УДК 678.046:539.612

V. V. Yatsenko, PhD (Chemistry), assistant professor (BSTU);
O. M. Kasperovich, PhD (Engineering), assistant professor (BSTU);
I. V. Prokopovich, senior researcher (state institution "Scientific and practical center of the state Committee of Forensic Examinations of the Republic of Belarus");
I. Ye. Brokareva, student (BSTU);
E. V. Efimova, student (BSTU)

SPOILAGE AT THE THERMOFORMING OF LAYERED MATERIALS

Steady growth of plastics industry necessitates the disposal of waste products from them. More and more manufacturers seek to include recycled materials and their technological waste in polimers compositions.

Blending polymeric materials commonly used in the preparation of thermoformed articles from sheets of thermoplastics. Thermoforming process is cost effective, as it requires a significant investment in tooling in the manufacture of small batches of parts.

In this study we investigated species discard practical use products, namely bath made by a combination of methods of thermoforming and contact molding coextruded sheets of ABS plastic with polymethylmethacrylate.

Results of the study showed the veracity of the submitted samples assumption that as a raw material in the manufacture of sheets used recycled materials, which led to marriage in the finished product.

Introduction. Nowadays plastics are leading in production scope among raw materials which are used more and more in all branches of economics. More than 150 types of plastics are produced in the world. In perspective increase of plastics production up to 50 mln tons was planned. Such increase in production, processing and use of plastics determines the necessity of utilization of foul products from them. A significant number of means, methods, technologies of plastics reworking to receive products. More and more manufacturers strive to use recyclable materials and their manufacturing waste. With that we should take into account the fact that assortment of products received from recyclable materials is primarily determined by the properties of material and quality of received products.

Contemporary needs of the society have determined the determination of science and industry to produce mixtures of plastics to receive materials with necessary properties. The conformity to the principle of making mixtures and their properties are determined by the influence of a range of factors primarily by materials of the mixture.

Lately the use of thermoforming parts from multilayer fabrics is considered to be perspective for production of products for different purposes: from details of the cabins of automotive, tractor, highway engineering to common bathtubs. Thermal molding is alteration of the form of flat bars (sheets or films) from thermoplastic polymer material at elevated temperatures to volume molded articles.

The process of thermal molding consists of the following stages:

– heating of the moldable material up to the temperature of high-elasticity state;

– mold pressing at custom tooling for thermal molding;

– cooling in the form to the temperature at which configuration of molded product achieves stable sizes;

– removal of the end product from mold.

The thickness of the molded sheets can vary from 0.05 to 15.00 mm [1].

The process of thermal molding is economically profitable as it does not require key investments to the tools during production of small lots of articles. The problem is in special requirements to failure resistance, blow stress of the molded part. The operating conditions, aesthetic requirements to the product determine use of coextruded ABS plastic with poly methyl methacrylate (PMMA). ABS plastic has the necessary impact resistance capability and the layer of PMMA prevents from ageing under UV-light exposure and adds specular «gloss» to the surface [2].

Main part. In this work types of failure of common use products, namely acrylic bathtubs made by combining methods of thermal molding and contact molding from sheets with the width of 3.4 mm.

The samples for tensile strength tests, tensile strain were triplex sheets consisting of PMMA layers, ABS-plastic and polyester pitch filled with fiberglass from different manufacturers. However, a significant disadvantage during the processing of the material is irregularity in the distribution of temperature patterns during heating of the sheet of plastic in connection with composite preparation of processed material and consequent uneven drafting in different parts of the end product.

The samples were cut out of molded products in three different parts under different drafting, in the result specimen 1.1, 1.2, 1.3 – from the first sample and 2.1, 2.2, 2.3 – from the second sample, also they were tested for breaking strength, tensile strain at extension and routinely solubility: Table 1, Table 2.

Table 1

General characteristics of the material

Sample	Total thickness	Layer ABS, mm	Layer PMMA, mm	The layer of polyester pitch, mm
No. 1 is the sheet from the manufacturer 1	5	3	1	1
No. 2 is the sheet from the manufacturer 2	4	1.1	0.15	2.75
No. 3 is the sheet from the manufacturer 3	4.15	3.8	0.35	–

Table 2

The tensile strength for different samples of acrylic baths

Sample	Relative elongation, %	Tensile strength, MPa	The observed result
1.1	15	68.2	Exploded
1.2	5.6	42.8	Exploded
1.3	9.2	66.1	Exploded
2.1	6.5	11.1	Exploded
2.2	8.6	13.6	Exploded
2.3	7.5	9.5	Exploded

Analysis of physical and strength properties of the tested samples has shown their significant difference for materials made by different manufacturers. It can be connected with use of recyclable materials as part of sheet material components. To prove that speculation material solvent fastness was tested. The tests of the materials have shown different solvent fastness at room temperature and at boiling temperature of solvents. The results of the tests can be seen at Table 3.

