Using of the nanotextiles for removing of microbial pollution

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Abstract: This paper describes using of nanotextile materials in the filtration device to remove microbial pollution. Nanotextile is non-woven textile formed by fibres with average length 50-300 nm. The size of pores is 0.30 µm ± 0.12 µm, it means membrane should be able to catch every microorganisms. For microbial simulation was selected *Escherichia coli,* occurs in digestive tract of warm-blooded animals and it is indicator of fecal contamination of water. Contaminated water was filtered under pressure 0.5 bar (50 kPa) and subsequently was performed microbial analysis of filtrate. As control sample was used unfiltered contaminated water. A high efficiency of selected filtration materials are shown in the conclusions of our paper.

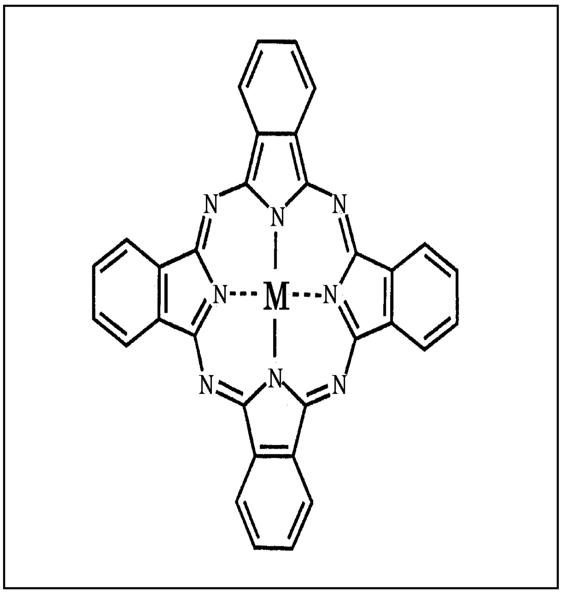
Key-Words: Escherichia coli, nanotextiles, filtration

Introduction

In recent years, nanomaterials (NM) are in centre of scientific interest and began to be used in various fields of industry, agriculture, pharmacy or medicine [1]. The basic building elements of NM are nanoparticles [2]. Nanoparticles (NP) are characterized by size about 1-100 nm at least in one dimension and they have different shapes: nanotubes, nanofibres, crystalline structures or fullerenes. NP occur in nature as secondary products of industrial processes. They are part of atmospheric particles and natural events as eruptions, erosions and fires. The count of products made from NM is estimated to be hundred to thousands tons per year and these numbers will increase [3]. NM can be made from any substance. In nanoform is available 44 elements of The Periodic Table of Elements and their compounds. Nowadays, are most commonly used NM from metals (nanosilver, nanoiron), silicon, carbon (dendrimers, carbon nanotubes) and from metal oxides (titanium, zinc, cerium) [4]. NM apply as support for catalysts, sunscreen components, components into silicon chips or to strengthen tennis rackets [5]. To NM are added phtalocyanines (FTC) due to their antimicrobial properties. FTC are 2D synthetic analogues of porphyrine, consisting from four isoindol subunits connect with nitrogen atoms. FTC and their metal derivates are used in preparation of pigments and dyes, they are also applicable in the manufacture of electronic and optoelectronic devices [6].

Fig. 1 Phtalocyanine molecule (Internet)

This paper deals with the usage of nanofibrous materials modified with FTC. The paper follows



previous experiments with nanofibrous structures, designed for the filtration of water. With FTC modification we wish to increase the removal of microorganisms.

Material and Methods

FTC derivatives was synthesized in The Centre of organic Chemistry (COC, Rybitví, Czech republic). The water-soluble FTC derivates are prepared by substitution of the FTC skeleton in order to prepare a cationic FTC with antimicrobial effect. Microfiltering material SPURTEX was made in SPUR a.s. Zlín.

In the experiment, selected materials were used (see tab. 1), which were drenched in distilled water before the experiment. For the simulation of microbial pollution, the bacterium *Escherichia coli* was selected. *E. coli* was incubated in TSB (Biokar Diagnostics, France) for 18 h at 37 ˚C. Subsequently, *E. coli* was centrifuged (3000 RPM) and washed with solution saline. This procedure was repeated twice. From the resulting suspension was made solution for experiment with density 10^6 cells/ml.

Saline solution with addition of *E. coli* CCM 7929 (Czech collection of microorganisms) 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 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 ºC.

Results

In figure 1 is the comparison of selected membranes and their antibacterial abilities.

Fig. 2 Selected membranes and their antibacterial abilities

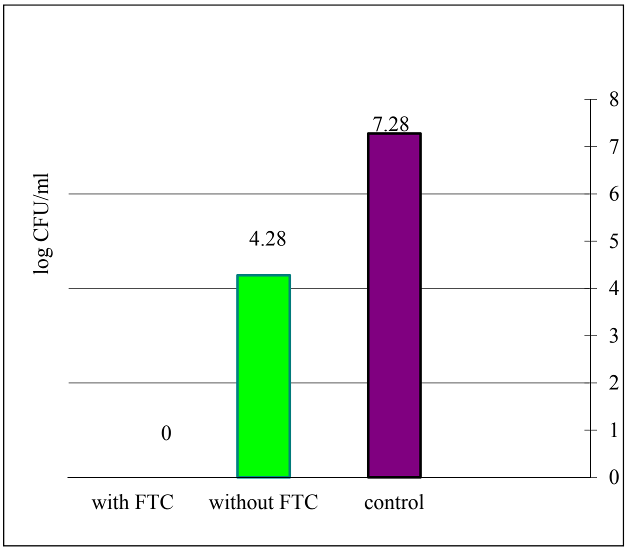


Table 1 Selected materials and their parametres

sample	material	volume [ml]	time [s]	efficiency [%]
without FTC	PVDF	60	8.10	99.88
with FTC	FTC 177F1z1 O2BC	60	7.31	100

Discussion

During the experiment was confirmed our assumption high efficiency of NM with addition of FTC to remove microbial pollution of water. Material without addition of FTC reduced *E. coli* counts for three degrees comparing with controls, material with addition FTC had 100% success. High efficiency of membrane with addition FTC can be caused by positive charge of FTC membrane, which makes better connections with negative ions in cell wall of *E. coli*.

A similar conclusion had been reached Merchat et al. [7] in their work with porphyrins, which are similar photosensitive agents such as FTC. Minnock et al. [8] found out gram-pozitive bacteria are more sensitive to photosensitive agents then gram-negative, because of the cell wall structure. This conclusions confirm Banfi´s et al. [9] paper, who when examine synthetic FTC found, that gram-positive *Staphylococcus aureus* was more sensitive than gram-negative *E.coli*. Mikula et al. [10] discovered that FTC with concentration FTC 2 $g.l^{-1}$ causes serious damaging cell wall after 3 hours exposition. Using metalophtalocyanines was achieved reducing for five degrees comparing with control. This suspension was lit by white light. This same type of FTC reduced after illuminating by red light counts of microorganisms for 5.5 degrees [11]. Došek et al. [12] reached filtration efficiency 98.84-99.31% at the same filter condition.

Conclusion

In this paper filtration materials with and without addition of FTC were compared. We analysed their ability to capture, or more precisely, to leak *E.coli*, which is natural colonizer of the digestive system of warm-blooding animals and it is an indicator of faecal contamination in water. The results of microbial analysis show high filtration efficiency of selected materials. The next objectives of our papers will be testing FTC durability and resistance to washout, the development and testing of membranes with functionalized surfaces and nanobiocides that could be a more effective alternative for cleaning and water treatment.

Acknowledgement

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