COMPARISION OF THE SELECTED NANOMATERIALS USABLE DURING THE TREATMENT AND PURIFICATION OF WATER

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Abstract

Water pollution encourages the development of innovative treatments of wastewater which we can reuse. The aim of this study was to compare the filtration ability of selected nanomaterials for water clarifying and treatment. Commercially used microfiltration materials SPURTEX from SPUR a.s. Zlín were compared to each other.

Escherichia coli CCM 7929 was selected for the representation of microbiological contamination. This bacterium is an important indicator of faecal contamination and its occurrence in water is strictly monitored. The spreading of this bacterium in a human being is the cause of a range of digestive and urogynecological illnesses.

100 ml of contaminated water was filtrated at a pressure of 0,5 bar through a filtration device, which is made from anticorrosive steel and was sterilised before the experiment. For every sample, parameters of filtration were determined (filtration time, amount of bacteria before and after filtration, efficiency of filtration, etc.). In the samples, *Escherichia coli* on VRBL agar (Biokar Diagnostics, France) was determined using the plate cultivation method during 24 h at a temperature of 37 ˚C.

The conclusions of this study can show how to reuse wastewater with this filtration method which is relatively fast, effective and financially advantageous.

Keywords: nanomaterials, filtration, *Escherichia coli*

1. INTRODUCTION

According to World Healthy Organization 2014 [1] an estimated 748 million men, women and children lack access to an improved source of drinking water, billions of people lack access to safe water that is reliably and continuously delivered in sufficient quantities, some 2.5 billion people live without basic sanitation facilities and hundreds of millions of people do not have soap and clean water to wash their bodies and perform simple practices that prevent the spread of diarrhoeal and respiratory illnesses. Water is both the most abundant and the most important substance which nature provides to sustain life for plants and animals. Its availability is limited while its overall demand per capital has increased considerably due to population explosion and the increasing sophistication of people [2]. That is why, people have to develop new ways of water cleaning. Membrane processes are very important during water treatment. Even when these procedures are done properly, they can reduce the number of microorganisms by a maximum of one or two orders of magnitude. Membrane processes usable during water treatment include microfiltrations, ultrafiltrations, nanofiltrations and reverse osmosis [3] [4]. Particles of TiO_2 have attracted attention because TiO_2 is a promising material for various applications including photoelectrochemical activity, solar energy conversion, photocatalysis and as a biologically compatible material. Recently it has been demonstrated that metal oxide nanoparticles exhibit excellent biocidal and biostatic action against gram-positive and gram-negative bacteria [5]. It has been suggested that nanostructured TiO2 on UV irradiation can be used as an effective way to reduce the disinfection time, eliminating pathogenic microorganisms in food contact surfaces and enhance food safety .The bactericidal effect of TiO_2 has been reported on pathogenic bacteria in food, such as *Salmonella choleraesuis, Vibrio parahaemolyticus*, and *Listeria monocytogenes*, as well as *Pseudomonas aeruginosa* [6] [7].

This paper deals with the usage of nanofibrous structures modified with TiO_2 and without these nanoparticles. The aim of this study was to find out antimicrobial activity of selected materials. The paper follows previous experiments with nanofibrous structures, designed for the filtration of water.

2. MATERIALS AND METHODS

In the experiment, selected materials were used (179 CH05BC, SU22542+TiO_2, 177F121O2BC, PL 1206-2*, PL1151-3*). Characterization of selected materials in table 1 are placed. These membranes were drenched in distilled water before the experiment. For the simulation of microbial pollution, the bacteria *Escherichia coli* were selected. Saline solution with addition of *E. coli* was poured into a filtration device in the upper part of the apparatus. Pressure was applied through the filling valve and during the experiment was rectified by a manometer. Filtration material was anchored to the filtration head. The sample of water was transported through the filter and after 100 ml of water was added, the filling valve closed. During the experiment, the time of flow of the filtrate was measured. In the sample, coliform bacteria were established by plate cultivation method on VRBL agar (Biokar Diagnostics, France) for 24 h at 37 °C. Unfiltered solution of saline solution with addition of *Escherichia coli* was used as a control tool.

Table 1 Characterization of selected membranes

identification of sample	sample	material	areal weight ($g.m^{-2}$)
1	SU22542+TiO_2	polyurethane	4.2
2	177F121O2	polyurethane	3.8
3	PL 1206-2*	PVDF-HFP	6.5
4	PL1151-3*	polyurethane	4.2

3. RESULTS

In table 2 is the comparison of efficiency of selected membranes and their antimicrobial abilities and the other parameters measured during the experiment. In the last row the count of *Escherichia coli* before filtration is shown. After the filtration, the pictures of filters with the captured bacteria were taken by an electron microscope (fig. 2 and fig. 3).

