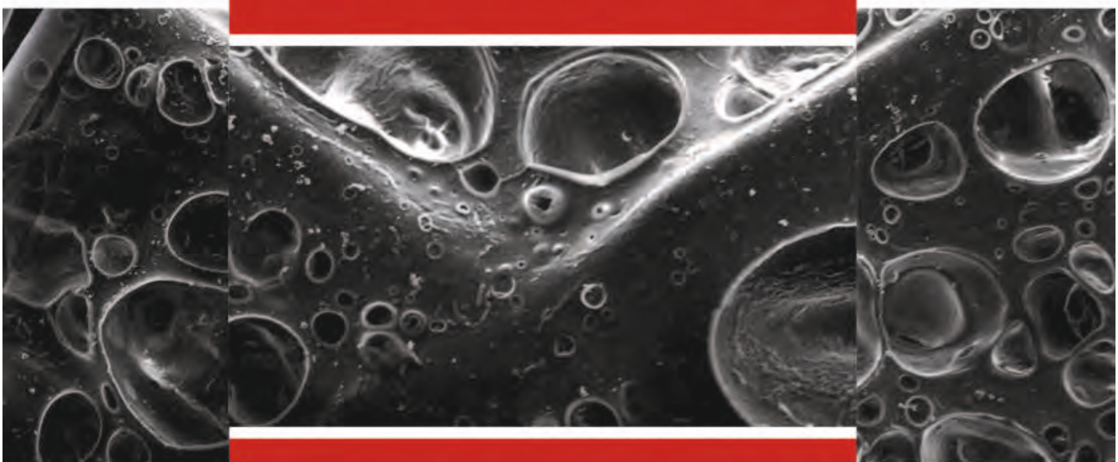
Workshop of Students´ Presentations 2021



„Membranes and Membrane Processes“

Organised by Czech Membrane Platform and MemBrain

24th November, 2021

Straz pod Ralskem, Czech Republic

EVROPSKÁ UNIE
Evropský fond pro regionální rozvoj
Operační program Podnikání
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PRŮMYSLU A OBCHODU

Book of Abstracts

Workshop of Students' Presentations 2021

„Membranes and Membrane Processes“

24st November, 2021

Straz pod Ralskem, Czech Republic

Organized by:

Czech Membrane Platform

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and

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FOREWORD

Dear ladies and gentlemen,

You are already receiving the ninth book of abstracts of the Workshop of Students' Presentations (WSP) 2021. Its creation is linked to the development of membrane technologies in the Czech Republic, which was completed ten years ago by the project of the Membrane Innovation Center in Stráž pod Ralskem. It was built on a green field thanks to the activities of MEGA a.s. and started its activities in 2014. The construction of the center was supported by the Ministry of Education, Youth and Sports from the Operational Program Research and Development for Innovations.

The aim of the WSP was to offer students and PhD students in the field of membrane and electromembrane technologies the opportunity to publish their research and scientific activities. The members of evaluation committee select the awarded works among the presented lectures and posters. The most of the participants presented their results at other events organized by the Czech Membrane Platform subsequently, especially at the MELPRO and MEMPUR conferences.

Of course, a pandemic situation has significantly affected the organization of the events. Because of this, the workshop in 2020 took place in the form of online presentations and we will see about the current year 2021.

The organizers of WSP, the Czech Membrane Platform and the Membrane Innovation Center, firmly believe that this activity will continue to prosper in the future and will do everything to ensure that we also meet at the next, already the tenth year of WSP.

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RHEOLOGICAL PROPERTIES OF POLYOLEFIN MELTS

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Abstract: Rheology studies deformation and flow of liquids. Water or honey, for example, flow in "normal" Newtonian way, but ketchup or polymer melts (non-Newtonian fluids) do not. We were interested in rheological characteristics of polyolefin melts with ion-exchange resins used in ion exchange membrane manufacturing. In this study a screw extruder with capillary rheological extrusion die was used.

We examined 3 different polyolefin binders – Elite 5811, Exceed 1018CA and LDPE LD 605BA and mixes, which were prepared from Elite 5811 with additive Struktol TR 016 and different amounts of ion-exchange resin fillings (15, 30, 45 and 60 wt%). Temperature of melts in all measurements was set at 140 °C. Measurements were performed on a range of RPMs (0.1 – 40). Capillary dies with variable diameters (1, 1.5 and 2 mm) and L/D ratios (LD10, 20 and 30) were used.

We concluded that behaviour of the materials depends on the geometry of the particular capillary, which shows the melt does exhibit flow anomalies. Because of the non-newtonian behaviour of the melt, the values of measured shear rate, stress and dynamic viscosity were apparent. Therefore, corrections calculated by the PolyLab OS software had to be used to compensate for the non-parabolic flow profile and pressure drop at the capillary entrance. Weissenberg-Rabinowitsch and Bagley corrections were performed for both pure and filled binders. The real shear rate seems to be higher for the same value of shear stress, but the corrections cannot be described as very reliable due to insufficient instrumentation and software imperfections. Mooney corrections for wall slip had to be calculated manually and appear to be unnecessary for pure binders because of a low wall slip rate. With just 30 wt% filling however, the wall slip velocity rises considerably and increases the apparent shear rate by up to 80 % at higher screw rpm.

With an increasing degree of filling, the viscosity, as expected, increased too, but the trend is not linear. Within the individual capillary geometries, an increase in pressure and decrease in flow rate through the capillary were observed when increasing the filling of the mixture.

ENHANCED OIL RECOVERY – INJECTION WATER DESALINATION BY HIGH-TEMPERATURE ELECTRODIALYSIS

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Abstract: The field of renewable energy has made considerable progress in the past decade. Despite this progress, oil and gas still remain the world's main energy source [1]. Chemical enhanced oil recovery (EOR) is considered to be one of the more efficient oil recovery techniques, which are used in the recovery of leftover oil and residual oil trapped in the reservoirs. A water-polymer solution is injected into the reservoir to displace the oil, thus allowing its removal. In order to reuse the injection water, it needs to be desalinated while maintaining high polymer concentrations in the water. Several processes could be used to achieve this goal, electrodialysis looking to be the most promising one of them [1][3].

