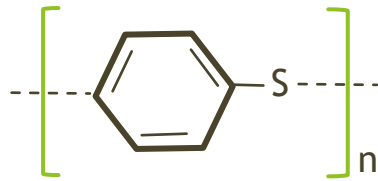


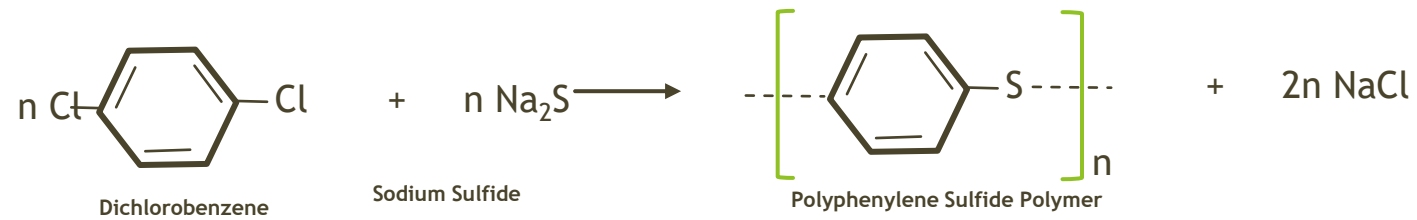
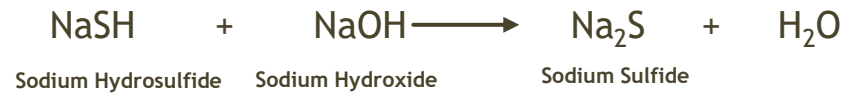
POLYPHENYLENE SULFIDE (PPS) PROCESS



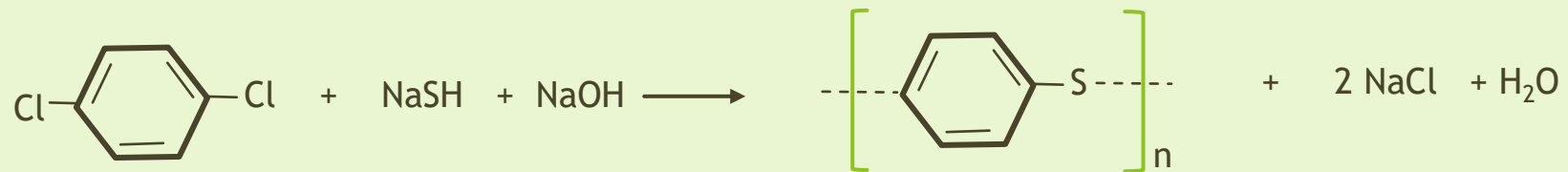
ENEX INTERNATIONAL

POLYPHENYLENE SULFIDE PROCESS

Chemistry



Overall



GENERAL :

1. PPS BACKGROUND

**Development History ---- To Present
First Plant on-Stream
Construction of Second Plant**

2. ENEX PROCESS

**Secure in Enex Design Confidence
Improved Performance Over Earlier Plants**

3. FLASH & QUENCH PROCESS - INDEPENDENTLY OR IN PARALLEL

4. SPECIAL REQUIREMENTS - RAW MATERIALS OR EQUIPMENT

Special raw Materials or Equipment Would Depend on Desired Use / Application

5. OUR SERVICES:

We work with Clients from Conceptual to Detail Engineering, support in Procurement, Construction, Commissioning and start-up of the plant.



COMPARISON – PPS PROCESS – ‘flash’ vs ‘quench’

EACH PROCESS HAS ADVANTAGES / DISADVANTAGES

FLASH PROCESS

Higher yield efficiency (92 + %)

Polymer MW 18,000 – 22,000

(Further increase MW to 45,000 + by post heat treatment)

Operational Stability / Ease – Best Control Practices

Better quality control

QUENCH PROCESS

Higher MW Directly ~50,000 + mw (MFR Low as 75)

Lower yield efficiency (~88%)

Longer Batch Cycle Time (Reactors)

Temperamental Operation – Slightly More Complicated Than Flash



PPS Market Applications

▶ The global polyphenylene sulfide market size is expected to reach at USD 2.14 billion

