Glue produced by recycling Polystyrene

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Abstract

According to the bibliography, over 20% of the Solid Waste consists of plastic. One category of the Solid Waste is the polystyrene (PS), which can be used as a material of cementation. PS can melt under the reaction of the appropriate solvent and become liquid glue.

This kind of glue, the polystyrene glue, can cement not only a specific category of material but many other materials of general use as well. It has been noticed that this glue has good results in wood cementation.

In Aristotle University of Thessalonica there have been studies in the cementing ability of the polystyrene glue in different kinds of wood in contrast with the PVAc, which have reached the conclusion that the polystyrene glue has good results in cementation. Yet, some more improvements in the polystyrene glue should be made, according to the results of the research. Also more than forty carpenters have answered a questionnaire and their opinion for the specific glue is positive enough.

This polystyrene glue can be produced in a pilot unit, which is situated in the Municipality of Kozani in West Macedonia in Greece. This unit has been built for the production of this glue, but because of lack of investing interest, the process of production has stopped.

This product, due to its general use and the low production cost, can become very competitive. It is also a product, which is really possible to replace the traditional white PVAc glue for wood, under circumstances of further research.

Key words

Polystyrene, glue, plastic waste, recycling

1 Introduction

Nowadays waste disposal has become so important that science is trying to find ways of waste reduction and effective waste disposal. Landfills, Incineration units, RDF and Compost units, waste decrease and separation at the source are some of the new methods used in waste treatment (GEORGE TCHOBANOGLOU ET AL.1993, J. SCHIERS 1998, AGR MANSER ET AL 2000).

Plastic waste is a significant proportion of domestic and industrial waste. The directive of European Union (DIRECTIVE 94/62/EU), related to the waste produced by packing pro-

cedures and the Greek legislation (Greek Law 2939/2001) have specified certain targets and deadlines, that require a systematic approach to the problem by all member states, and of course Greece. According to the target set by the directive in question the plastic waste management must include 50-65% recovery, 25-45% recycling, as well as a minimum of 15% recovery of each material used in packaging.

Plastic recovery and recycling is determined by a number of parameters. One significant issue concerns the organizing of the whole procedure, including waste collection, transport and supply. Another point to be taken into consideration is the production of plastic material of certain technical specifications, which presuppose a successful procedure of the recycling of plastic wastes. Moreover, any attempt for plastic recycling is limited by the available techniques, which are not well developed so far (D.PANAGIOTAKOPOULOS 2002). In particular the current technology of plastic recycling focus on mechanical recycling, chemical recycling and energy recovery.

The technology used in this project is related to chemical recycling. It is innovative and leads to the production of glue by dissolving certain types of plastic waste used for packing products. The technology of processing recycled plastic for glue production is based on an innovative idea, for which a Greek patent was issued.

2 Plastic materials in MSW

According to measurements which took place in major Greek cities (D. PANAGIOTAKOPOULOS 2002), plastics are about 7% to 15 % of the total Municipal Solid Waste (MSW). The results of the study appear in the following table.

Table 1 Composition (%) of the Municipal Solid Waste

Component	**Range (%)**	**Typical (%)**
Organic		
Food waste	35.0-60.0	46.0
Paper	15.0-25.0	20.0
Plastics	7.0-15.0	8.5
Textiles, Rubber, Leather, Wood	4.0-8.0	5.0
Yard waste	-	1.5
Inorganic		
Glass	2.5-16.0	4.4
Tin cans, Aluminum	2.8-10.0	5.0
Dirt, ash	2.0-12.0	3.0
Etc.	-	6.5

The plastic materials found in **MSW** fall under the following seven categories.

- Polyethylene terefthalate (PETE/1)
- High-density polyethylene (HDPE/2)
- Polyvinyl chloride (PVC/3)
- Low-density polyethylene (LDPE/4)
- Polypropylene (PP/5)
- Polystyrene (PS/6)
- Other multilayered plastic materials (7)

3 Technical properties of the glue and method of production

During the last few years an innovative technology has been under development in the Municipality of Kozani, a town situated in northern Greece. After long-lasting laboratory testing and evaluation glue of general use is now ready to enter industrial production. This product can face the competition against the established brands in the market.