One of the aims of this project is to evaluate the feasibility of using high-temperature electrodialysis in the recovery of a substantial amount of already used injection water provided in EOR. During the electrodialysis of the injection water, performance parameter tests were conducted on homogeneous ion-exchange membranes to determine their usability in the recovery process. A moderate degree of optimization was necessary throughout the entire testing period to ensure a replicability of the tests. The membrane module was assembled using EDR-Z clamping panels, 10 pairs of FUJIFILM 10 homogeneous ion-exchange membranes and two pieces of PTFE cation exchange membranes were used on the edges of the membrane stack. Silicone distributors with built-in mesh were placed between each of the membranes to ensure a sufficient contact between the liquid phase and the membranes [2][4].

Standardized salt tests were conducted at 25 °C and 50 °C at both electrode polarities. These standardized tests were followed by a series of performance parameters tests at 50 °C. The performance parameter tests were carried out on 10 kg batches of the injection water, until the conductivity of the dilute reached a value of 1 mS/cm. CIP (cleaning-in-place) was not carried out between the tests. The values of total voltage, stack voltage and electrical current as well as the conductivity, temperature and pH level in each circuit was registered in 10-minute intervals.

The results show, that the use of electrodialysis is highly recommended in the desalination of the injection water used in EOR. A high degree of desalination could be observed in each of the tests. The ion-exchange capacity of the membranes had a slowly decreasing trend with each consecutive test. This fact can be attributed to membrane fouling. Energy consumption was mainly influenced by the length of the tests. However, this process requires further testing on a large-scale membrane module to accurately assess its industrial applicability.

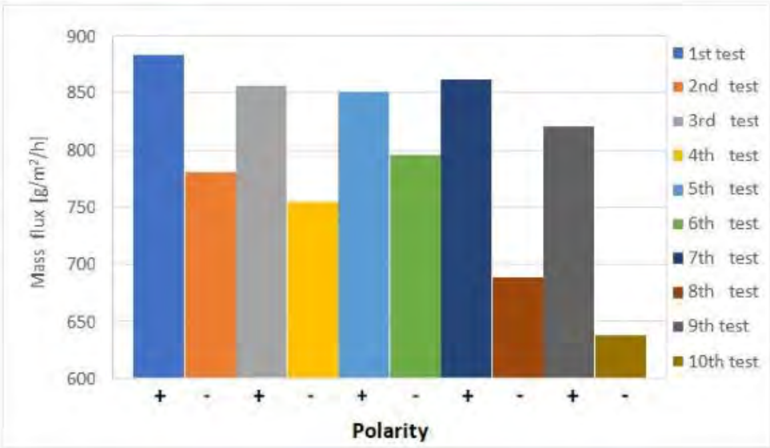

Fig. 1 : Average ion-exchange capacity for each performance parameter test

Key words: enhanced oil recovery, water-polymer solution, high-temperature electrodialysis, homogeneous ion-exchange membranes

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ELECTROCHEMICAL CHARACTERIZATION OF DISULFONATED ANTHRAQUINONES FOR APPLICATION IN NEGATIVE ELECTROLYTE OF REDOX FLOW BATTERIES

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Abstract: Based on ever-growing demand for effective technology that would be able to store electricity from renewable, but irregular, energy sources, redox flow batteries (RFB) have undergone intensive development in recent years. Although inorganic salts are already in use in RFB electrolytes, their price is often high and thus organic substances are under intensive research as more economical alternatives. For the practical application in RFBs the following properties are required: sufficient solubility of organic substances in aqueous electrolytes, suitable redox potential and fast electrode reaction kinetics and electrochemical stability upon cycling. The disulfonated anthraquinones (AQDS) are particularly promising candidates as redox-active material for negative RFB electrolyte. In our research, we have studied 2,7-AQDS and 2,6-AQDS salts with various counter ions, investigating their electrochemical properties together with chemical stability and solubility in aqueous neutral electrolytes. Electrochemical characterization consisted of voltametric measurements on stationary and rotating glassy carbon disc electrode. From these measurements, we obtained relevant parameters (kinetic parameters, formal redox potential, diffusion coefficient) using custom written MATLAB script. Solubility in corresponding sulphate-based supporting electrolytes was evaluated by UV-VIS spectrometry analysis of the saturated solutions. The most prospective substances were chosen for further investigation in a laboratory flow battery single-cell.

PVDF MEMBRANES MODIFIED WITH NATURAL SUBSTANCES FOR WATERTREATMENT PROCESSES

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Abstract: Water polution and scarcity are one of urgent concerns around the world. Membrane processes such as membrane destilation (MD), reverse osmosis (RO) or microfiltration (MF) have a grate potential to deal with these problems. These processes are not new technologies but there is still space for improvements. Membranes and membrane modules can be further modified to enhance its efficiency, energy consumption and permeate quality [1]. MD is one of the most promising membrane processes, because of its low cost, energy saving and lower pressure demand compared to other pressure driven processes. To properly perform this process, the hydrophobic membrane is necessary [2]. As a base polymer, PVDF was selected. It exhibits excellent chemical durability, mechanical strength, thermal stability and most importantly, it is naturally hydrophobic. Unfortunately pristine membrane has low efficiency in separation processes and it is prone to fouling. Thus, further modification is needed [3]. One way to search for solutions in creating new membrane materials is to look at those created by nature. The goal of the work is to prepare hydrophobic-hydrophilic separation materials inspired by nature (e.g. lotus leaf effect, Namib Desert beetle) [4-5]. Because PVDF is inert material, membrane surface activation is necessary to perform modification. Piranha solution, as highly reactive oxidant, was used to furnish membranes with hydroxyl groups. Activated membranes (PVDF-OH) were further modified with naturally occurring substance – 1% cinnamic acid (PVDF-Cin1). Each acquired membrane was characterized with various instrumental methods: 1) goniometry for contact angle (CA) and surface free energy (SFE), 2) atomic force microscopy (AFM) for surface imaging and calculate surface roughness, 3) bubble point method for pore size and pore size distribution, 4) X-ray diffractometry (XRD) spectrum for crystalline phases and 5) Zeta potential measurements for a surface charge. What was surprising, despite the presence of hydroxyl groups on the surface, activated membranes CA was higher than pristine one (from 121.65° before activation to 130.43° after activation), due to increased roughness of the surface. The use of cinnamic acid as modifier caused further increase of CA and (from 130.43° before modification to 135.58° after modification). Etching with Piranha solution increased dispersive part of SFE and decreased polar part of SFE. Modification with cinnamic acid further decreased polar part of SFE. Roughness of PVDF-OH increased significantly in

comparison to PVDF, although after cinnamic acid the surfaces of the membranes was smooth out. Etching with Piranha solution increased pore size for 4.92% and cinnamic acid modification further increased that value. Values of zeta potential were significantly higher for both PVDF-OH and PVDF-Cin1.
Modification of PVDF membranes increased hydrophobicity, which can result in improvement in water flux. Further examination is needed to evaluate the membrane fouling.