- ▶ **Electronic industry:** Connectors, contact rails, heat shields, contact pressure discs and special types for semi conductor production
- ▶ **Automotive industry:** "under the hood", fuel and brake and Turbo charger components
- ▶ **Medical industry:** Parts for surgical instruments sterilizable medical, dental, and laboratory equipment.
- ▶ **Mechanical engineering:** Compressor and pump-parts, gears, valves, slide bearings, chain guides and base plates
- ▶ **Chemical industry:** Valves, taps, bushings, pumps, nozzles, tubes and rollers
- ▶ **Thermal Power Plants:** Coal Thermal Power Stations Filter bag Application.
- ▶ **Aerospace and Defense:** Replacement of Metal in Military Equipment for weight reduction
- ▶ **Coatings:** Corrosion protection of ferrous metals in Chemical and Construction Industries.
- ▶ **Infrastructural Projects:** Subway Insulators, PPS Compounds in Bridge Construction.

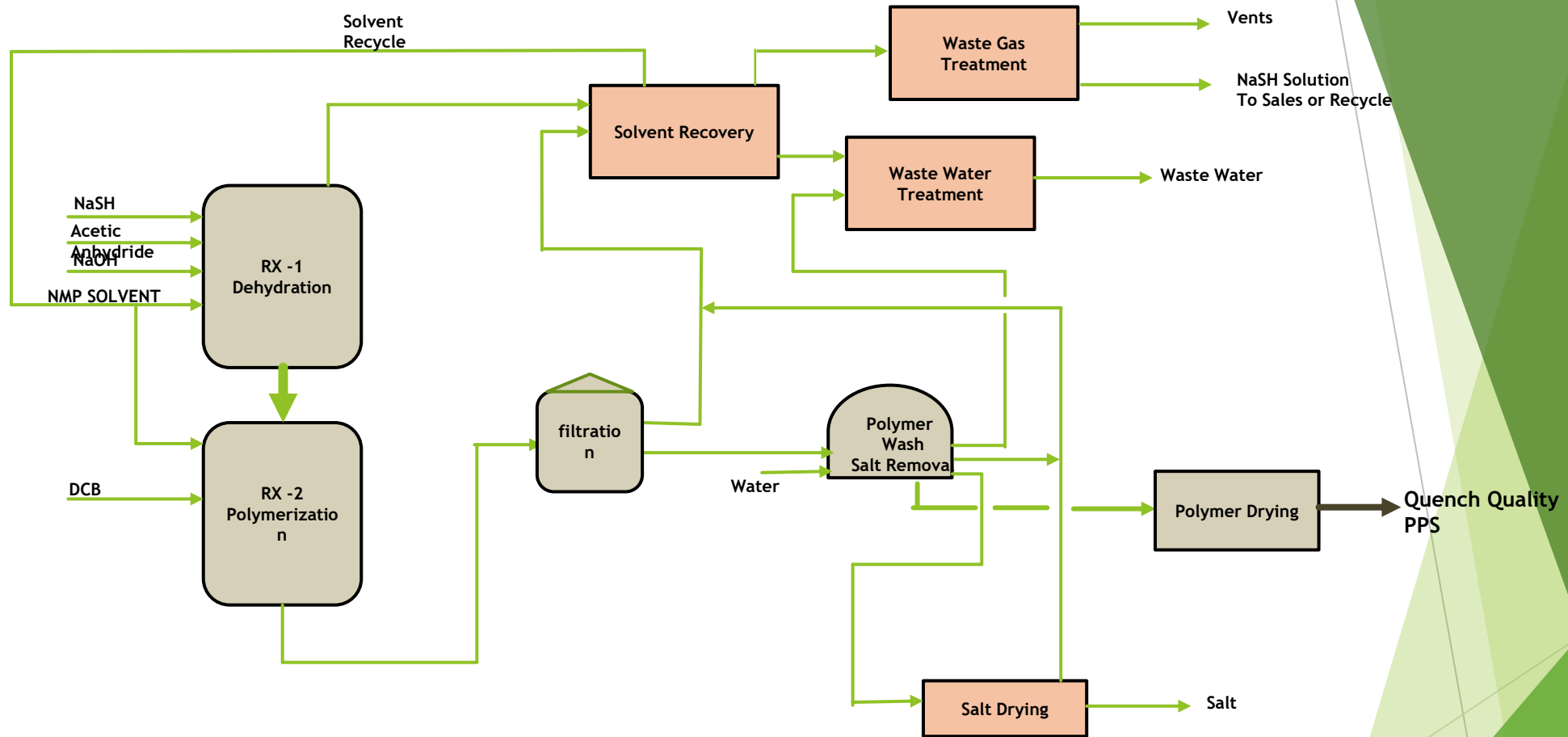
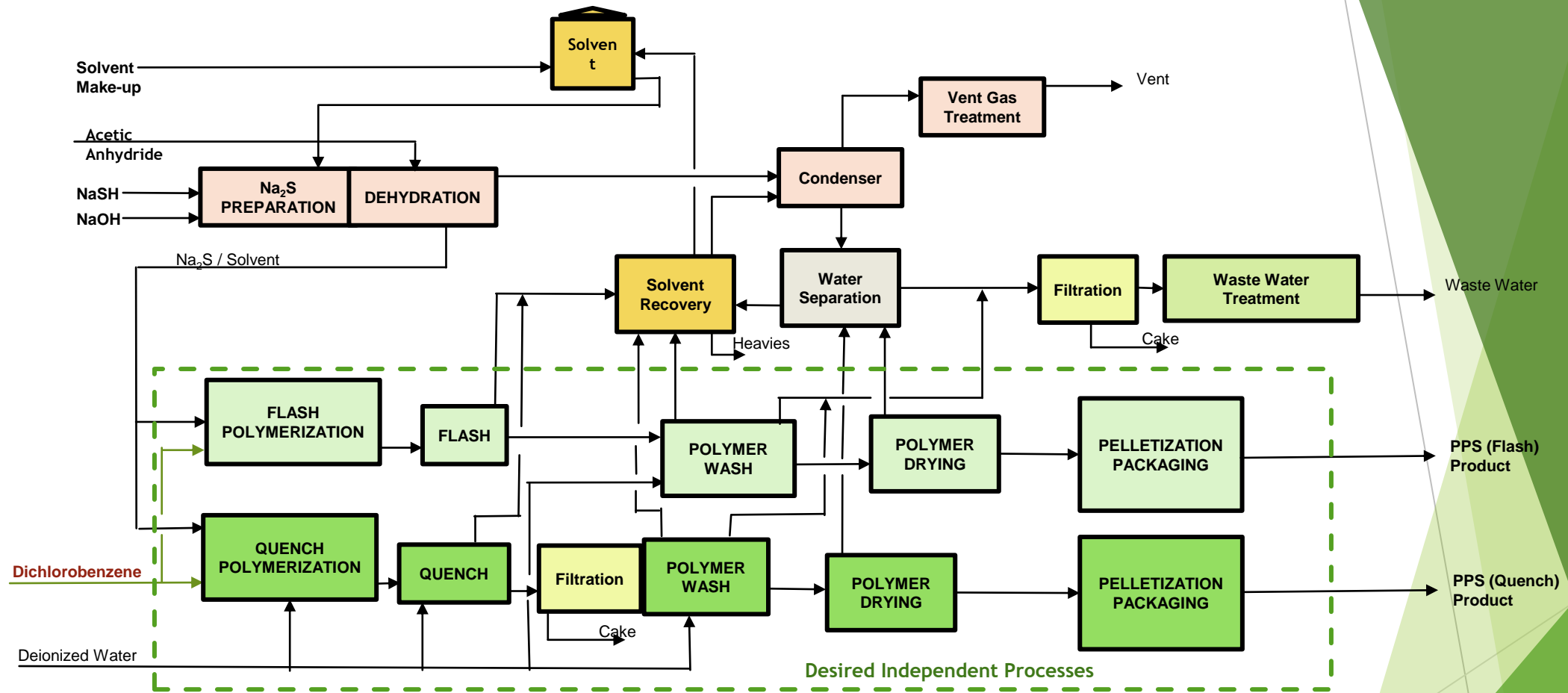