The production of glue in this way was invented by a carpenter in the Municipality of Kozani due to a casual event. His invention was patented by the Greek Organization of Industrial Property with number 1004906 (INT CL, 2005). The new product can be produced by two categories of plastic, PS and EPS, if a proper solvent is mixed with any of the two plastics in a proportion of 20% and 80% respectively. A further 10% of niter solvent is added to the above mixture in order for the basic substance of the glue to form.

The amount of plastic needed is much less than the amount of the produced glue. According to our measurements 1kgr of recycled plastic can give 3kgr of glue. A pilot unit has been built in the Municipality of Kozani for the production of the glue, but due to financial problems it has never been put into operation. The following flow chart shows the steps to be taken for the mass production of the glue.

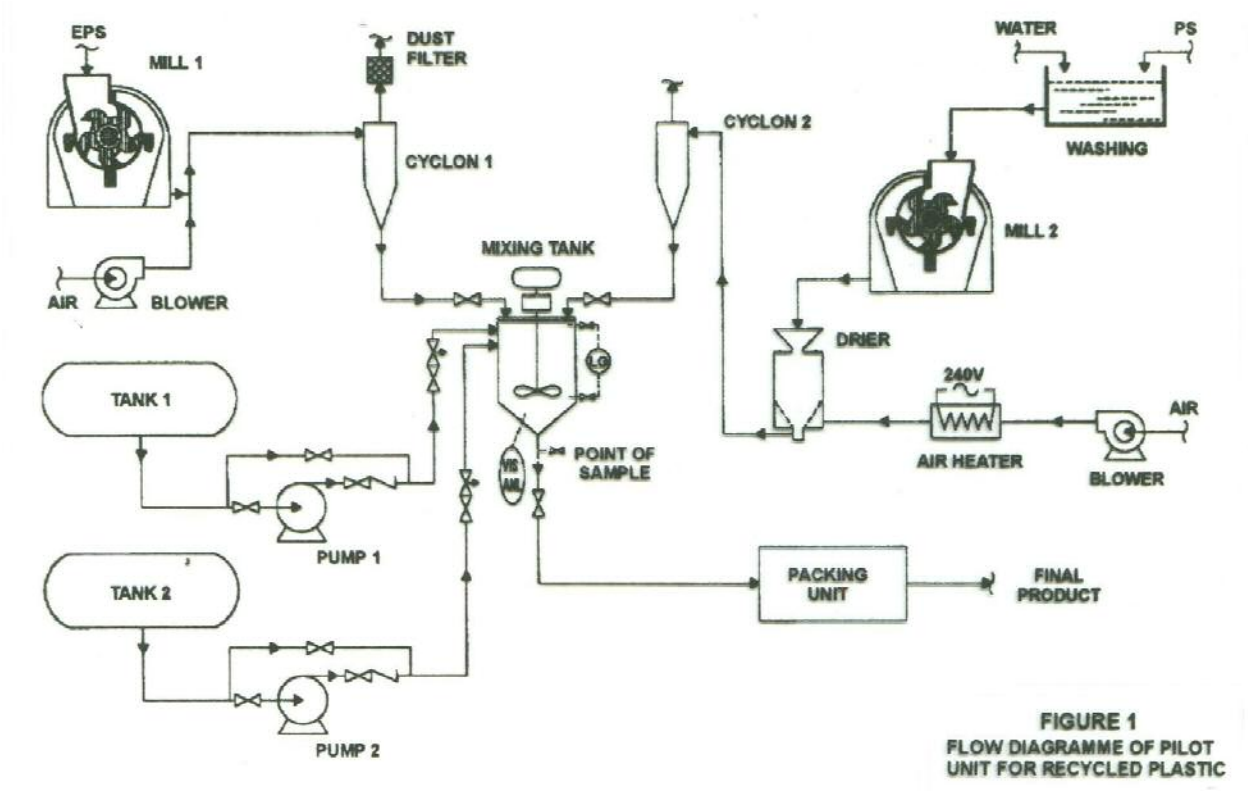

Figure 1 Flow chart of the glue production

One of the main advantages of the method is the fact that the first material, polystyrene PS, is easily found as a packing material, which can be found everywhere, especially in stores of electric and electronic devises. So the cost of the raw material is almost zero and its collection is very cheap (AGR MANSER 2000).

