Knowledge Hub

OCEAN WISE Reducing EPS marine litter in the North East Atlantic

Review of EPS and XPS as Raw Materials

Report | Summary

Executive Summary

Polystyrene (PS) is a plastic which is abundantly used in manufacturing and construction. It is produced in multiple forms including general purpose polystyrene (GPPS) and high impact polystyrene (HIPS). There are also two kinds of polystyrene foam, expanded polystyrene (EPS) and extruded polystyrene (XPS). The main difference between EPS & XPS is their production method.

There is confusion between the two types of foam (EPS & XPS) with their names being mixed and seemingly unstructured online. The trademarked name Styrofoam (which is XPS), has become a common name for both types of foam in North America.

Many chemicals are added to the base compound styrene, from which polystyrene is produced, to create the final product. Previously, chemicals have been used that have since been found to be damaging to human health and the environment. These are being phased out and regulations have been put in place.

Over recent decades, the demand for polystyrene has increased. A growing percentage is being recycled, but most is still landfilled or incinerated.

Find the full report and database:

www.oceanwise-project.eu

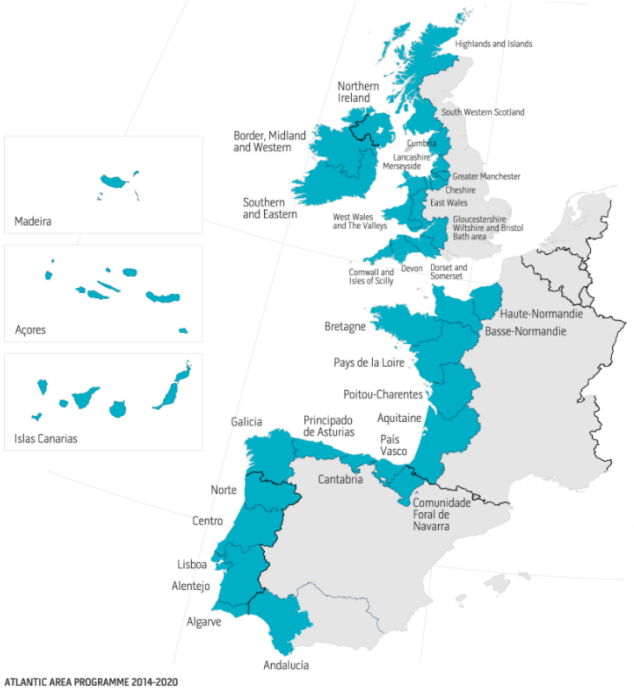

Figure 1: Map of countries participating in the OceanWise project

The OceanWise project covers the Atlantic Area which is shown in blue above, but it is important to consider the movement of EPS and XPS for this action so other EU countries were included.

Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION

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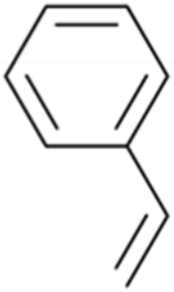
Polystyrene Production

Polystyrene was discovered in Germany in 1839, however, commercial production of polystyrene started in the 1930s. Expanded PS was invented by the Dow Chemical Company in 1954.



All PS grades have as a base of their composition the same monomer, styrene. Styrene is obtained in two steps, first by combining ethylene with benzene in the presence of a catalyst to yield ethylbenzene. This compound is then dehydrogenated at 600-650 °C by passing ethylbenzene and steam over a catalyst to get a very pure form of styrene. Styrene is put through a process of suspension polymerisation to create polystyrene beads.

Despite its advantageous properties, PS (as a homopolymer) is brittle and flammable, it softens in boiling water and, without the addition of chemical stabilizers, yellows upon prolonged exposure to air. Because of this, the homopolymer is often mixed with other chemical additives.

Types of Polystyrene

Taking into account the production mode and composition, there are four grades of PS: the most basic is general purpose (GPPS) or crystal polystyrene, then there are high impact polystyrene (HIPS), expanded polystyrene (EPS) and extruded polystyrene (XPS).

Common uses for EPS include: insulation, flotation, construction fill in, recreation, transport of fragile goods, transport of food, serving of food, protective equipment , agriculture.