Project was supported by NCU Young Researchers Grant (PDB/Granty wydziałowe), and "Excellence Initiative - Research University" Grants4NCUStudents (26/2021/Grants4NCUStudents)

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INFLUENCE OF POSTTREATMENT ON THE TRANSPORT AND SEPARATION PROPERTIES OF HOLLOW FIBRE MEMBRANES FOR GAS SEPARATION

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Abstract: Membranes in form of hollow fibre modules are nowadays one of the most frequently used one for separation of gas mixtures. That's because of their high surface per volume ratio. The separation is based on sorption-diffusion mechanism. For this mechanism of separation is crucial thin separation layer on inner or outer side of the hollow fibre. However, during the manufacturing process are formed little pores in this separation layer. The transport in these pores is based on Knudsen diffusion, what can cause significant loss of separation properties. Because of that there are used several modification methods, to deal with the defects in the separation layer.

In our work we have studied two types of modification – material relaxation and covering the hollow fibre with thin layer of another polymer. These modifications we studied on hollow fibres B20_2 and B27_6.

For material relaxation we tried two different approaches. Few hollow fibre modules we have dipped in the ethanol and then put for 24 hours to hot air dryer, which was tempered to 50 °C. The set of other same type hollow fibre modules we only put in the hot air dryer at tempered to 50 °C for 24 hours.

For covering hollow fibre modules with thin layer we used PDMS solution with different concentrations – 2%, 1% and 0.5%. We dipped hollow fibre module and then put in hot air dryer for 2 hours approximately. We also studied the influence of temperature in the hot air dryer. One set of hollow fibre modules we have tempered to 40 °C and other to 80 °C.

We have compared the selectivity and permeance of treated and untreated hollow fibre modules. Since these membranes may be used for separation of biogas mixture. We studied permeances of carbon dioxide and methane. There were made measurements at different pressures.

From the results we can conclude that only heating to 50 °C doesn't cause enough material relaxation to heal the separation layer defects. However, using simple alcohols as ethanol and heating to 50 °C slightly increase. For B20_2 selectivity increases from 9.98 to 24.8 by soaking in ethanol and heating to 50 °C and for B27_6 from 21.8 to 25.9. However, the permeance of carbon dioxide decreased for B20_2 from 11.6 GPU to 9.6 GPU and for B27_6 from 102.2 GPU to 14.2 GPU.

In the experiments with covering our fibres with PDMS we find that the concentration of PDMS in range of concentrations from 2 % to 0.5 % doesn't make visible difference in increasement of selectivity. As well the influence of temperature wasn't visible. However, we can say that treating the fibres with PDMS solution make significant improvement of separation properties. For B20_2 selectivity averegly increases from 9.98 to 43.7 by covering it with PDMS and heating to 40 °C and for B27_6 from 21.8 to 36.15. The carbon dioxide permeance for B20_2 doesn‘t significantly changed. For B27_6 it decreased from 102.2 GPU to 67.7 GPU.

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SEPARATION OF RACEMIC THYROXINE BY NANOFIBROUS COMPOSITE MEMBRANE WITH CHIRAL SELECTOR

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Abstract: Thyroxine is the main hormone secreted into the blood system by thyroid gland in his inactive form, which is converted to an active form by liver and kidneys. Thyroxine and thyroid hormones play important roles in digestion, heart and muscle function, brain development and maintenance of bones. L-Thyroxine is used for diagnosis of thyroid diseases and for their treatment, while D-Thyroxine has immunomodulatory function and is not currently used in medicine.[1]

Optical purity of L-Thyroxine is crucial for a safe everyday treatment of patients. In this study, we have focused on chiral separation of racemic Thyroxine by a chiral self-made membrane. Membrane separation is easily scalable and cost-efficient on a large scale. First, preferential sorption of D,L-Thyroxine by the chiral membrane in aqueous environment was screened[2] and after that pertraction experiments were made. Samples were taken in regular time intervals and analyzed by high-performance liquid chromatography. The first experiment showed a difference in the concentration of enantiomers after 2 hours, when concentration of L-enantiomer was 45% and D-enantiomer was 55%, which documents that the L-enantiomer is preferentially adsorbed into the membrane.

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RECOVERY OF $MG(OH)_2$ BY MEMBRANE CRYSTALLIZATION FROM RO BRINES

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Abstract: The main goal of our work was to analyze the process of membrane crystallization of magnesium hydroxide using ion-exchange hollow fibres. Our task was to assemble a membrane module, which consists of hollow fibres, and then test it under experimental conditions. The module was tested with model solutions of $MgCl_2$ and NaOH, the NaOH solution being a 1.25-fold stoichiometric excess. Our product was precipitated $MgOH_2$. After verifying the operation on model solutions, the module was subsequently tested on solutions that were prepared based on real RO Brines [1, 2]. At the end of the experimental part, we evaluated our measured data and the usability of the module. When testing the module, achieved conversion values were in the range of 40% to 60% and the purity of the product ranged from 69% (for real RO Brines solutions) to almost 100% (for model $MgCl_2$ and NaOH solutions).

Keywords: membrane crystallization, hollow fibres, magnesium hydroxide, brine

Acknowledgement: This work was carried out in the frame of the IP project (Decision Nr. 6/2018) supported by the Czech Ministry of industry and trade and in the frame of project LO1418 supported by the Czech Ministry of education, youth and sports. The project utilizes Membrane innovation centre infrastructure.

