Selective nanoparticle layer for ceramic membranes

Romaniuk O.R., Kyrii S.O., Dontsova T. A., Yanushevska O.I.

Department of Technology of Inorganic Substances, Water Purification and General Chemical Technology, Faculty of Chemical Technology
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine. E-mail: kysvit@gmail.com

Introduction. Ceramic membranes are highly regarded for their exceptional qualities, including resistance to high temperatures, chemical substances, and long-lasting durability [1] and highly desirable for implementation in a wide range of industrial processes.

To increase selectivity and filtration efficiency of ceramic membranes a layer of nanoparticles can be incorporated on their surface: titanium oxide (TiO_2), zirconium oxide (ZrO_2), aluminium oxide (Al_2O_3), and others [2,3]. The presence of this layer can enhance the filtration properties of the membrane by enabling the selective permeation of specific substances while effectively retaining contaminants.

The aim of the study is to synthesise a selective layer based on titanium (IV) oxide for use as a selective layer of a ceramic membrane in the water treatment process.

Methods. The hydrothermal synthesis method was used to obtain TiO_2 samples: isopropyl alcohol and titanium isopropoxide were added to a stirred reactor. With constant stirring for 15 min, 1 mL of distilled water was added to the reactor dropwise. The formation of a white suspension was observed. After stirring, the suspension was placed in a Teflon reactor, then reactor was placed in an oven for 12 h at 170 °C to synthesise TiO_2. The resulting samples were dried at 80 °C for further studies.

Results and discussion. TiO_2 was applied using two methods: spin-coating and dip-coating. After that, the coated substrates were dried at ambient temperature for 24 hours, followed by a calcination step at 800 °C for 3 hours.

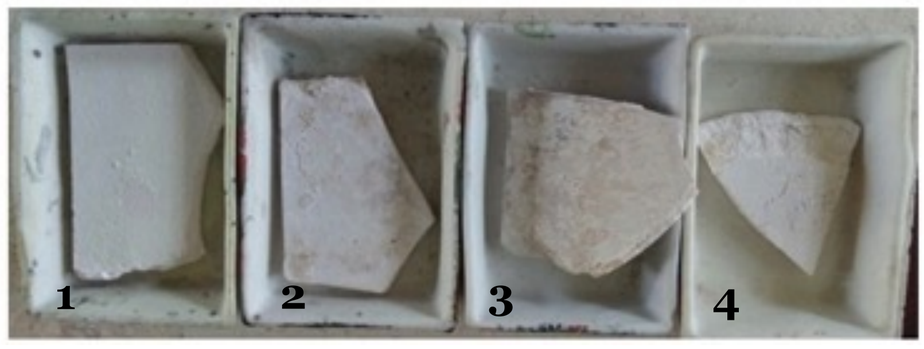

Fig. 1. Membranes coated with a layer of suspension TiO_2 after calcination at different temperatures: 1 – 300 ˚C; 2 – 400 ˚C; 3 – 500 ˚C; 4 – 600 ˚C

The morphology and thickness of the selective layer was determined using the SEM method of the lateral end of the membrane chips.

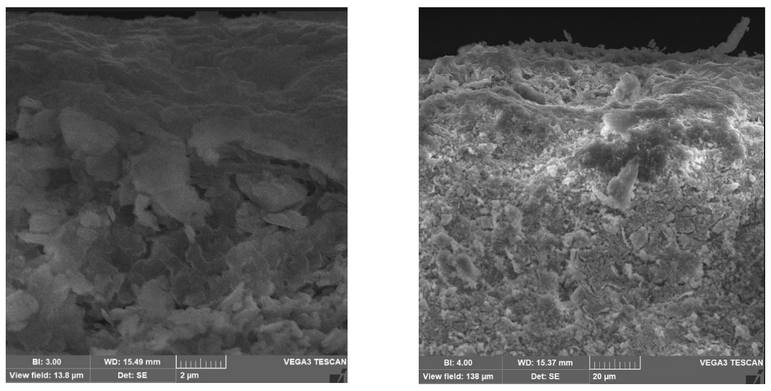

Fig. 2. Microphotographs of the surface of the selective layer on the side chip of the membrane sample, which was coated with TiO_2 suspension by spin-coating method

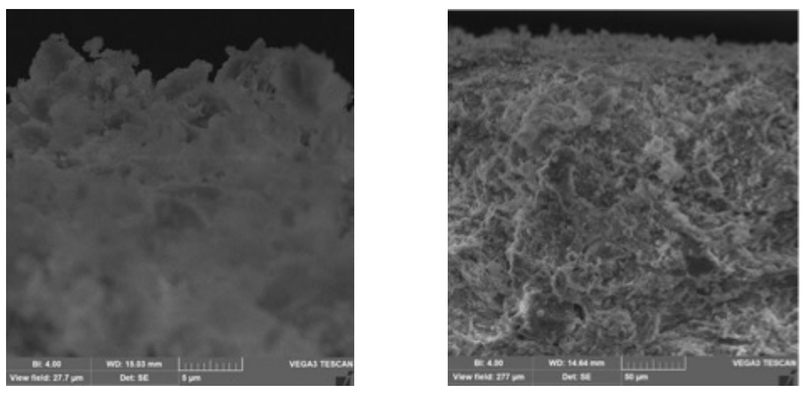

Fig. 3. Microphotographs of the selective layer surface on the side chip of the membrane sample, which was applied with TiO_2 suspension by dip-coating method

The samples were synthesised by **spin-coating** method (Fig.2): the prepared suspension was applied within 30 s at a substrate rotation speed of 1000 rpm, and then the samples were calcined at 500 °C for 2 hours.

The **dip-coating** method (Fig.3): the substrate is dipped into the solution at a certain speed, held in the solution in a stationary state and removed at a constant speed.

SEM images show the morphology of the applied selective layer, which is typical for ultrafiltration and microfiltration membranes.

The micrographs demonstrate the heterogeneity of the substrates and the top layer, as well as the difference in the thickness of the selective layer.

Conclusions. It was found that the spin-coating method allows for a thinner coating layer, but, like the dip-coating method, does not provide a uniform membrane surface.

References

1. Dontsova T., Kutuzova A., Bila K., Kyrii S., Kosogina I., Nechyporuk D. Enhanced Photocatalytic Activity of TiO2/SnO2 Binary Nanocomposites // Journal of Nanomaterials.-2020.-2020.-P. 1-13.
2. Serhiienko A., Dontsova T., Yanushevska O., Nahirniak S., Hosseini-Bandegharaei A. Ceramic membranes: new trends and prospects (short review) // Water and water purification technologies. Scientific and technical news.-2020.-2(27).-P. 4-31.