International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 13, Number 11 (2020), pp. 3555-3558
 https://dx.doi.org/10.37624/IJERT/13.11.2020.3555-3558

# Modification of Microfiltration Membranes with Ultraviolet Radiation to Separate Oil-In-Water Emulsions

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**Abstract**

Oil traps and sedimentation tanks are used to treat emulsified wastewater containing oil products. Their disadvantages are the duration of the process, insufficient degree of purification. Poorly treated wastewater is subjected to repeated dilution, or stored for a long time in tanks, after which it enters water bodies, which leads to degradation of biocenoses. Based on the foregoing, it is relevant to use high-performance and low-energy technologies, one of such methods for wastewater treatment is membrane methods. To increase the efficiency of the process of microfiltration of the emulsion, a membrane of cellulose acetate, PTFE and hydrophilic PTFE was treated with UV radiation. As a result, a decrease in the initial mass of the membrane, an increase in the specific productivity with a slight decrease in the delaying ability was revealed. A 1.5-fold increase in specific productivity was established for a water-oil emulsion. The retention capacity of the membrane after processing for petroleum products decreased by 8.6%. The retention capacity of membranes with a hydrophobic surface, on the contrary, increases. The calculations determined that after the PTFE membrane treatment, the degree of NP removal from the model oil emulsion increased by 15.2%. The treatment of membranes with UV radiation leads to an increase in the specific productivity of the membranes with a slight decrease in the retention ability for hydrophilic membranes, and leads to an increase in the retention ability of a hydrophobic PTFE membrane.

**Keywords:** Water-Oil Emulsion, Oil Products, Microfiltration, Membranes, Cellulose Acetate, Polytetrafluoroethylene, Ultraviolet Radiation.

## I. INTRODUCTION

The most important problem for the protection of water bodies is the pollution of wastewater with oil products. Oil refined products, as well as crude oil, which are so widely used in industry and the national economy, getting into atmospheric, industrial and domestic wastewater, enter natural objects, thereby disrupting the course of natural biochemical processes. This causes the degradation of rivers, lakes, seas, groundwater, and also reduces soil fertility. The oil content is standardized for all types of water,

Oil traps and sedimentation tanks are used to treat emulsified wastewater containing oil products. Their disadvantages are the duration of the process, insufficient degree of purification. Poorly treated wastewater is subjected to repeated dilution, or stored for a long time in tanks, after which it enters water bodies, which leads to degradation of biocenoses. Based on the foregoing, it is relevant to use high-performance and low-energy technologies, one of such methods for wastewater treatment is membrane methods. In membrane separation processes, the characteristics of the liquid separation process deteriorate over time, a layer of poorly soluble salts (reverse osmosis), gel (ultrafiltration, microfiltration) form on the membrane surface - this phenomenon is called concentration polarization. As a result, equipment shutdown and membrane washing with appropriate cleaning solutions are required, in the worst case membrane replacement. In this regard, it is advisable to modify the membranes, in particular, they treat the surface of the membranes with low-temperature plasma [1], microwave radiation [2,3], ultraviolet (UV) radiation [4] and chemical reagents [5-7].

Often, surface treatment with UV radiation is performed to change the surface properties and performance of the membranes. In [8], two different methods were used for the photochemical modification of a polyetherosulfone membrane to increase surface wettability and reduce adsorption contamination. The filtration efficiency of the modified membranes was compared with the characteristics of a commercially available polyetherosulfone membrane and a regenerated cellulose membrane. Modification by UV radiation made it possible to obtain membranes with practically the same wettability as that of a regenerated cellulose membrane; the wettability increased by 30% compared to the original polyethersulfone membrane. Also, a significant decrease in irreversible adsorption contamination was found in the modified membrane, which led to a constant decrease in the filtrate flow; to the original buffer stream using any modification.

In [9], the authors investigated a method for increasing the hydrophilicity of a polyethylene terephthalate film by exposure to ultraviolet radiation with a power of 1000 W for a total of 30–40 min. After modification, the contact angle with water of the modified film was reduced to 0, and the degree of water absorption of the modified film was increased from 85% to 104%. The mechanical and physical properties of the modified film after treatment with ultraviolet radiation did not deteriorate. According to the results of scanning electron microscopy, it was found that the surface of the modified film became rough and polymer particles appeared. Infrared Fourier spectroscopy showed that particles on the surface of the modified films probably include COOH and OH groups. X-ray diffraction results showed the formation of crystalline material. Finally, differential scanning calorimetry thermograms showed that the modification process improved the thermal stability of polyethylene terephthalate.