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PARTICLE SEPARATION BY MICROFILTRATION MEMBRANES BASED ON NONWOVEN MATERIALS

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Abstract: The existing water resources in the world are decreasing nowadays due to domestic, agricultural, industrial and similar wastes. Therefore, the treatment of wastewater is important for our present and future. The membrane process (microfiltration and ultrafiltration), chemical destabilization (conventional coagulation) and electrochemical destabilization (electrocoagulation) are the most common processes for the wastewater filtration. Non-woven materials are commonly used in the decontamination process for the particle separation removal larger than 1 µm [1]. Non-woven materials have randomly oriented fibers creating pores that the fluid can flow through. They have many advantages that can be controllable such as pore size, the density of fibers and design. They are also cheap material for the water filtration. In this work, the non-woven membranes were prepared and they have been used for the particle separation. The performance of non-woven membranes such as flux, and the relationship between pore size, air permeability, and lamination process were investigated.

Acknowledgment

This work was supported by the Ministry of Industry and Trade – TRIO project 17758- Recycling of technological waters in the beverage industry.

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POSSIBILITIES OF USING NANOFIBERS IN THE PROCESS OF MEMBRANE DISTILLATION

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Abstract: Membrane distillation (MD) is thermally-driven process in which only vapor molecules pass through a hydrophobic membrane. Thanks to this mechanism, the membranes in MD can achieve a higher salt rejection than 99 %. MD appears to be a promising technology in the desalination process of highly concentrated solutions and wastewater treatment [1]. The main limitations of MD are low flux and fouling of the membrane surface, causing its wetting. Nanofiber materials have potential in finding new types of membranes to mitigate these causes [2]. This work is focused on the preparation and characterization of nanofiber PVDF membranes and subsequent comparison with a commercially available microfiber PP membrane. Testing was performed on a laboratory MD unit using a direct contact membrane module (DCMD). Membranes were compared in filtration tests with salt solution and with leachate from the municipal waste landfill. The nanofiber PVDF membrane was prepared with two different weights by needleless electrospinning. The most interesting filtration tests were performed with a temperature difference of 10 ˚C where nanofiber PVDF membrane with a weight of 3 GSM achieved almost 2.5x higher flux (avg. 8 $kg \cdot m^{-2} \cdot h^{-1}$) than the microfiber PP membrane. In contrast, a nanofiber PVDF membrane with weight 11.23 GSM was unsatisfactory for these experiments and it was discarded. The salt rejection of the PP membrane during the saline tests was almost 100 %, compared to the PVDF membrane, where the rejection decreased with the more concentrated solution (dropped to 94 %). The rejection of the both membranes tested with leachate was comparable and the higher flux (6.11 $kg \cdot m^{-2} \cdot h^{-1}$) during these tests was measured again with a nanofiber PVDF membrane with a weight of 3 GSM.

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INFLUENCE OF ELECTRODIALYSIS ON FUNCTIONAL PROPERTIES OF WHEY PROTEINS

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Abstract: The mineral content significantly affects the functional properties of whey proteins. Our work focuses on the influence of demineralization by electrodialysis and the influence of electrodialysis operating temperature on whey protein functional properties. Sweet whey was demineralized at 15 and 50 °C, final conductivity was 2 $mS \cdot cm^{-1}$. Following functional properties were evaluated: viscosity, emulsifying properties, colloidal stability, heat-stability and gelling properties. The viscosity and flow properties of whey were not observed to be affected. Demineralization has improved emulsifying properties, colloidal stability, and heat-stability. Furthermore, the effect of electrodialysis operating temperature on the colloidal stability of whey proteins was proved when demineralization at higher temperatures led to the acquisition of colloidally stable samples. Demineralization did not have a clear effect on the gelling properties. The samples after demineralization showed higher water-binding activity, but the gel stiffness was higher for gels of natural whey. Demineralization promoted the elastic character of the gel. The effect of electrodialysis operating temperature on the gelling properties of whey proteins was not confirmed.

Key words: Electrodialysis, Whey, Proteins, Stability

USE OF CONDUCTIVE MEMBRANE TO PREVENT BIOFOULING IN MBR

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Abstract: Membrane (bio)fouling is limiting factor, which affects application of membrane bioreactors (MBR) for wastewater treatment. Lots of studies have been devoted to mitigate this negative phenomenon (Hamedi et al., 2019). One of solution is to use a weak pulsed or static electric field, which affects the growth of microorganisms on the membrane surface, thus mitigating biofouling (Formoso et al., 2017). The principle of this method consists in the electrostatic interaction and repulsion between the membrane surface and cells of microorganisms, which show a negative charge (Akamatsu et al., 2010).

To prepare conductive membrane, a copper textile MEFTEX 30 (Bochemie, CZ) was cover with nickel through chemical reaction. Such metal textile was then laminated to commercial membrane MV020T with 200 nm pores size (Microdyn Narid, Germany). As a binder between textile and membrane, the polyurethane was used. The lamination process was carried out on RPS L600 device at a temperature of 75^{o}C, a pressure of 0.5 kN with a feed speed of 1 m·min^{-1}.

Due to similar properties (for instance permeability about 800 l·m^{-2}·h^{-1}·bar^{-1}) to laminated membrane MV020T+textilie Cu-Ni, membrane MP005 with 50 nm pores size was chosen as a reference. Prior to long-term filtration test with activated sludge, the critical flux was estimated for reference (21 l·m^{-2}·h^{-1}) as well as conductive MV020T+textilie Cu-Ni membrane (16 l·m^{-2}·h^{-1}). During long-term test, conductive membrane was tested with and without alternating current (10 V). In this system, copper plate was used as an anode (+) while conductive membrane was a cathode (-). In the case of MV020T+textilie Cu-Ni membrane with applied electric current (had no influence on character of activated sludge), continuous decrease in transmembrane pressure was observed compared to other membranes.