Expansion and solution of ABS-plastic in thinners proves the speculation that as raw material for sheets from the second and the third manufacturers raw material containing recycled material was used. It is widely known that during production of regranulate ingress of different streaks is possible, in particular, streaks of other polymers, which solvent fastness is determined by material response during swelling [3].

To determine the presence of recyclable materials and polymer streaks in ABS-plastic infra-red spectrums (IRS) of swollen and dry samples were taken.

Table 3

The solubility of ABS plastic samples

Sampe number	Xylene	Acetone	Toluene
1	Didn't dissolve	Didn't dissolve	Didn't dissolve
2	Dissolved	Swelled	Swelled
3	Didn't dissolve	Dissolved	Swelled

The samples were chosen with the help of microscalpel and microscopic needle in field of microscopic vision and put at the window of diamond cuvette. The spectrums were measured at infrared Fourier-transform spectrophotometer VERTEX 70 by BRUKER with attachment for diamond cuvette by Pike with resolution of 4 cm^{-1} after averaging of cumulated spectrogram containing 32 scans. The spectrums were recorded within the range of 4000–400 cm^{-1} with use of RT-DLaTGS-detector. Fig. 1 and Fig. 2.

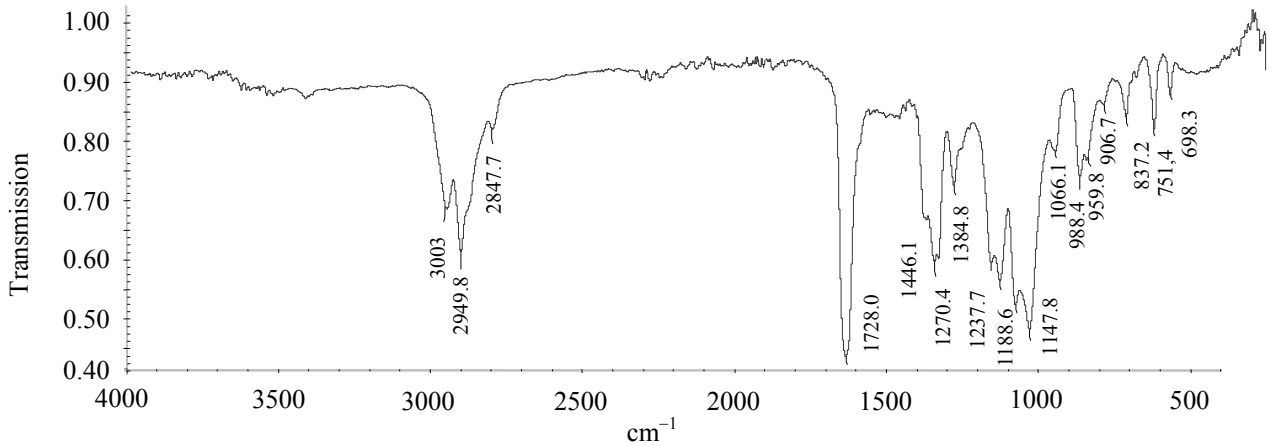

Fig. 1. IRS of swollen in acetone part of sample No. 2 of molded sheet of ABS-plastic

