

## PREPARATION OF ADHESIVES FROM THE EXPANDABLE POLYSTYRENE WASTE

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### Abstract

In daily life, expanded polystyrene foams (EPS) are widely used as packaging material, construction material, and in household appliances as well as many others. On the other hand, waste EPS has caused lots of environmental pollutions because it cannot be decomposed by the natural processes. With law 211/2011, to add in 2016 romanian entrepreneurs in construction sector had to find a friendly solution with the environment for recycling EPS. This article aims to present one of these Styrofoam organically recycling and also to prepare and use in the laboratory an adhesive from expandable polystyrene waste.

**Key words:** adhesive, environment, expanded polystyrene

### INTRODUCTION

Polystyrene is extracted from oil. Thousands of small units of styrene, called monomers, link together to form large molecules of polystyrene by a process called polymerization (Figure 1) (<http://www.jmt.in/what-is-expandable-polystyrene-eps.html>).

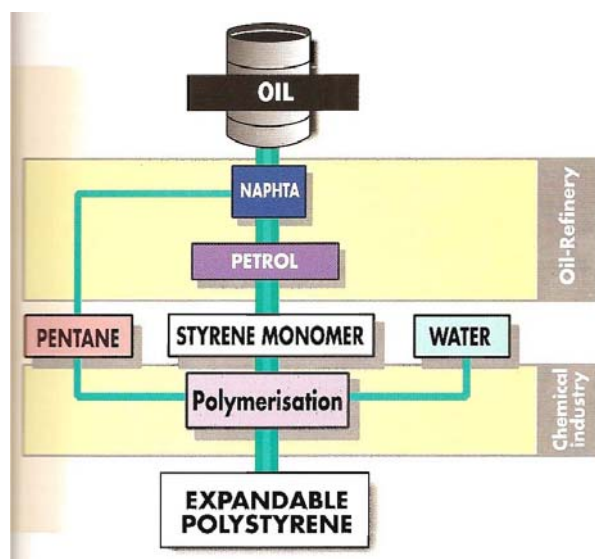


Figure 1. The polymerisation of EPS  
(<http://www.jmt.in/what-is-expandable-polystyrene-eps.html>)

The expanded version of polystyrene is about forty times the volume of the original polystyrene granule (Maharana T., 2007). Originally discovered by Eduard Simon in 1839 in Germany by accident, EPS foam is more than 95% air and only about 5% plastic. EPS, or Expandable Polystyrene is among the biggest commodity polymers produced in the world. EPS is a solid foam with a unique combination of characteristics, like lightness, insulation properties, durability and an excellent processability. EPS is used in many applications like thermal insulation board in buildings, packaging, cushioning of valuable goods and food packaging (Figure 2) (<http://www.plasticseurope.org/what-is-plastic/types-of-plastics-11148/expanded-polystyrene.aspx>).



Figure 2. The versatility of EPS

Expanded polystyrene (EPS) is an innovative building material that lends to the design and structural integrity of many building projects (Figure 3). Since the 1950s, EPS has been recognized as a mainstream insulation material.



Figure 3. EPS used in constructions

The municipality from Bucharest has rehabilitated thermally from 2009 to now, up to 2314 blocks and another 758 are in rehabilitation (Figure 4).

([http://www.hotnews.ro/stiri-administratie\\_locala-20650690-analiza-cate-blocuri-fost-reabilitate-termic-bucuresti-cati-bani-cheltuit-cat-sigure-sunt-cladirile-anvelopate-caz-incendiu.htm](http://www.hotnews.ro/stiri-administratie_locala-20650690-analiza-cate-blocuri-fost-reabilitate-termic-bucuresti-cati-bani-cheltuit-cat-sigure-sunt-cladirile-anvelopate-caz-incendiu.htm))



Figure 4. Building rehabilitated with EPS

The amount of expanded polystyrene used in thermal isolation, is large. The impact of these works on the environment is high (parks and

gardens filled with polystyrene beads and large pieces of polystyrene) (Figure 5).

When discarded in nature, expanded polystyrene threatens birds and aquatic fauna, especially because it has a very low density, which makes it able to float or drift. Styrofoam fragments are lethal to fish and birds that come to consume. (<http://www.sigurec.ro/ro/despre-sigurec/reciclez1/reciclarea-polistireului.html>) Time decay is very high, about 900 years, making from polystyrene an important source of pollution.

