A method for producing adsorption materials from thermoplastic waste

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SUMMARY

The compositions of polymer composites produced from thermoplastic waste (polyethylene and polyethylene terephthalate), heat-expanded graphite (HEG), and blowing agent were developed for the creation of adsorption materials. The adsorption and physicomechanical properties (abrasion, grindability, density, porosity, specific surface) were investigated.

One of the most tangible results of human activity is the formation of waste, among which plastic waste occupies a special place by virtue of its unique properties. The annual contribution of Russia to the formation of plastic waste is 1 million t, which, however, is suitable for processing and can be used as recycled polymer resources. The problem of recycling plastic waste is therefore most pressing, but the problem of purifying industrial wastewaters is also fairly acute [1].

The most widely used methods for purifying wastewaters are sorption methods. The simplicity of implementation, the lower energy requirement, and the high effectiveness of the technologies make them attractive. But they are expensive processes because of the costly adsorption materials.

The aim of the present work was to search for new ways to use plastic waste, with the production of products of value to the national economy, and to create new composite adsorption materials noted for high effectiveness in the purification of wastewaters and low cost.

From this point of view, the use of polyethylene terephthalate (PETP) and polyethylene (PE) waste in the creation of new sorption materials for the purification of wastewaters, with high effectiveness and at low cost, is very promising, as the materials are readily available, are easily processed, can be modified by filling, and have a good combination of physicochemical properties [1]. Thermoplastic waste can be processed by traditional methods – injection moulding, pressing, blow-moulding, extrusion, and so on [1, 2].

Heat-expanded graphite (HEG) was used as filler. HEG is a new-generation material and possesses all the positive qualities of graphite (chemical inertia, hydrophobicity, a large specific surface, resistance to corrosive media). The use of carbon sorbents as catalysts and absorbents for the purification of drinking and wastewater has been known for a long time [3]. In industry, wide use is made of active carbons, graphene sorbent, fullerences, and carbon fibres (viscum, busofit, perlite, etc.).

The sharp increase in polymer material prices has prompted manufacturers of products to search for ways to lower the expenditure on materials for products. The optimum solution is to create a microcellular structure of polymer materials. The possibility of using foamed polymer and fibre materials as sorbents for the purification of water and air, the sorption of petroleum products, and the extraction of heavy metals and other valuable components is well known [3]. Porous polymer materials have become competitors to traditional filter materials such as ceramics and metal ceramics, filter fabrics, papers, etc. This is due to a number of advantages that are inherent in porous polymer materials: cheapness (by comparison with ceramics and metal ceramics), the possibility of achieving higher productivity, and the
possibility of sufficiently accurate control of pore size. Furthermore, polymer filters can be moulded, giving them practically any shape. The development of various methods for producing porous polymer materials based on a wide range of polymers and the presence in them of a combination of valuable properties determine the wide application of polymer filters in industry, in water preparation and water purification systems, and in the medical and microbiological industry [4].

The foaming of such plastics as polystyrene (PS) and polyurethane (PU) has long been used and is fairly common [1, 4]. The foaming of PETP and PE, however, is extremely difficult and is used extremely rarely.

A promising method for producing porous materials is foaming using special chemical additives introduced into the polymer – blowing agents [1, 4]. Blowing agents are chemical compounds that break down when heated, emitting CO₂ gas which foams the polymer.

The materials selected for investigation in the production of adsorbents were recycled polyethylene (RPE), recycled polyethylene terephthalate (RPETP), and foaming agents Hydrocerol CF 40E and Hydrocerol VM 70; heat-expanded graphite (HEG) was used as the filler.

The optimum compositions and process parameters for the foaming of RPE and RPETP were determined. A foamed composite was prepared by simple mechanical stirring of components with subsequent injection moulding at temperatures of 160–190°C for RPE and 240–270°C for RPETP. The blowing agents were introduced in a quantity of 0.5–2.0 wt% (Table 1) [4].

The adsorption composite material was manufactured with the addition of HEG waste in a concentration of 10 wt%.

The obtained specimens have a porous structure perceptible to the naked eye (Figure 1) and a lower density.

Table 1. The composition and physical properties of the composites

<table>
<thead>
<tr>
<th>No.</th>
<th>Composition of composite</th>
<th>Ratio of components (parts)</th>
<th>Density (g/cm³)</th>
<th>Porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 g of RPETP + 0.05 g of CF 40E</td>
<td>100:0.5</td>
<td>1.2</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>10 g of RPETP + 0.1 g of CF 40E</td>
<td>100:1.0</td>
<td>1.0</td>
<td>18.7</td>
</tr>
<tr>
<td>3</td>
<td>10 g of RPETP + 0.15 g of CF 40E</td>
<td>100:1.5</td>
<td>0.9</td>
<td>26.8</td>
</tr>
<tr>
<td>4</td>
<td>10 g of RPETP + 0.2 g of CF 40E</td>
<td>100:2.0</td>
<td>0.8</td>
<td>34.8</td>
</tr>
<tr>
<td>5</td>
<td>10 g of PETP + 0.2 g of CF 40E</td>
<td>100:2.0</td>
<td>0.9</td>
<td>31.0</td>
</tr>
</tbody>
</table>

The obtained composite material was ground mechanically to a grain size of ~2 mm (Figure 2), and its physicomechanical properties (density, bulk density, pore volume, specific surface, abrasion, grindability, absorbed moisture) were investigated (Table 2).

As can be seen from the results of the investigation, composites 1 and 2 possess strength properties (abrasion,
grindability) that adequately meet the requirements for absorption materials. An adsorbent produced by the given technology has a bulk density comparable with that of activated carbon (0.46–0.53 g/cm³).

IR spectroscopy showed that in the composite RPETP + 10 HEG + 2 CF 40E there are active groups –OH and –C=O in the ester group. In this case, it is possible to speak not only of physical but also of chemical adsorption of substances. The effectiveness with which water is purified by the given adsorbent was assessed on model solutions of phenol and copper. The effectiveness of purification with respect to phenol was 52%, and with respect to copper 64%.

As a result of the work conducted, composite adsorbents have been created for the purification of wash and wastewaters, and the process parameters for their production have been selected: moulding temperature of composites 260°C. Here, the optimum composition of the composites is as follows (wt%): RPETP + 10 HEG + 2 CF 40E and RPE + 10 HEG + 2 VM 70. It has been shown that the obtained materials are mechanically strong and possess low bulk density and good porosity, which enables them to be recommended as adsorption materials.

**REFERENCES**