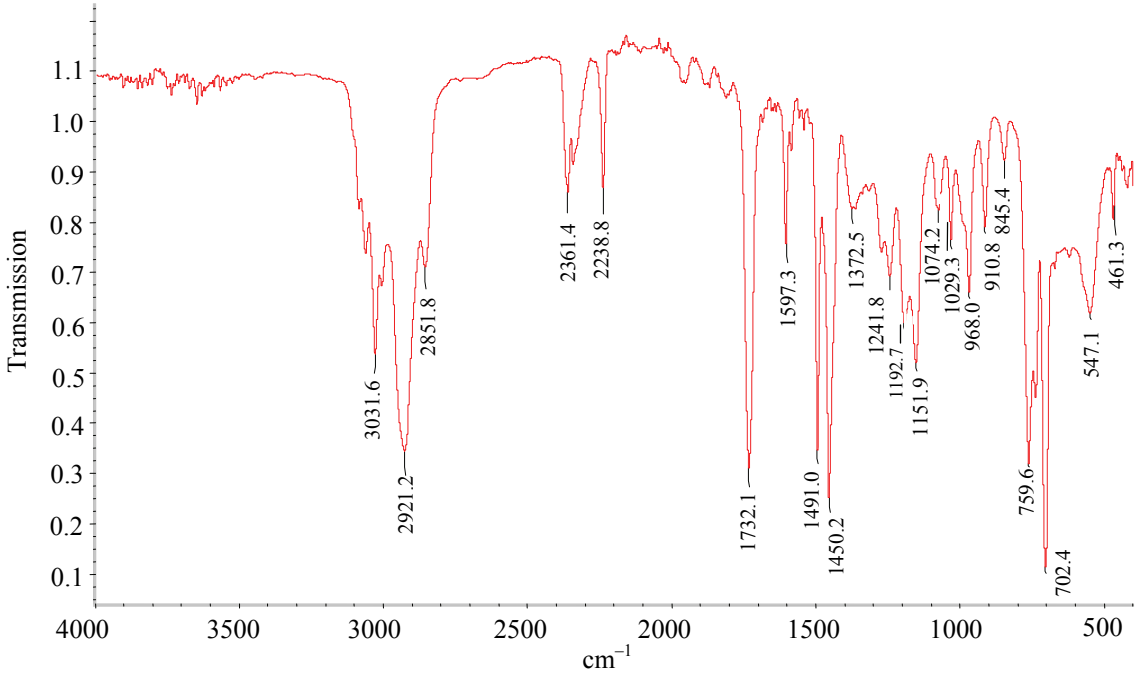

Fig. 2. IRS of swollen in toluene part of sample No. 2 of molded sheet of ABS-plastic

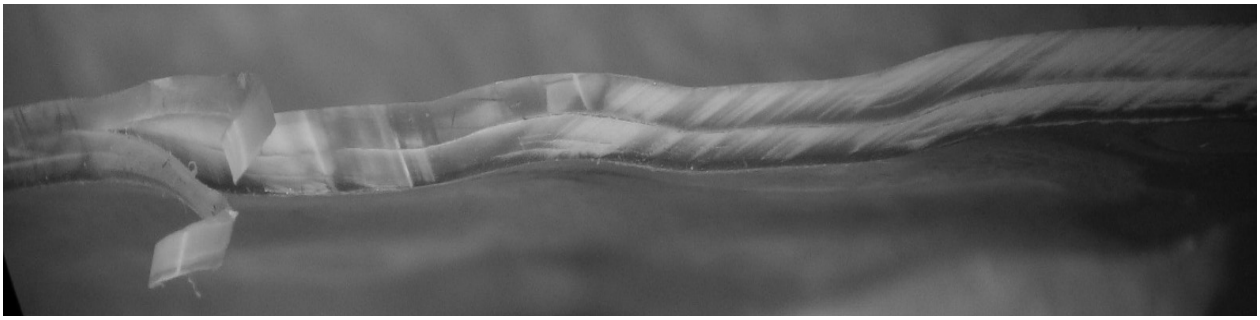

Fig. 3. Sectional view of the defect in polymer layer from which drip cups were made, in field of view of microscope МСП-2 (magnification to 54x)

Appearance of absorption bands in the region 2238 and 2361 cm^{-1} indicates that ABS-plastic of different manufacturers contains foreign inclusions, has different composition, which has a great influence on its performance properties.

Introduction of recycled material is proved by Figure 3 where breaking of the sheet is clearly visible. Such character of material distribution in the product shows that the molded material is a mixture of incompatible materials with clear bedding interface [3]. It is possible at poor mixture and distributions of the mixture materials during extrusion compression molding, at different polarity and nature of polymers.

Conclusion. In the result of the tests different character of destruction and dissolution in provided samples was established, which was caused not only by structure of the material under test, but also by crosswise direction and drafting rating of the sample. It is obvious that the use of recycled materials in the content leads to receiving defective end products.

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Received 22.04.2014