Figure 4
PPS PROCESS SCHEMATIC - QUENCH PROCESS

- Used Only in Quench Process
- Common to Both Flash & Quench Processes

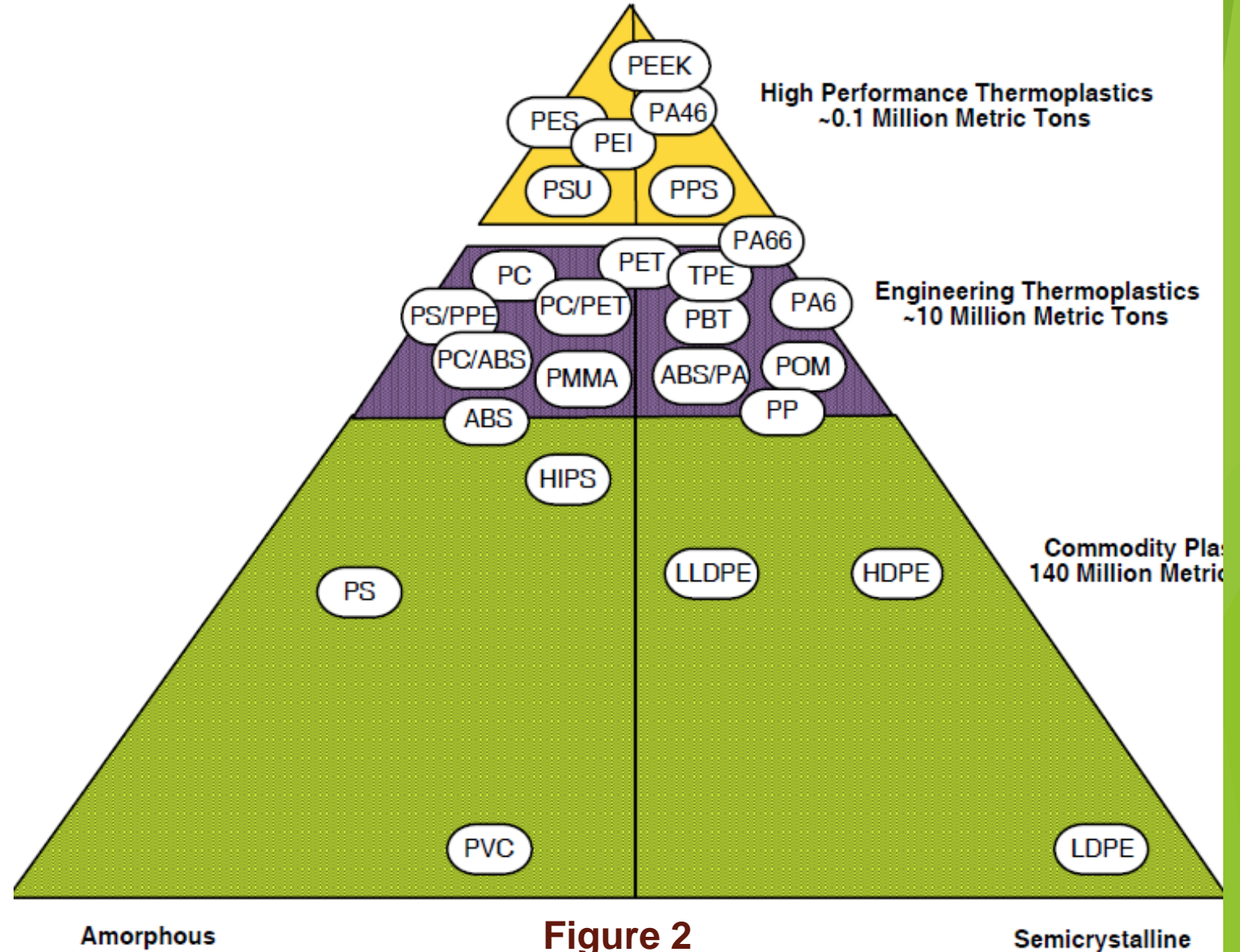


POLYPHENYLENE SULFIDE - Combined Flash & Quench Processes

- Shared Processes**
- Na₂S Preparation
 - Reactor Systems
 - Solvent Feed System and Recovery
 - Wastewater Treatment
 - Vent Gas Treatment
 - DCB Receiving / Distributing
 - Deionized Water System
 - Warehouse / Utility Systems

World Consumption of Thermoplastics—2009 (not to scale)