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ADSORPTION OF ANTI-INFLAMMATORY DRUGS ON CARBONACEOUS SORBENTS

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Abstract: Currently, traces of drugs have been found not only in technological water streams produced by pharmaceutical industry but even in natural water and groundwater. The occurrence of drugs and their metabolites in the environment shows that the biological stage of the wastewater treatment plant is not able to completely remove these contaminants. Therefore, it is necessary to apply effective methods for removal of drugs from contaminated water. Adsorption is not only an efficient technology for the separation of organic substances from water, but also a frequently applied method [1]. However, the application of commercial active carbon (AC) is associated with high operating costs. For this reason, the use of a cheaper adsorbent – biochar – was studied too. Biochar is produced by pyrolysis from economically undemanding input biomass (agricultural waste, sewage sludge) without subsequent activation [2]. However, biochar often does not achieve the removal efficiency of organic pollutants such as active carbon. Nevertheless, there are impregnation possibilities of carbonaceous sorbents, which leads to an increase of biochar adsorption capacities. One option of impregnation is the use of commercially available ionic liquids (quaternary ammonium salts – R_4NX). It is known fact that salts of halogenated organic acids (e.g. contaminant-COONa) react smoothly with low-polar quaternary ammonium salts R_4NX via ion exchange reaction producing low soluble high molecular ion pairs (contaminant-$COONR_4$) [3].

In this work, biochar obtained as a by-product in the gasification process of waste biomass [3] was tested as a suitable sorbent for removal of the two anti-inflammatory halogenated drugs – Flufenamic acid and Diclofenac. The sorption of mentioned drugs on biochar was compared with two types of active carbon (powdered (PAC) – Silcarbon CW20 and granulated (GAC) – Hydraffin CC8X30). It was also tested possibilities of biochar impregnation by ionic liquids (cetyltrimethylammonium bromide and 20% aqueous solution of poly(diallyldimethylammonium) chloride) for possible increasing of sorption capacity. We compared sorption capacities of *ex-situ* (modification of biochar by R_4NX before sorption) and *in-situ* (co-action of R_4NX and biochar) impregnated biochar. Sorption experiments were carried out in a magnetically

stirred (400 rpm) 250 mL round bottomed flasks using an electromagnetic stirrer equipped with Starfish attachment for parallel reactions. The appropriate quantity of biochar was added to 250 mL of synthetic wastewater contaminated with appropriate drug (possibly after the addition of R_4NX). The concentration of tested drugs in aqueous solutions varied between 10-100 mg/L. Stirred suspensions were immediately filtered and analyzed. The concentration of tested pharmaceuticals in the aqueous filtrates was quantified using voltammetric determination [4].

Results of sorption kinetics show that adsorption of Diclofenac and Flufenamic acid on biochar does not achieve the removal efficiency of drugs adsorption on commercial active carbon (tested GAC or PAC). However, *in-situ* impregnation of biochar using commercially available ionic liquids increases removal efficiency of tested pharmaceuticals. Obtained data also prove that the sorption of drugs by *in-situ* impregnated biochar with ionic liquids is two times faster than sorption by biochar alone and three times faster than using commercial AC. As document the sorption isotherms, sorption capacity of *in-situ* impregnated biochar for tested drugs almost reaches sorption capacities of both tested active carbons. The higher efficiency obtained using co-action of biochar and ion liquids could be explained by the one-layer adsorption of ion pairs (contaminant-$COONR_4$) on the heterogeneous biochar surface described by Langmuir isotherms. It was demonstrated that a more laborious two-steps technique, based on the initial preparation of impregnated biochar by the action of R_4NX with subsequent application of this modified sorbent is much less effective than simple mixing of biochar with R_4NX directly in the treated model wastewater. Described technique based on co-action of biochar with selected R_4NX enables attainment of removal efficiency comparable with commercial active carbons containing at least twice higher specific surface area as biochar.

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DECOLORIZATION AND TREATMENT OF INDUSTRIAL WASTEWATER BY INDIRECT ANODIC OXIDATION

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Abstract: The aim of this work was to evaluate the possibility of decolorization and treatment of effluents from textile, paper and rayon industry. Industrial wastewaters share a few common characteristics, such as high COD, BOD, TOC, AOX, conductivity, temperature and coloration, that makes them hard to treat. Therefore, new approaches like anodic oxidation, membrane technologies or adsorption methods are appealing [1]. As textile and paper effluents contain salts like sodium chloride or sodium sulphate [2], the indirect oxidation willingly takes place. Hence, we focused on this method and tested it at various conditions. Structurally different azo and aminoantrachinone dyes were used as model organic pollutants, since they represent hardly degradable organic matter. Also, these groups of dyes belong amongst the most frequently used in the textile and paper industry [3]. The decolorization and mineralization of the dye is uneasy task due to its high stability, therefore strong oxidizing agents need to be used for its decomposition. The formation of oxidants depends on conditions like pH, material of anode, supporting electrolyte, etc [4]. We evaluated the rate of decolorization, which is connected with the chromophore disintegration, in the most common electrolytes used during dyeing process. We also compared the influence of pH on structurally different dyes and tested anodes made of boron doped diamond (BDD), platinum and graphite for decolorization and degradation. A suitable method for monitoring the effectiveness of decolorization of model wastewater was UV-VIS spectroscopy. The time intervals corresponding to chromaticity change of electrolyzed solution were measured and kinetic constants were assessed. Results showed that the decolorization rate is higher in the presence of NaCl than Na_2SO_4 in the whole pH range and the structure of the dye has a direct impact on the velocity of the decolorization process. The efficiency of oxidation was also taken into consideration by evaluating the parameter COD and parameter TOC, which convey the information about mineralization. The drawback of this method is formation of undesirable by-products, which was monitored through AOX and LC-MS analysis. Different approaches to minimize the formation of harmful substances and also the economical side of the process were discussed in this work.

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SEPARATION OF RACEMIC COMPOUNDS ON POLYIMIDE-BASED MEMBRANE

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Abstract: Most of the organic substances involved in biochemical processes including drugs are chiral and each of the enantiomers of these molecules could cause dramatically different biochemical response. During drug preparation and administration, it is therefore very important to use optically pure substances and prevent ineffective or even dangerous forms of these substances from entering patients' bodies. Although a number of drugs has already been redeveloped as single enantiomers, there is still a lot of racemic compounds among established and recently approved drugs. Membrane separation processes could provide effective solution for enantiospecific separations of these compounds thanks to continuous and easy operation and low capital costs. Among various membrane materials, polymers have been proven to be very useful thanks to their chemical and long-term mechanical stability. In this work, we examined enantioselectivity of a resilient polymeric membrane based on commercially available Matrimid. In series of sorption and pertraction experiments, we investigated interactions and transport of D, L – Tryptophan through the pure Matrimid membrane. We found that Matrimid structure preferentially interacts with L – Tryptophan, which was confirmed using molecular simulations and the three-point model. To enhance the transport properties of the polymeric membrane, influence of the thickness of the membrane and additives to the polymeric matrix has been studied. Addition of polypropylene glycol to the casting solution in various amounts increases dramatically the permeability of the membrane, while retaining its selectivity towards L – Tryptophan.