Table 2 Selected membranes and their antimicrobial abilities

sample	time	CFU/ml	log CFU/ml before filtration	log CFU/ml after filtration
1	18.96	1069	6.92	3.03
2	21.80	204	6.92	2.31
3	87.75	12638	6.92	4.10
4	15.89	22	6.92	1.34

4. DISCUSSION

In our experiment nanomaterials with antimicrobial compounds were compared. We recorded no significant effect of these compounds. The results of our experiment did not confirm that the application of TiO_2 to nanotextiles will increase antimicrobial efficiency. The efficiency of selected membranes was quite high. It ranged between 99.84-99.99 %. Reduced efficacy can be caused by inappropriate size of pores, damage during handling or material need extended contact with bacterium. Membranes 177F121O2BC and PL1151-3* had the highest efficiency. Membranes with addition of chlorhexidine (66.25 % and 77.34 %) had the lowest efficiency. The results of our experiment confirmed a relatively high ability to remove microorganisms. Water treated this way can be used for watering or recreational purposes. For drinking water, we can simply use membranes with very high antimicrobial abilities. However, it can assume that some of these applications on the filter surface can prevents the formation of biological grows. This hypothesis will be subject to further examination. Hilal´s study et al. (2004) found out that PVDF membranes modified by interfacial polymerisation with PEI no colonies of *Escherichia coli* were found on the modified membrane samples whereas 172 colonies grew in the same conditions as on the surface of the initial PVDF membrane. These data indicate that modified membrane surfaces possess strong bactericide properties and should be potentially more resistant to biofouling. According to Zhang and Chen (2009) [8] it's believed that the metal oxides carry the positive charge while the microorganism carry the negative charge, this causes electromagnetic attraction between microorganism and the metal oxides which leads to oxidization and finally death of the microorganism. Polyethersulfone (PES) membranes against *Escherichia coli* was tested. The growing of *Escherichia coli* on the surface of initial and modified samples was compared. In the control tool grew out on 150 colonies of *Escherichia coli* the initial PES membrane sample after incubation while only a few colonies were found on the membrane modified with 2-dimethylaminoethylmethacrylate. This means potentially strong bactericide properties and will be probably more resistant to biofouling (Hilal et al. 2003). Sivakumar´s et al. study (2013) [9] founded antibacterial activity of TiO_2 coated high-density polyethylene films with the addition TiO_2. They measured zone of inhibition (in mm) and concentration 0.8 % w/v caused inhibition of zone 35 mm on bacterium *Escherichia coli*. That is why the addition of TiO_2 nanoparticles is a very promising resolution in water treatment and clarification for the future.

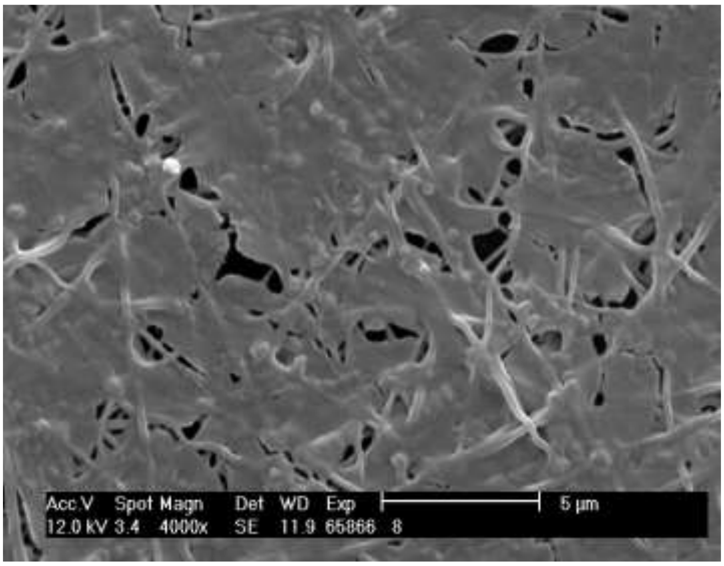

Fig. 2 Escherichia coli captured on nanotextile (scaling factor 4000x)

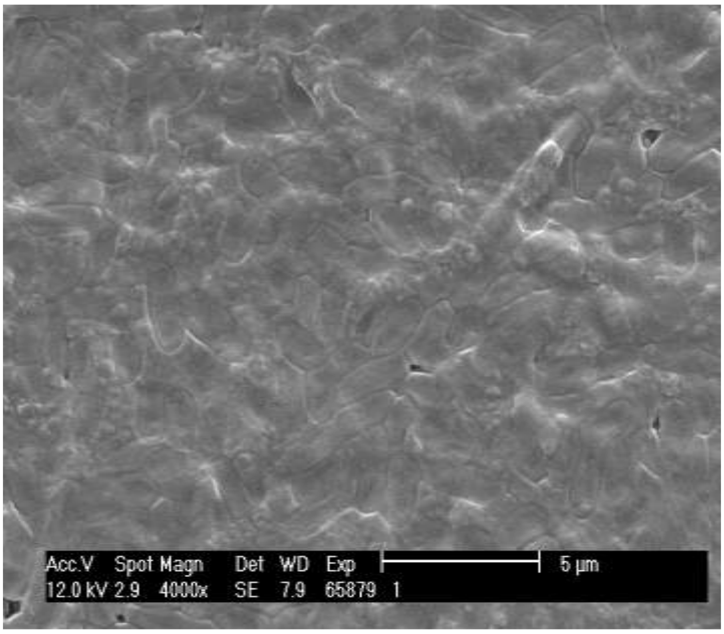

Fig. 3 Escherichia coli captured on nanotextile (scaling factor 4000x)

5. CONCLUSION

In this paper, microfiltration materials were compared. We analysed their ability to capture, or more precisely, to leak *Escherichia coli*, which is an indicator of faecal contamination in water. The results of microbial analysis show high filtration efficiency of selected materials. Used antimicrobial compounds shown no significant effect on microbial reduction from waste waters. The next objectives of our papers will be to find materials for safe usage in food and agricultural industry, the development and testing of membranes with functionalized surfaces and nanobiocides that could be a more effective alternative for cleaning and water treatment. It means membranes resistance to nanoparticles washout and high antimicrobial effect.

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