Another advantage of the method is the very good properties of the glue.

The production unit can give thee types of glue, in proportion with the additives, as it is explained in the following paragraphs.

The glue produced with the above mentioned technique is the first type of glue and it can be used for sticking small or big pieces of wood, metal, glass, paper, leather. It is transparent and can be coloured at our desire. Moreover, its kinematic viscosity at 20^{o} C is 1800 mm^2/s. It can also serve as the basic material to produce complex adhesive products.

The glue produced in this way has been tested at the Aristotle University of Thessaloniki (IOANNIS FILIPPOU ET AL, 1999). Its testing has led to the conclusion that it can stick at least four different kinds of wood much better than traditional wood glue found in the market. The following diagram shows the adhesive performance of PVAc and PS glue in pine, oak, mdf1 and mdf2 types of wood.

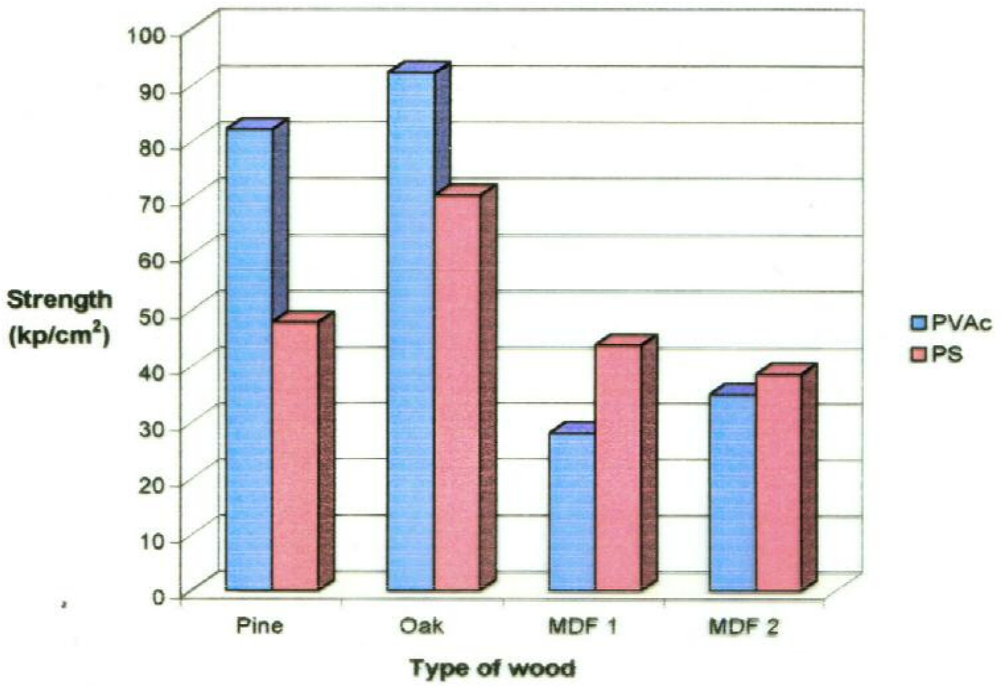

Diagramme 1: Adhesive Performance of product*

Abbildung 2 Adhesive performance of product according to ASTM D905-89 and ASTM D 1037- 72a.