Certainly, knowledge of the basic principles of membrane clogging mechanisms leads to effective measures to prevent congestion becomes premature. As mentioned before, the phenomenon of membrane clogging in all membrane systems occur; But effective and timely repairs and cleanings are desirable guarantees the system during operation. Food preparation system simultaneously with the design. The main unit is refined and designed in accordance with it. What process to use for preparation .It depends a lot on the characteristics and nature of the feed. Despite the specification and analysis. The variety that takes place on the feed, however, is the design of the unit based on the information obtained from pilot experiments. As a general rule, suspended particles, ferrous compounds and other particles that have the ability to form they have a dense gel layer on the membrane, should be removed before contact with the membrane and in the preparation stage. In some cases, compounds such as chlorine may be used to reduce the microbial load of the feed.

Add ozone and peroxides to the feed solution. These compounds are in the pre-preparation stage and before membrane contact must be removed. Otherwise irreparable damage to the membrane will bring.

To inoculate dimethylaminoethyl methacrylate into a membrane from a styrene-butadiene-styrene triblock copolymer (SBS), the authors of [11] used ultraviolet radiation as an initiator of polymerization. It was found that the degree of vaccination depends on the exposure time, dimethylaminoethyl methacrylate concentration and temperature. The authors found that with an increase in the processing time, the moisture capacity of the membrane increased, as in previous works.

As a result of exposure to ultraviolet radiation, according to the authors' research, the roughness of polymer membranes increases, the moisture capacity and the wetting angle increase, at which the mechanical strength of the film does not deteriorate. An increase in the degree of crystallinity of the polymer and the formation on the surface of new compounds including COOH and OH groups were also established. In some works, ultraviolet radiation has found application as a polymerization initiator.

Due to the fact that ultraviolet radiation increases the wettability of the membrane surface, which in turn increases the permeability, this method was used to modify microfiltration membranes designed to separate oil-in-water emulsions. The purpose of the work is to intensify the process of separation of water-oil emulsion by treating microfiltration membranes with ultraviolet radiation.

## II. METHODS

To increase the productivity and degree of separation of oil emulsions, we modified the thin-film microfiltration membranes from polytetrafluoroethylene (PTFE) with UV radiation using a laboratory setup in atmospheric air. As an initial membrane for modification, we used a microfiltration polymer membrane with a diameter of 47 mm made of PTFE of the Phenex AF0-0514 brand manufactured by Phenomenex with an average pore size of 0.45 μm, a microfiltered composite membrane made of PTFE with a hydrophilic surface of the MFK-3G brand manufactured AO Vladipor, with a pore size of 0.45 μm and a microfiltration thin-film polymer membrane with a diameter of 47 mm from cellulose acetate with an average pore size of 0.2 μm, manufactured by AO Vladipor. The processing time for UV radiation ranged from 1 to 30 minutes, in the wavelength range of 280-320 nm and with a UV radiation power of 36 watts.

To establish the effect of UV radiation on the membranes, we measured the mass of the membranes before and after processing with UV radiation using an analytical balance of the CAUW-220D brand.

The moisture capacity of the membranes was determined by wetting the membrane with distilled water and the content of the mass fraction of moisture in% was determined using an AND ML-50 moisture meter. The principle of thermogravimetric analysis is implemented in the ML-50 moisture analyzer, in which the sample is dried using a halogen lamp and the moisture content (in%) is determined, as well as other values calculated on the basis of the difference between wet and dry weight.

The main parameters of membrane separation were installed on a laboratory membrane installation. For separation, a 3 % model oil-in-water emulsion was prepared. The emulsion was prepared from distilled water and industrial oil of the I-20 brand by dispersing using a laboratory mixing device at a speed of 2500 rpm, sodium dodecyl sulfate was used as a surfactant. The concentration of oil products in the initial model emulsion was more than 32 g / $dm^3$. In the process of membrane separation of the emulsion, the following parameters were established: operating pressure 0.3-0.35 MPa, emulsion temperature 23 ° C, emulsion salinity 96 mg / $dm^3$, pH 7.2 pH.

The oil content in the model emulsion and in the filtrates was determined by IR spectrometry using a KN-3 concentrator. The principle of operation of the device is based on a photometer measuring the optical densities of a solution of oil products, fats and nonionic surfactants in carbon tetrachloride in the infrared region of the spectrum. The concentration of oil products in the emulsion was measured in a two-wave mode. In the first (measuring) channel, a spectral radiation section of 2930 ± 70 $cm^{-1}$ is used. In the second channel, a spectral region of 3333 ± 70 $cm^{-1}$ is used, in which oil products do not absorb infrared radiation.