It is resistant to photolysis, or the breaking down of materials by protons originating from a light source. This, combined with the fact that Styrofoam is lightweight and therefore floats, means that over time a great deal of polystyrene has accumulated along coasts and waterways around the world.

It is now considered the main component of marine debris. While it can be recycled; the recycling market is diminishing it. In many communities people are told that their recycling companies will not accept polystyrene products. Those that are recycled are remanufactured into things like cafeteria trays or packing filler.

(<http://cleanbayarea.com/recycling-environment/how-styrofoam-is-bad-for-the-environment/>)



Figure 5. Polystyrene scrap remaining after rehabilitation

LAW NO. 211/2011 on waste regime, updated in 2016 prohibits throwing Styrofoam in landfills.

With the introduction of this law, the large amounts of unused EPS led to a need for recycling even by those who use this material for thermal insulation in constructions.

## MATERIALS AND METHODS

### 1. Advanced recycling of EPS

An example of 'give way' 'it is a construction company in Bucharest that found that expanded polystyrene recycling can even bring profit. They bought an EPS recycling system from a chinese specialized company dealing with the production of specialized equipment in recycling. Foreign company wants to buy material that results from recycling in order to reuse it, because in Romania there is interest in introducing it back into circulation. This recycling system is unique in Romania. The machine is equipped with a superior worm wheel motor that acts a role to break down large pieces of polystyrene granules mixture. Afterwards, the balls are heated to a temperature between 160-180°C, melting away. During combustion, it releases smoke and gas that are not very toxic. If this temperature range is exceeded, they become black and therefore cannot be reused (Figure 6).



Figure 6. System of recycling EPS

Polystyrene waste requires cleaning in advance before placing them in the recycling machine. This is the main drawback.

### 2. Recycling EPS in laboratory

The preparation of expandable polystyrene adhesives from the waste was performed in the Environment Engineering Laboratory, from the Land Reclamation and Environment Engineering Faculty - U.A.S.V.M Bucharest. For this experiment we needed 100 ml of acetone, about 150 g of expanded polystyrene,

cylinder, glass container for mixing materials, spatula (Figure 7).

At the introduction of expanded polystyrene in acetone, it seemingly disappears, and the gas bubbles in the material, when they were released, create an effect of effervescence (Figure 8). A small volume of propanone can dissolve an impressive amount of polystyrene (Figure 9). This experiment takes only minutes and is easy to repeat.



Figure 7. The quantity of polystyrene for experiment



Figure 8. Polystyrene in propanone



Figure 9. Dissolved polystyrene



## RESULTS AND DISCUSSIONS

### 1. Specialized recycling of EPS

With the specialized recycling system of EPS, result a model foam at the moment, which later becomes solid and brittle, with a density much higher than classic polystyrene (Figures 10, 11).



Figure 10. Foam of polystyrene



Figure 11. Pile with foam of polystyrene

This foam is subjected to chemical processes and then transformed into picture frames, helmets for cyclists, hangers and more (Figure 12). Compared to traditional materials with wooden frame, it is advanced in the aesthetic strength, durability and corrosion. It has simple techniques impression pigeon. Moreover, the cost is less. Consequently, it becomes popular to many customers. Within only 3-4 years of rapid market dominated by traditional products of wood framing and became the new environmentally friendly material applied decoration, outdoor advertising and construction materials industry and planning.



Figure 12. Frame and helmets made of polystyrene foam

### 2. Laboratory experiment

As a result of the experiment, we obtained a gel which can be used as an adhesive. We tried – and managed to bond plastic and even ceramics (Figures 13 and 14).



a)



b)

Figure 13. a) Before bonding, b) After bonding



a)



b)



c)

Figure 14. a) Before bonding, b) After bonding

The remained gel in the experiment was placed in special forms from silicone, resulting small art objects that could easily be loved (Figures 15, 16 and 17).



Figure 15. Molding process



Figure 16. After removal of form



Figure 17. After removal of form

## CONCLUSIONS

Expanded polystyrene can be harmful to the environment if is not properly exploited. Once updating the Law 211/2011 entrepreneurs in construction will have to use an advanced system of recycling of EPS. Expanded Polystyrene is completely recyclable; it can be transformed into new foam packaging or durable consumer goods like cameras, coat hangers, CD jewel cases and more.

## ACKNOWLEDGEMENTS

The authors are grateful to SICOR SRL, Bucharest for providing support.

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