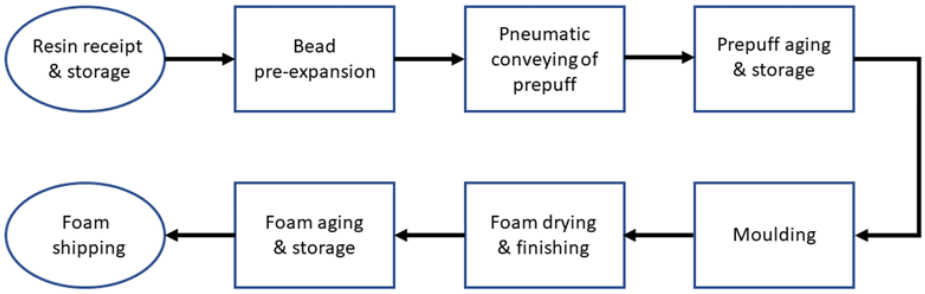


Figure 2: No. of EPS Manufactures/Transformers in Focus Countries

EPS Production

EPS goes through a series of changes that take it from a small pre-expanded PS bead, which is about 1 mm in width, to an expanded bead forty times that diameter; this process is shown in Figure 2. Pure EPS is not resistant to weathering or sunlight, and it is flammable, so generally coatings such as epoxy, different kinds of paint and non-flammable substances can be applied to the surface.

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XPS Production

XPS is produced by combining the crystal PS beads and the blowing agents directly in an extruder under pressure. The polymer/gas mixture is forced downstream to an area with lower pressure and temperature, causing the beads to expand and extrude from the machine in large plates, which can then be thermoformed if a different shape is needed. The plates, or moulded forms are then cut or trimmed to size. To ensure stable dimensions upon delivery, plates are aged after cutting.

XPS is commonly used in insulation and the serving of food.

Concerns

Product descriptions online appear to mix EPS and XPS without clear understanding of the production processes. Additionally, the name Styrofoam, trademarked by Dow Chemical, is a brand of XPS used in building insulation. However, especially in North America, this name is commonly used for EPS and other XPS products.

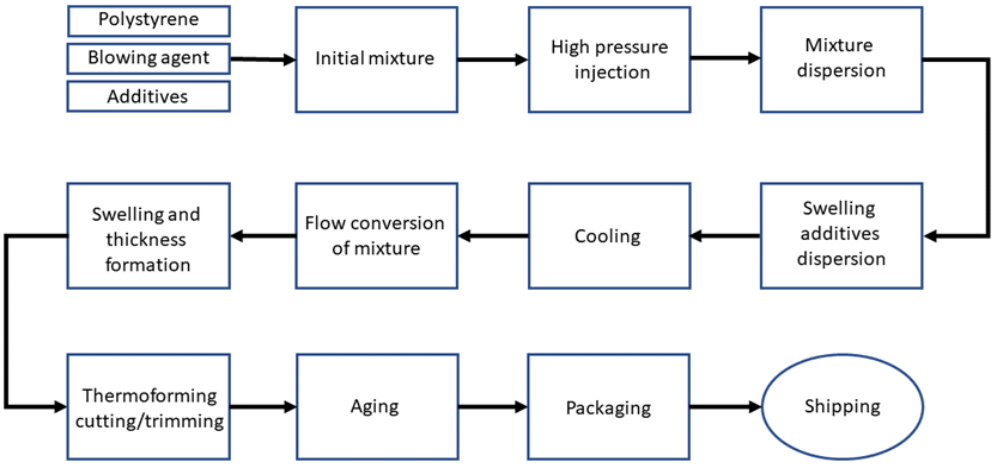

Figure 3: EPS Production demand in six of the focus countries

GPPS - Often injection moulded to create highly transparent products, e.g. petri dishes, cookie trays, bakery cake domes.

HIPS - Widely used in the food packaging industry because of its properties with regard to strength, hygiene, visual appearance and ability to retain heat, while also not deforming because of general warm water application.

EPS - EPS foam is perhaps the most commonly used plastic foam in everyday life. Its most remarkable property is that it consists of 98 % air. This means that it has a very low density and very good insulation properties due to the many small air pockets. Additionally, it can be moulded into any needed shape and it is shock absorbing and compression resistant.

XPS - XPS has the same chemical composition as EPS, but the different production process causes a closed structure with smaller, more uniform, air pockets. This stronger structure makes XPS ideal for construction purposes due to its higher compressive strength and superior thermal performance.