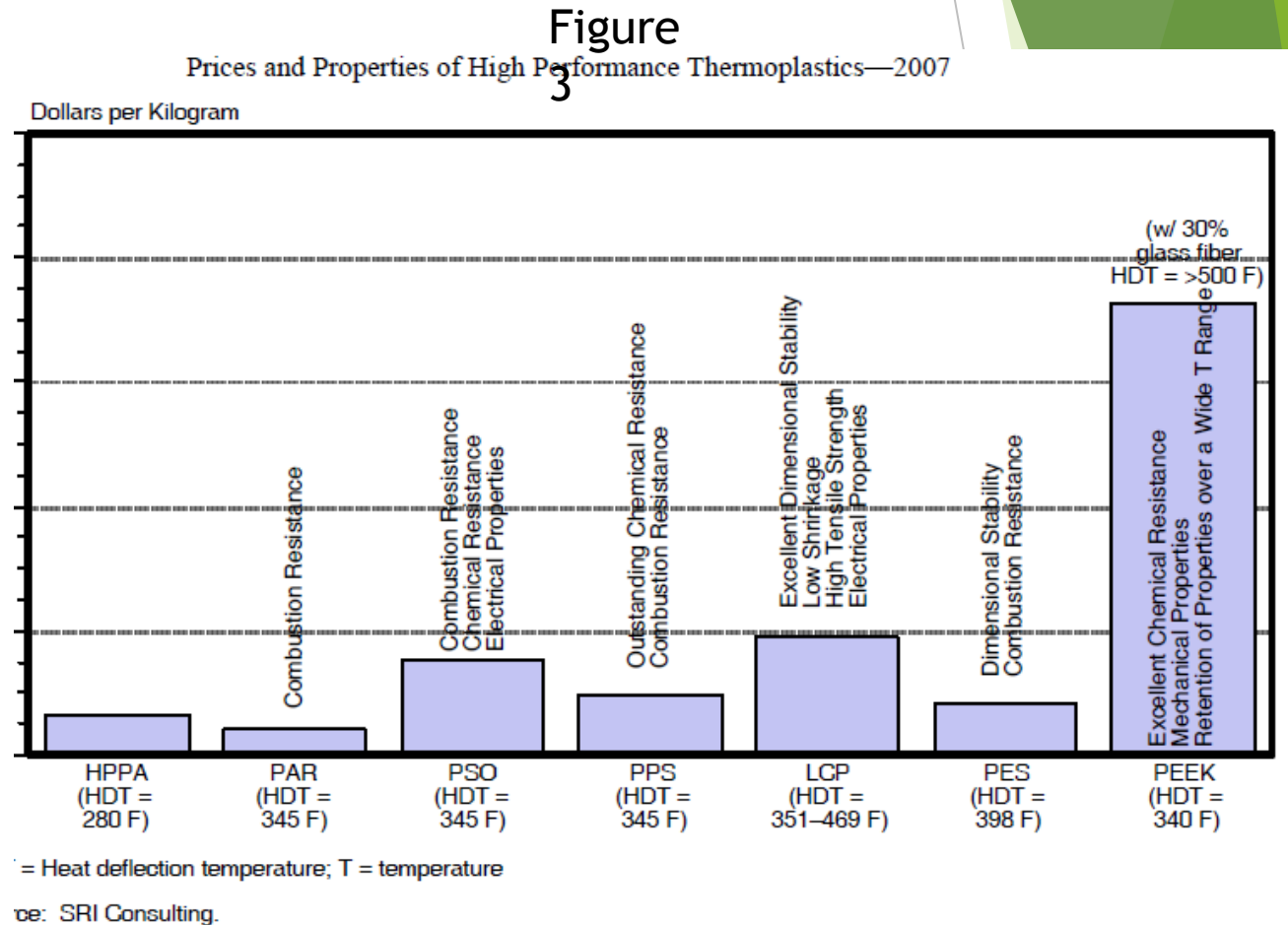
- ▶ The triangle in Figure 2 provides an overview of the thermoplastic's world for amorphous and Semi crystalline materials in the different price/performance sectors.
- ▶ In 2009, world consumption of these thermoplastic materials was approximately 150 million metric tons.
- ▶ Commodity thermoplastics accounted for 174 million metric tons.
- ▶ Engineering thermoplastic compounds (with ABS compounds included) for 10 million metric tons and high-performance thermoplastics for only 0.1 million metric tons.



