Conductivity (W/m-K)	0.14	0.22	0.027-0.0418	0.14	0.23
Thermal Expansion (μm/m-K) (20°C)	120	80	0.08-70	225	95

Mechanical Properties

	General Purpose PS (GPPS)	High Impact PS (HIPS)	Expanded PS (EPS)	Rubber bands (natural)	Legos (ABS)
Young's modulus (GPa)	2.9	1.9	0.0065-0.04	-	1.9
UTS (MPa)	46	80	0.08-0.911	3.5-35	40
Elongation at break (%)	2%	40%	5-13.4%	300-900 %	20%

Polystyrene Products

- Sheet or Molded
- Disposable Cutlery
- CD
- Foams
- Insulation (Thermal & Acoustic)
- Packaging
- Shock Absorption

Food containers (HIPS)

Packaging (EPS)

Lab supplies (GPPS)

Polystyrene Recycling

Polystyrene can not be recycled

Polystyrene Disposal:

- Burial (Landfill)

Stable to bury (without contamination)

Without UV and oxygen long degradation times

- Incineration

Requires high temperatures to combust properly

High energy content (good fuel)

- Discarded (Thrown away into the environment)
- Reduce / Reuse / Recycle

Conclusion

- **Polystyrene (PS)** is a thermoplastic polymerized from styrene monomer by addition
- **Cheap to produce**, hence one of the most popular polymers
- **Pure PS** is brittle (GPPS), adding polybutadiene makes it tougher (HIPS)
- **Foam form of PS** can be produced by adding a blowing agent (EPS)
- **Applications** include packaging and containers