References:

Antoniadou, P. *et al.* Integrated evaluation of the performance of composite cool thermal insulation materials. in *Energy Procedia* (2015). doi:10.1016/j.egypro.2015.11.214

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Chemicals

Analysis of additives in plastics, and their transfer in the environment, today represent a challenge for environmental chemists. Like other plastics, the additives composition of EPS/XPS is complex, as a large diversity of additives can be used depending on the final application of the material.

Precursor Compounds

Styrene monomers are the main component of polystyrene.

Nucleating agents

The goal in manufacturing EPS is to create cells which are homogeneously distributed and of similar size. Dispersing a nucleating agent throughout the polymer allows for better control of the number of cell formation sites and, thus, leads to a homogeneous structure.

Blowing agents

The blowing agent creates the particular cellular structure of EPS by expanding the beads to 40 times their initial size.

Flame retardants

Plastics can be highly flammable, making them a potential hazard when used in construction. To mitigate this risk, flame retardants are added.

Antioxidants

Antioxidants are used to protect the material from thermo-oxidative degradation. They reduce the appearance of yellowing, cracking or more general surface

Absorbed Chemicals

→ Studies have confirmed that many hydrophobic organic chemicals in the environment can be accumulated in plastics and transferred to seawater once they reach the marine environment.

Surfactants

There are multiple uses of surfactants. One is during the suspension polymerization by decreasing the surface tension, another is as a surface treatment to strengthen the outer coating, a third use is to eliminate the accumulation of static electricity on the surface.

Plasticizers

Plasticizers make the plastic more flexible via a lowering of the glass transition temperature.

Pigments

Carbon Black is used in a number of polymer and coatings applications, including as an infrared opacifier in EPS foams. The good infrared absorption characteristics of such black EPS foams provide improved thermal performance compared to white EPS.

Multiple studies are being undertaken to study leaching of chemicals from polystyrene products to the environment and organisms. Particularly, the leaching of chemicals in to food.

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Use and Disposal of Plastics and Polystyrene

Plastics are a family of hundreds of different materials with a wide variety of properties. They are organic materials that can be either fossil fuel base or bio based.

Although the generated waste of plastics in Europe is very high, and although recycling of materials like EPS is very low, some studies have shown that EPS seems to still be the best solution for certain packaging requirements.

The recycling rate for EPS waste in Europe in 2017 was 27 % in total, for EPS packaging waste 34 %, and for EPS construction waste 8 %.

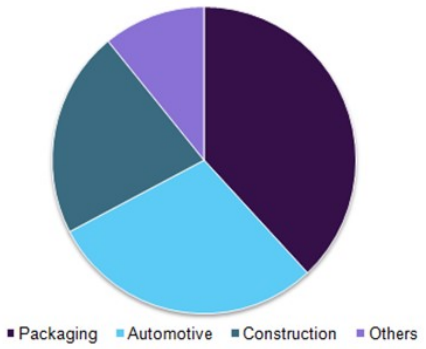

Figure 4: Global EPS market in % in 2016.

Two categories of plastics: thermoplastics and thermosets.

- Thermoplastics can be melted when heated and hardened when cooled.
- Thermosets undergo a chemical change when heated, so they cannot be re-melted and reformed.

Regulations

Chemicals used in polystyrene are regulated to protect human and environmental health.

Regulations:

⇒ The EU REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulation No. 1907/2006.

⇒ The European Directive 2011/65/EC on the Restriction of the Use of Certain Hazardous Substances in electrical and electronic equipment (EEE).

⇒ The European Commission regulates the substances that can be used in materials and products intended to come into contact with food in the EU regulation (EC) No 1935/2004 (updated with the regulation EC) No. 450/2009).

⇒ Strategic Approach to International Chemicals Management (SAICM) (2006).

⇒ In the U.S., the Food and Drug Administration (FDA) regulates packaging materials under section 409 21USC348 [7]4 of the federal Food, Drug, and Cosmetic Act.

Other Key Findings

PS weathering (degradation), interaction with organisms, and reactions with the environment can change the rate and type of compounds released from PS into the environment or organisms.
Different companies use different chemical formulations, sometimes with proprietary chemicals. The safety datasheets (SDS) from different companies shed light on some of the components and additives used for the different grades of polystyrene.