Worldwide Consumption—2009: 150 Million Metric Tons

Prices and Properties for High Performance Thermoplastics

- ▶ When an application requires resistance to high temperature and combustion or chemical resistance, PPS is the material of choice in various industries.
- ▶ On a price/performance basis, PPS is most often selected
- ▶ High performance thermoplastics are going to replace Metals.
- ▶ Asia Pacific is anticipated to witness a substantial growth on automotive, oil and gas, paints and coatings, and medical sectors. This will fuel the PPS Industry expansion over the next few years.



OTHER WASTES – 10 kta Plant

Organics:

A small amount of heavy organics, 4-5 kg/hr, from solvent recovery, will require incineration disposal.

If an incinerator is not already on site, one may be included in the design.

Solids:

Solid off-specification PPS would vary in the range of 30 to 90 kg/hr depending on the molecular weight of PPS being produced at the time.

A good approximation would be ~ 50 kg/hr.

Market may be gained for this off-spec PPS. If not, it may be safely disposed to landfill.

PLOT SIZE – 10 KTA PLANT

If offices, control room, shipping, receiving, raw material storage, warehousing, etc. is to be included, an area **300M x 100 M** may be considered. However, if this is at an existing site, perhaps no storage of DCB is required, perhaps no offices, etc. and plot size could be reduced.

The basic process will preferably take place in a seven-level structure with downward gravity flow, for energy conservation, and reduced land space.

POLYPHENYLENE SULFIDE - FLASH PROCESS

Yield & Energy

Raw Materials

Dichlorobenzene
Sodium Hydrosulfide
Acetic Anhydride
Sodium Hydroxide

By-Products

Sodium Chloride / Sodium Acetate
Water
H₂S (Contained in RX Vent Gas)
Heavy Waste Products

Other

Nitrogen required for inert blanket & purge
Deionized water for product washing
Solvent - Initial charge + make-up

Energy Requirement ~ 1380 – 1530 Kcal/kg PPS
Depends on design parameters

ENEX - PPS - Basic Engineering Design (BED) - Deliverables

Process Information

- Full disclosure of production technology
- Plant operating parameters and methods
 - Plant start-up procedure
 - Plant shutdown procedure
 - Emergency procedures
 - Safety and operation practices

Process Flow Diagrams

Process and Instrumentation Drawings (P&IDs)

Material Balance - detailed

Utility Summary

- Flow diagrams
- Consumptions & Requirements

Heat (Energy) Balance

Chemicals & Catalyst(s) requirements

Preliminary Plot Plan

Equipment List

Equipment Sheets– Vessels, Exchangers, Distillation Columns
Special Equipment

Dimensions

Internals

Design and operating temperatures and pressures

Surface areas (Exchangers)

Metallurgy – Required / recommended materials of construction

Special design / construction considerations

(Continued)

ENEX - PPS - Basic Engineering Design - Deliverables (Continued)

Instrumentation Index

 Inline Instrument Data Sheets

 Instrumentation Data sheets, control loops, logical interlocks

Relief loads and primary relief devices sizing

Material Safety Data Sheets

Environmental considerations

 Preliminary Hazard Overview

 Process and WasteWater – Treatment requirement / methods

Electrical Drawing and Loading

ENEX - Post BED Support

Following delivery of the Plant BED and until the final normalization of the UNIT operations, ENEX personnel will be available if and as (within prudent reasoning) requested to meet with the Client or their appointed Detail Design, procurement or construction companies for discussions and/or further assistance. An allowance of 100 man days assistance is normally included. Such support options, as chosen, may include, but not be limited to:

- Equipment Readiness for Service
- Construction scheduling and oversight
- Operator training
- Start-up assistance
- Product Optimization
- Product Development
- Quality Control
- Economic Evaluations

Other programs as defined

Product Development Support

ENEX will work with the Client to jointly evolve project definitions, Commercial Plant objectives and goals; ENEX main goal is the best progression and protection of the Client's interests in development of quality products to achieve ultimate competitive, advantageous entry into PPS manufacture and sales.

ENEX will keep as confidential all technical, commercial or other information and data developed or supplied by its Client, its affiliates or associated partner companies.



THANK YOU

