MATERIALS SCIENCE

SORPTION OF SYNTHETIC SURFACTANTS BY “POLICON” MATERIALS

M. M. Kardash, N. B. Fedorchenko, A. V. Pavlov, A. I. Shkabara, M. E. Yas’ko, and O. V. Nikiforova

The effect of the initial concentration of synthetic surfactant (SSF) in wastewaters on sorption was investigated, and Policon materials were recommended for use in the tertiary treatment stage where the concentration of SSF does not exceed 0.8 mg/dm$^3$. It was noted that increasing the temperature of the effluents by 60° allows significantly extending the period of steady-state flow of the process and the depth of treatment remains high. The selectivity of Policon materials with respect to the SSF contained in synthetic detergents was investigated. The high efficiency of the materials in ultrafiltration of the components of synthetic detergents was demonstrated.

Human industrial activity has led to important worsening of the environmental situation as a result of pollution of air (by gaseous emissions) and water (by products contained in wastewaters from plants). The problem of treating water to remove many organic substances such as synthetic surfactants (SSF), phenols, and aromatic compounds that perturb the natural balance of waters occupies one of the highest positions.

SSF are an extensive group of compounds that differ in structure and chemical nature. These substances can be adsorbed on the phase interface and reduce the surface tension of water. The structures of SSF entering bodies of water do not change for a long time and significantly affect their physico-biological status by worsening the oxygen regime and organoleptic properties of water. This has led to severe standards for the residual SSF content in open bodies of water: as a function of the environmental pressure on the region, they vary from 0.1 to 5 mg/dm$^3$.

The technology for treating wastewaters to remove SSF is oriented toward exhaustive extraction or decontamination of these substances. The analysis of current water treatment methods shows that coagulation, precipitation, biological, and physicochemical methods are most frequently used. The most exhaustive degree of treatment is attained with ion-exchange materials, but in this case it is either necessary to use a multistage treatment system or preliminary treatment with other methods [1, 2].

One approach to the successful solution of the problem of removing SSF from wastewaters is to create new, highly effective materials. A new class of chemisorbents manufactured with reduced-stage technology by polycondensation filling was developed in the Department of Chemical Engineering at the Engels Institute; they have stable physicomechanical and sorption properties in preliminary preparation and treatment of aqueous media. Studies were conducted in [3] on removal of SSF from industrial wastewaters from production of synthetic detergents (SD) which simultaneously contained other polluting ingredients — sulfates, phosphates, ammonium nitrate compounds, and petroleum products. It was noted that removal of SSF in low concentrations is the most complicated in such media.

The quality of wastewater treatment is a function of both the conditions of conducting the treatment (rate of passage, qualitative and quantitative composition of the effluents, temperature conditions of the sorption process) and the performance characteristics of the chemisorbents. The permeability is an important property of chemisorbents; it is a function of the volume of meso- and macropores, which play the role of transport channels. A complex, multifunctional system of poly structures


Fig. 1. Kinetics of sorption of SSF \((C = 1.36 \text{ mg/dm}^3)\) at 20 (1) and 80°C (2) by Policon K (a) and Policon A (b) materials.

Fig. 2. Effect of the structure of unmodified (a) and modified (b) Policon K material on the efficacy of treatment of wastewaters to remove SSF \((C = 0.8 \text{ mg/dm}^3)\) at 20 (1) and 80°C (2).

**TABLE 1. Characteristics of Chemisorption Filter Materials**

<table>
<thead>
<tr>
<th>Material*</th>
<th>Polymer matrix</th>
<th>Functional groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policon A</td>
<td>Epoxy-4,4-isopropylidenediphenol</td>
<td>=NH, ≡N</td>
</tr>
<tr>
<td>Policon K</td>
<td>Phenol sulfo cation-exchanger</td>
<td>−SO₃H, −OH, −COOH</td>
</tr>
<tr>
<td>Policon Km</td>
<td>Modified sulfo cation-exchanger</td>
<td>−SO₃H, −OH, −COOH, ≡NH, ≡N</td>
</tr>
<tr>
<td>Policon Am</td>
<td>Modified Epoxy-4,4-isopropylidenediphenol</td>
<td>Same</td>
</tr>
<tr>
<td>Policon A; Policon K**</td>
<td>Epoxy-4,4-isopropylidenediphenol–Phenol sulfo cation-exchanger</td>
<td>“”</td>
</tr>
<tr>
<td>Policon Am; Policon Km**</td>
<td>Modified Epoxy-4,4-isopropylidenediphenol–Modified sulfo cation-exchanger</td>
<td>“”</td>
</tr>
</tbody>
</table>

*Fibre base — copolymeric polyacrylonitrile tow.
**Laminar arrangement of Policon A and Policon K materials in the filter at a ratio of 7:3 pts. by wt.

located on different supramolecular levels is formed in Policon materials, and the permeability of the polymer skeleton can be regulated by different methods of modification.

The accessibility of the functional groups can be increased by fabricating material with longer crosslinks in the skeleton of the ion-exchange matrix by incorporating an additive to the monomerization composition in the stage of synthesis of the anion exchanger (with which the fibre filler was subsequently impregnated) [4] or by creating a highly porous material [5], since increasing the meso- and macropores, which play the role of transport channels in the material, will increase the rate of sorption processes.

Experimental lots of Policon materials were prepared by previously developed technology [6]. After conducting the process, the conditioned materials were ground to a particle size of 3-5 mm and placed in sorption modules with an inner diameter of 0.014 m (for a diameter:height ratio of 1:9). The experimental studies were parallelly conducted on different chemisorbent compositions (Table 1) at atmospheric pressure of 0.1 MPa, fixed water temperature of 20-80°C, and passage rate of 1.5 liter/h. The initial concentration of SSF in the treated water was 1.36 mg/dm³.

Sorption was evaluated by the residual SSF content in the treated effluents by the fluorimetric method on a Fluorat-02 liquid analyzer. The processed experimental data are presented in the form of sorption curves in Fig. 1. The curves for both the