PEBAX® 2533 MIXED MATRIX MEMBRANES CONTAINING IONIC LIQUID DECORATED ZEOLITIC IMIDAZOLATE FRAMEWORK (ZIF-8@IL) FOR CO_2 SEPARATION

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Abstract: Gas separation is indispensable in many industrial processes, including biogas upgrading, flue gas treatment, and hydrogen purification[1,2]. In this work, zeolitic imidazolate framework (ZIF-8) was firstly functionalized by polyethyleneimie (PEI) then decorated with ionic liquid (IL). The prepared ZIF-8@IL particles were incorporated into Pebax® 2533 matrix to prepare ZIF-8@IL/Pebax® 2533 mixed matrix membranes (MMMs). The effects of filler content (5, 10, 15 and 20 wt%) on the physicochemical properties and CO_2 separation performance of MMMs were investigated. The IL modified ZIF-8 particles were characterized by using attenuated total reflection-Fourier transform infrared (ATR-FTIR), scanning electron microscope (SEM), X-ray Diffraction Analysis (XRD), and thermal analysis combined with FTIR spectrometer (TGA-FTIR). The morphology, surface chemistry, and the gas separation performance of the fabricated ZIF-8@IL/Pebax® 2533 MMMs were characterized by using SEM, ATR-FTIR, and gas permeance measurements, respectively. In comparison to the pristine Pebax® 2533 membranes, CO_2 permeability of MMMs containing 15 wt% ZIF-8@IL increased 123% to 1241 Barrer, and the CO_2/N_2 and CO_2/CH_4 ideal selectivities increased from 17 and 12 to 76 and 25, respectively. The enhancements of CO_2 permeability and selectivity were resulted from the size sieving effects of ZIF-8@IL, the additional facilitated transport path for CO_2 molecules, and the enhanced CO_2 affinity to fillers by ILs. What is also important, ZIF-8@IL showed higher compatibility with polymer matrix due to the formation of hydrogen bond between amino groups and Pebax chains and the sealing effects of ILs. Consequently, the gas separation performance of the prepared MMMs was improved.

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HETEROGENEOUS ION-EXCHANGE MEMBRANES BASED ON VULCANIZED RUBBER AND WET-PHASE SEPARATION/INVERSION MEMBRANE FORMATION

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Abstract: Polymeric ion-exchange membranes (IEMs) are used in electromembrane separation processes. IM consists of polymer matrix with covalently fixed ions – functionals groups.

Cation exchange membrane contains negatively charged functional groups in structure and are selectively permeable for cations.

Anion exchange membrane contains positively charged functional groups and are selectively permeable for anions.

IEMs are divided according to their structure and preparation. Homogenous membranes contain only one polymer/copolymer matrix with covalently fixed functional groups. Heterogeneous membranes contain ion-exchange particles dispersed in an inert polymer matrix e.g., polyvinylchloride, polyvinylidenfluoridu, polyethersulfon.

In this work was studied non-standard ways of heterogeneous ion-exchange membranes preparation especially wet-phase separation/inversion membrane formation (dispersion of ion-exchange particles in solution with dissolved polymer binder, then coagulation in the presence of a coagulant) and its influence on electrochemical properties of ion-exchange membrane. Membranes created with these methods can be thinner but may contain pores. There are also more chemicals needed.

According to experimental data, membrane made of Polydimethylsiloxane (PDMS) had the best values, especially permselectivity.

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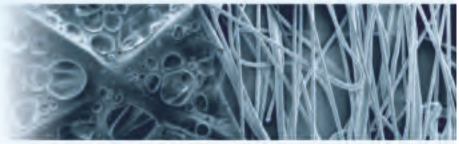
Česká membránová platforma, z.s.



Česká membránová platforma sdružuje odborníky a významné instituce zaměřené na výzkum, vývoj, inovace a aplikace membránových procesů v širokém spektru technologických a výrobních odvětví.

Hlavní činností platformy je propagace a popularizace membránových procesů, vzdělávání laické i odborné veřejnosti, vydávání odborných publikací a studií. Důležitou činností je organizace seminářů, workshopů a národních i mezinárodních konferencí.
Významná je spolupráce se subjekty využívajícími membránové procesy ve výzkumu, vývoji a konkrétních aplikacích s důrazem na inovace, transfer technologií a spolupráci mezi průmyslovou a akademickou sférou v České republice i v zahraničí.

V rámci projektu **Membrány pro život** (MEM4LIFE) CZ.01.1.02/0.0/0.0/17_105/0018786 realizovaný v období 2018 - 2022, se uskuteční zejména tyto aktivity:

- **zpracování Cestovní mapy průmyslové modernizace a zavádění pokročilých technologií**
- **aktualizace Strategické výzkumné agendy a Implentačního akčního plánu**
- **organizace konferencí MEMPUR a MELPRO**
- **pořádání workshopů a seminářů**
- **prohloubení spolupráce s Evropskou membránovou společností (EMS)**

Hlavní náplní projektu Membrány pro život je sestavení cestovní mapy, která shrne a definuje etapy směřující k průmyslové modernizaci a zavádění membránových technologií v různých průmyslových odvětvích. Dále je cílem projektu orientovat Českou membránovou platformu na popularizaci membránových technologií v českém prostředí. Prostřednictvím svých členů - vysokých škol, výzkumných organizací a průmyslových firem - přivést i další průmyslové podniky k využívání membránových technologií pro čištění odpadních vod a jejich recyklace. Propagací membránových technologií prezentovat již funkční recyklační jednotky a zařízení a tak povzbudit jejich využití u malých a středních firem a podpořit jejich využívání i u velkých společností .