The second type of glue consists of 80% of the first type of glue and 20% of other additives. It is transparent and can be coloured at our desire. Its adhesive performance is exceptionally good in building construction, particularly for indoor and outdoor work. Experiments on the second type of glue showed that it can stick floor or wall tiles, marble, indoor and outdoor wall facing with natural stone. Weather conditions, humidity or low temperature do not affect the adhesive performance of the glue.

The third type of glue consists of 65% of the first type and about 35% of other additives. It is transparent and can be coloured at our desire. It is used as a joint material and can be used to fix any leakages in metal or plastic pipes of hot or cool water, metal or plastic containers of liquids, as well as to stick metal or plastic layers. What is important is that its adhesive performance is not affected by the contact with fuels or other solvents.

Furthermore, the third type of glue can give two kinds of products with the addition of proper substances. The first kind of product is a type of artificial stone, which resembles stone found in nature, and the second one can be used for the production of several small or big items, such as flower pots, etc.

Another application of the third type of glue is the construction of door frames. If wood filings are mixed with the glue in a proportion of 40% and 60% of each product respectively, door frames can be created. The latter are then covered by laminated wood to give the appearance of beautiful interior doors. One of the advantages of this method is that it enables us to save natural resources. This glue can be further used to paint exterior walls by the addition of colouring substances. Walls and parapets painted with this dye presented extremely low water penetration.

The cost analysis of the market price of the product is demonstrated in the figure below (Fig. 3). The profit is 30 %, while the collection cost of the PS plus the production and packing cost come up to 70 %.

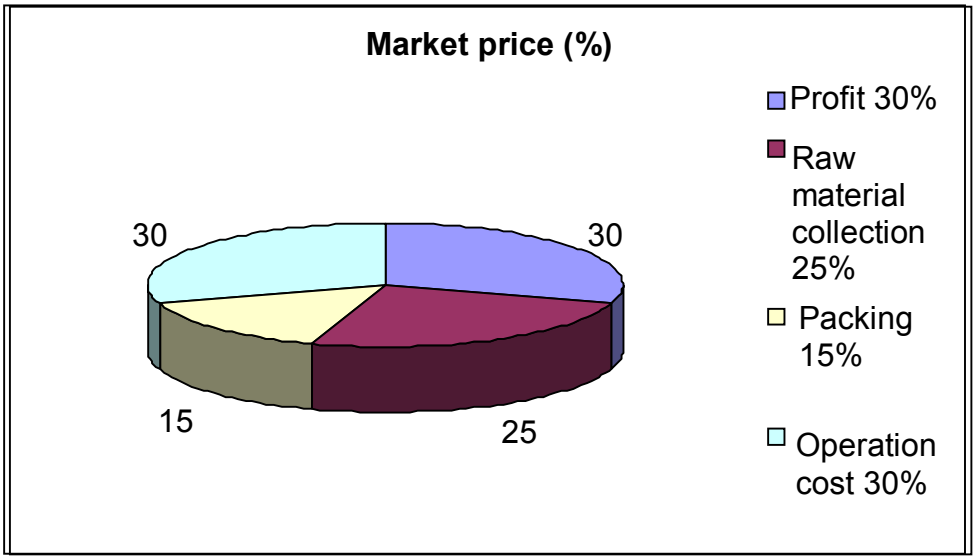

Abbildung 3 Cost analysis of the market price of glue

4 Conclusion

To sum up, plastic waste of polystyrene PS can easily used for the production of three types of glue. The produced glue is transparent with good fluidity and high resistance to dampness and temperature. All types of glue are competitive and profitable compared with the traditional materials already existing in the market.

More over the glue production, using polystyrene PS contributes to:

- the implementation of the targets, set by European Union for plastic recovery and recycling
- the development of existing, yet inefficient techniques, of plastic recycling
- the reduction of the Municipal Solid Waste, which lengthens the age of the landfills

- the saving of natural resources, since it can replaces the use of wood to a certain degree.

Finally it contributes to the protection of environment and public health.

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