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Expandable Polystyrene Production and Market Survey- A review

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Abstract

Polystyrene is a hard, solid, and transparent polymer and it is a type of polyolefin used to make a wide variety of consumer products. There are different types of PS which are general-purpose polystyrene (GPPS) and expandable polystyrene (EPS). Polystyrene which has foam properties is called expanded polystyrene (EPS). EPS is a rigid, tough, white, and closed-cell foam that is made of pre-expanded PS beads. EPS is used for disposable trays, plates, bowls, cups, packaging applications, construction, and insulation applications. EPS beads are produced by two basic processes: the batch process and the impregnation method. In this paper, we are going to reveal the different production processes of PS and its global consumption and market

Keywords: Polystyrene, Expandable polystyrene, polystyrene application, polystyrene consumption

1. Introduction

Polystyrene (PS) is a thermoplastic synthetic aromatic hydrocarbon polymer produced from a monomer called styrene as in figure 1 [1] . Polystyrene shape can be in a solid or a foam state at the room temperature with a transparent color [2]. Polystyrene can be combined with different colorants, additives, or other plastics such as polyethylene, and polypropylene[3]. Polystyrene melting temperature is 240 °C that is not suitable to make a mixture with some additives such as wood flour [4, 5].

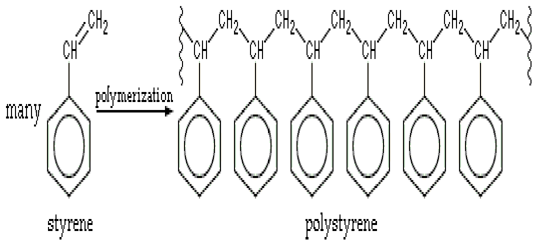

Figure 1: Polymerization of styrene

Polystyrene's chemical formula is (C8H8)n as a long chain hydrocarbon that alternating carbon atoms linked to phenyl groups [5,6]. Polymerization of styrene in suspension into spherical beads containing a blowing agent, and its finishing in a multi-step process. Incorporation of a blowing agent during the extrusion process of bulk polystyrene, with the polymer strands quenched in a water bath to avoid foaming and consequent strand cutting [7, 8]. There are different types of PS which are general-purpose polystyrene (GPPS) and expandable polystyrene (EPS) [9, 10]. GPPS is clear, hard, and brittle. It has a poor ability to absorb oxygen and water vapor and its melting point is low [11]. Polystyrene is a widely used polymer since it is produced in million tons per year [12]. It is used in many applications such as protective packaging, construction, cables, cables trays, insulation. In this paper, we are going to

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summarize the polystyrene production processes and global consumption of PS [13,14].

2. Different production processes

There are two different processes to produced expandable polystyrene. Figure 2 shows the block diagram of polystyrene production process [15,16].

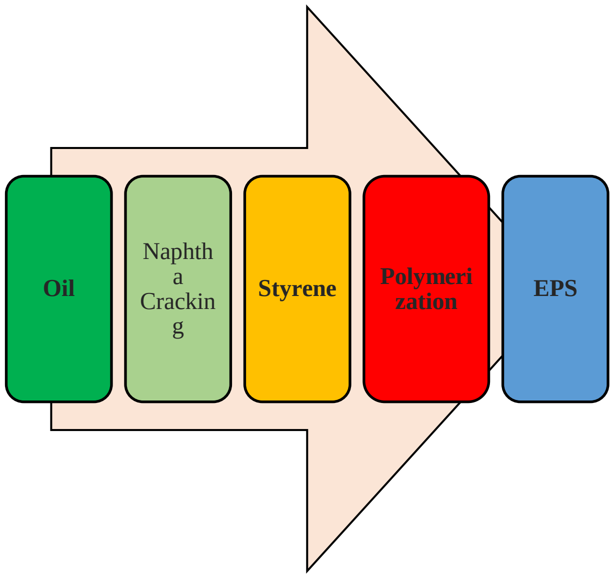

Figure 2: Polystyrene production process

2.1. Batch process

There are two ways to produce EPS via batch process. The first way is to manufacture EPS via batch suspension reaction followed by continuous dewatering, drying and size classification as per the following steps [17,18]:

- Styrene monomer, water, initiator, suspending agent, nucleating agent, and other minor ingredients are added into the reactor.
- The suspending agent and agitation disperse the monomer to form beads.
- Polymerization contained to 100 % conversion then cooling discharged to slurry tank.
- The slurry is centrifuged to removed suspension water then the beads are conveyed to pneumatic flash dryer to remove the surface moisture then the beads screened.