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Vědecko-výzkumná činnost Oddělení chemického inženýrství:

Vědecko-výzkumná činnost je realizována v rámci základního a aplikovaného výzkumu, formou doplňkové činnosti i v rámci konzultačních poradenských služeb v následujících oblastech:

1. Membránové separační procesy

- **Charakterizace separačních membrán**
  Studium a vývoj nových metod pro charakterizaci filtračních přepážek a mikrofiltračních membrán (distribuce velikosti pórů, integrity test, průtokové charakteristiky tekutin).
- **Mikro- a ultrafiltrace**
  Stanovení a studium procesních charakteristik, intenzifikační metody (např. vliv rotace membrány, fluidní vrstvy, statických vestaveb, dvoufázového toku kapalina-plyn a zpětného promývání membrány na retenci membrány a intenzitu toku permeátu), matematické modelování procesu zejména se zaměřením na separaci ve vícekanálových keramických membránách.
- **Nanofiltrace a reverzní osmóza**
  Stanovení a studium základních procesních charakteristik, diafiltrace, příprava velmi čisté vody, začlenění těchto procesů do složitějších technologických celků.
- **Difuzní dialýza a elektrodialýza**
  Separace anorganických kyselin ze směsí obsahujících anorganické kyseliny a jejich soli, stanovení základních transportních charakteristik, matematické modelování difuzní dialýzy. Studium transportu organických kyselin iontově výměnnými membránami. Výzkum rovnováhy roztok/membrána v binárních a ternárních systémech. Základní procesní charakteristiky elektrodialýzy.

2. Hydromechanické procesy

Stanovení filtračních charakteristik zařízení pro koláčovou filtraci tuhých částic z newtonské i nenewtonské kapaliny.

3. Čištění odpadních vod

Kombinované systémy čištění odpadních vod se zaměřením na membránové separace a biotechnologické procesy.

Přístrojové a softwarové vybavení:

- experimentální zařízení pro testování membrán a software pro vyhodnocení distribuce velikosti pórů
- míchané mikrofiltrační cely
- cross-flow jednotky pro ultrafiltraci a mikrofiltraci disperzních systémů
- mikrofiltrační jednotka se zpětným promýváním membrán
- jednotka pro nanofiltraci a reverzní osmózu Armfield
- univerzální testovací jednotka pro tlakové membránové separační procesy Rhodia
- přístroje pro měření zeta potenciálu a distribuce velikosti částic v disperzních soustavách (Brookhaven BI-Zeta PALS, Malvern Zetasizer Nano ZS)
- vsádkové dialyzační cely
- laboratorní kontinuální dialyzér
- laboratorní elektrodialyzér

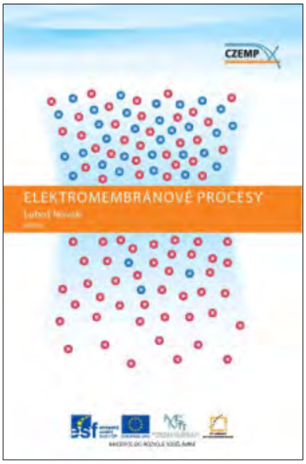

Vědecko-výzkumná činnost Oddělení ochrany životního prostředí:

1. Vývoj spektrálních metod prvkové analýzy se zaměřením na analýzu složek životního prostředí, biologických materiálů, materiálovou chemii a vzorků malých rozměrů zahrnující:
   – metody statistického plánování a vyhodnocení laboratorního experimentu s ohledem na řešenou problematiku
   – postupy přípravy vzorku pro roztokové i nedestruktivní analytické metody (kryogenní mletí, tavení, lisování, mikrovlnný rozklad)
   – využití optické emisní spektrometrie s buzením v indukčně vázaném plazmatu (ICP OES), hmotnostní spektrometrie s ionizací v indukčně vázaném plazmatu (ICP MS), atomové absorpční spektrometrie s elektrotermickou atomizací (ETA AAS), spektroskopie lasem indukovaného mikroplazmatu (LIBS) a rentgenfluorescenční spektrometrie (XRF)
2. Osud látek v životním prostředí (studium chování kontrastních látek na bázi gadolinia a jódu používaných v medicínských zobrazovacích technikách)
3. Vývoj metodik pro testování ekotoxicity nanomateriálů na půdních organismech
4. Vývoj metodik kryogenního mletí materiálů pro analytické a technologické účely
5. Toxikologické hodnocení léčiv – výpočet parametrů pro validaci čištění (PDE)
6. Testování nových elektrodových materiálů pro voltametrická měření. Studium voltametrického chování biologicky aktivních látek a kontaminantů životního prostředí. Vývoj nových elektroanalytických metod pro stanovení škodlivých látek v životním prostředí a bioaktivních látek jako jsou léčiva, vitamíny, pesticidy, aj.
7. Monitoring vodních ploch pomocí družicového dálkového průzkumu Země.

Přístrojové a softwarové vybavení:

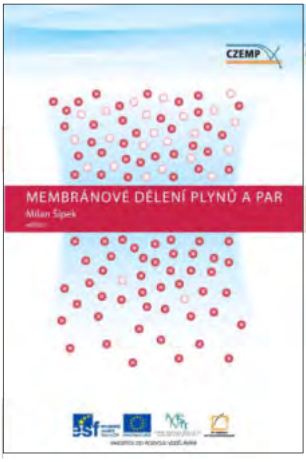
- Optický emisní spektrometr s buzením v indukčně vázaném plazmatu (Integra XL, GBC Austrálie)
- Hmotnostní spektrometr s ionizací v indukčně vázaném plazmatu (Optimass 9500 a Optimass 8000, GBC Austrálie)
- Atomový absorpční spektrometr s elektrotermickou atomizací (UltraZ, GBC Austrálie)
- Rentgenfluorescenční spektrometr (ElvaX, Elvatech)
- LIBS spektrometr (Lea S500, Solar TII)
- Příprava vzorku k analýze: tavička (LeNeo, Claise), Analytické přístroje:
- Analyzátor AOX Multi X 2500 se softwarem Multivin
- Kryogenní mlýn (Freezer/Mill 6875, Spex),
- mikrovlnný rozklad vzorků (Speedway Xpert, Berghof)
- Polarografické analyzátory Eco-Tribo Polarograph se softwarem POLAR.PRO
- Potenciostaty/galvanostaty AUTOLAB PGSTAT 12 se softwarem NOVA
- Spektrofotometrický analyzátor Libra S22, UV/VIS

Pracoviště poskytuje servisní a poradenské služby v oblasti prvkové analýzy.