The second way is to produce EPS via a batch suspension polymerization of styrene, with an inorganic suspending agent as per the following steps [19,20]:

- The internal chemicals are dissolved in styrene.
- This preheated solution is afterwards transferred into a reactor, pre-filled with demi-water and suspending agent, under agitation.
- Polymerization starts and continues till, to a certain polymer content, the blowing agent is added. The reaction goes ahead until the residual styrene reaches the target value, according to a proper temperature cycle and recipe.
- The final bead size is chemically controlled during the polymerization up to the desired diameter.
- After cutting, the EPS particles are rapidly cooled down and conveyed towards a drying unit within the pelletizing water stream.
- The continuous, centrifugal dryer separates the pellets from the water, which is recycled back to the pelletizer.
- The dried EPS micro pellets are then conveyed to downstream equipment for coating and packaging, and from there are supplied to EPS converters.
- The EPS beads and water are discharged to a holding tank then centrifuged to remove most of mother liquor after that the beads are conveyed to pneumatic dryer the beads screened then the finished product is conveyed to shipping container.

2.2. Impregnation method

In the impregnation method as per the following steps [21]:

- A polystyrene melt is impregnated with a blowing agent, usually a mixture of pentane isomers, at high temperature and pressure.
- The mixture is then homogenized in static mixers and cooled down in static mixer-coolers to a temperature suitable for further processing.
- The blowing agent is added by means of high-pressure pumps. Numerous kinds of additives that are required to produce high-quality EPS for the different product applications can be added through side streams, thus enabling the processing of liquid and solid additives, as well as master batches.
- The necessary homogenization for uniform additive distribution within the product is achieved by additional static mixers prior to palletization.
- Finally, the homogeneous, additive-loaded melt is extruded through die-holes and cut by a rotating knife in an underwater pelletizer to obtain micro pellets. There are several particle sizes classes available, ranging from 0.6 to 2.0

mm. Applying pressure to the water circuit during cutting prevents premature foaming of the particles.

3. Compounding mixing

The PS blend with additives is performed through two techniques: dry mixing and wet mixing. Dry mixing uses a very high speed mixer that mixes all the ingredients to produce powder [22,23]. In wet mixing, the extruder mixes the ingredients with a low or high-speed extruder mixer, and then the mixture is transferred to a melt the mixture by heaters. The mixture is cooled and cut into granules for processing [24,25]. Figure 3 shows the extruder components.

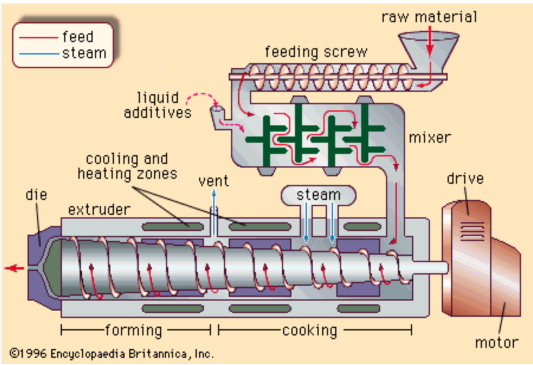

Figure 3: Extruder components

4. Expandable polystyrene applications

Expandable polystyrene is used boxes and containers for marble and food. It is also used in packaging, lightened concrete, insulation and light and heavy blocks [14,26]. It is applied in the construction activities such as: wall padding sheets, floor bodies, disposable forms [27]. Figure 4 shows the different applications of PS.

Figure 4: Foam applications

5. Market Review

Figure 5 shows that the global EPS consumption in 2019 was around 7 million tons expected to reach 8.5 million tons in 2025. Asia is the biggest consumer of PS with around 70 % of the total PS production due to the growth in economic development, especially in China and India. The latter is Western Europe as it consumes around 14 % of total PS production [28,29].

The PS Consumption is forecast to grow at 3.6 percent per year until 2025. Asia's polystyrene consumption growth rate is forecast to be about 6.6 percent per year between 2015-and 2025 [30, 31]. For the developed region of western and North America, consumption of polystyrene is expected to grow slowly at rates of 2.5 percent and 2.4 percent respectively between 2009 and 2025 [27]. Figure 6 shows that Egypt's EPS consumption is expected to grow at 5.2 percent per year until 2025, from 42 thousand tons per year in 2015 to 55 thousand tons in 2025.

For the global PS production, it was 15.5 and 15.61 million metric tons in 2018 and 2019, respectively. By 2024, it is expected to increase slightly to become 15.68 million metric tons owing to the new planned PS plants in Asia.

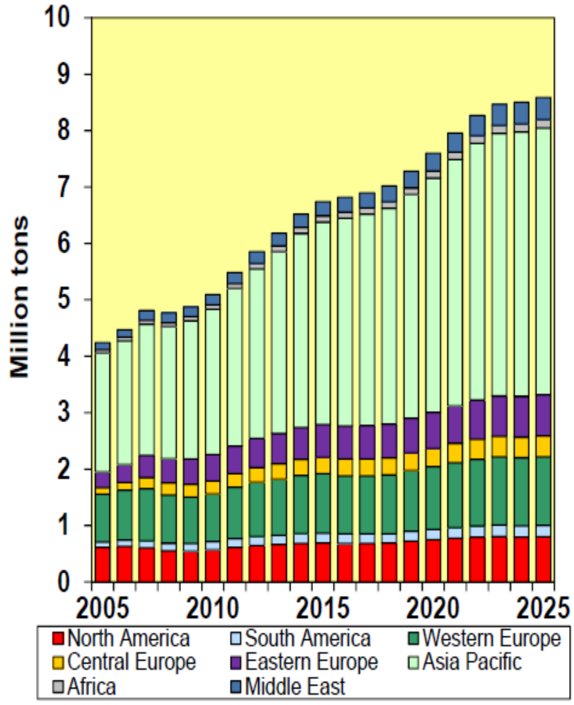

Figure 5: Global polystyrene consumption

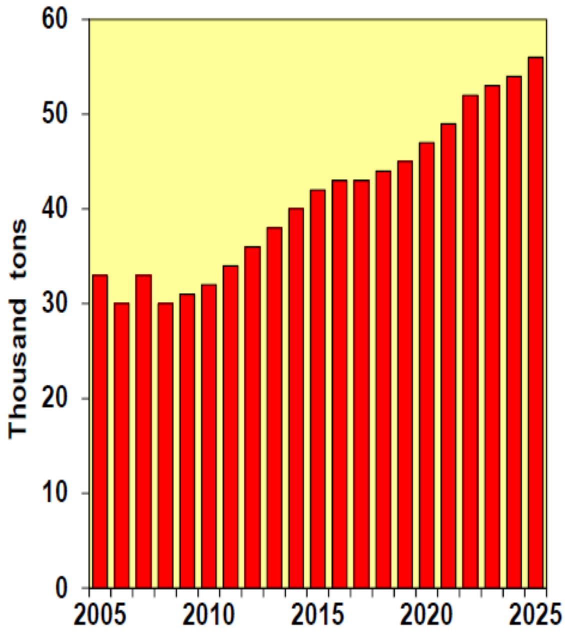

Figure 6: Egyptian polystyrene consumption

6. Conclusion

PS is categorized into two types: EPS and GPPS. PS products are essential in our lives as it is used for many applications such as bags, bottles, construction, insulation, and medical applications. There are two production processes for PS: the batch process and the impregnation method. PS is mixed with additives through two techniques: dry mixing or extruder mixing. The global and local market and consumption prove the importance of PS in our life. Much research is required to find new applications for PS, especially since it has unique properties.

7. Conflicts of interest

"There are no conflicts to declare".

8. Formatting of funding sources

List funding sources in a standard way to facilitate compliance to funder's requirements.

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