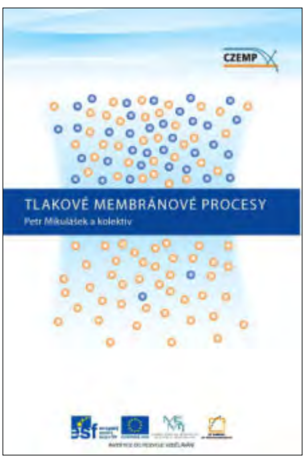
Kniha **ELEKTROMEMBRÁNOVÉ PROCESY** se zabývá problema?kou využi? iontově selek?vních membrán v průmyslu i v ochraně životního prostředí. Značná pozornost je věnována elektromembránovým separačním procesům (elektrodialýze, elektrodeionizaci), membránové elektrolýze a rovněž velmi aktuální problema?ce elektromembránových systémů pro konverzi energie (palivovým článkům a elektrolýze vody ve vodíkové ekonomice).

V monografii je popsána také teorie elektromembránových procesů.



Kniha **MEMBRÁNOVÉ DĚLENÍ PLYNŮ A PAR** popisuje metody, které nacházejí uplatnění v průmyslu chemickém, potravinářském a farmaceu?ckém a umožňují např. separovat vodík, oxid uhelnatý, oxid uhličitý, sulfan a jiné plyny ze směsí plynů, získávat dusík ze vzduchu, upravovat zemní plyn, odstranit páry organických látek ze vzduchu. V monografii pojednáno také o polymerních membránách pro dělení plynů a par a o teore?ckých aspektech tohoto procesu.

Do monografie je zahrnuta i kapitola o pervaporaci, velmi důležitém membránovém procesu dělení kapalných binárních směsí, kapitola o zušlechtění bioplynu a kapitola o membránové des?laci.

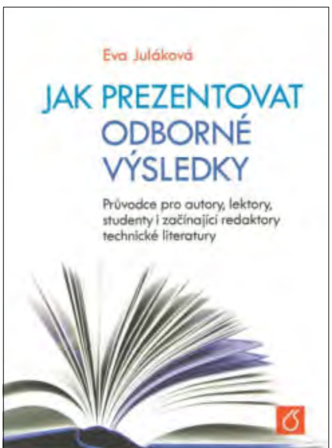


Kniha **TLAKOVÉ MEMBRÁNOVÉ PROCESY** obsahuje historický vývoj tlakových membránových procesů, popis membránových materiálů, zařízení a jeho prvků, teorii transportu látek membránami a faktorů ovlivňujících výkonnost procesů, teore?cký popis (modelování) toku při separaci, metody intenzifikace, návrh membránových jednotek a aplikace tlakových membránových procesů a zařízení v chemickém, farmaceu?ckém a potravinářském průmyslu, v biotechnologiích a při zpracování odpadních vod.

Publikace **MEMBRÁNOVÉ PROCESY** je určena všem pracovníkům, kteří se zabývají možnostmi využi? membránových procesů v nejrůznějších oblastech lidské činnos? a studentům přírodovědných a technických oborů. V deví? kapitolách kniha pojednává o teorii transportu látek membránami, membránových materiálech, tlakových membránových procesech (elektrodialýze, elektrodeionizaci, elektrolýze, elektroforéze, palivových článcích), membránových reaktorech a vybraných difúzních procesech (separaci plynů a par, pervaporaci, difúzní dialýze).

Membránové procesy v současné době nacházejí uplatnění v průmyslu chemickém, petrochemickém, potravinářském, vodárenském, elektrotechnickém, automobilovém, ve zdravotnictví, v energe?ce, v ochraně životního prostředí a mnohých oblastech našeho běžného života. O významu základních membránových procesů, které patří k technologiím 21. stole?, se lze dočíst právě v této brožuře.

Brožura je určena především učitelům technických předmětů a jejich studentům na středních školách, neboť informuje o nejdůležitějších membránových procesech, jejich principech a využi?.



Hlavním posláním knihy je určitě kul?vovat český písemný projev který zdaleka neřeší sofis?kované textové editory a které bohužel upadá snad je to současnou explozi textu všeho druhu které nemají šanci být všechny přečtené nelítostné nebo lépe neobratné zacházení s češ?nou a invaze anglické grama?ky do naší mateřš?ny i když předkládaná kniha není jenom češ?ně do anglič?ny a všech jazyků pla? že dobře v nich psát pokládá je dobře umět a tak se celou knihou lehce nese skromné přání autorčino nadchnout některé zvídavé čtenáře pro dráhu lektorů či dokonce redaktorů a to jistě není málo.
(prof. Bohumil Kratochvíl)

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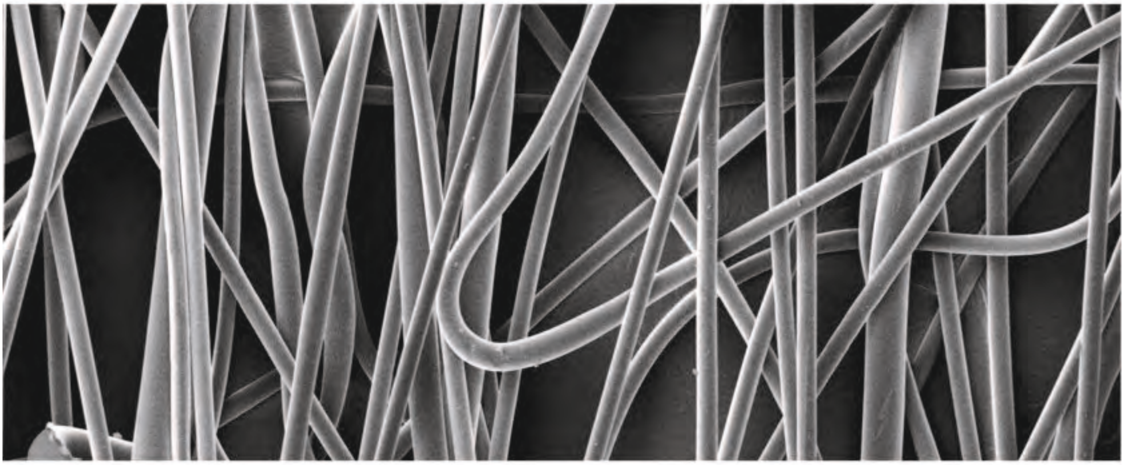

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