1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title:

HORIZON MSCA DN "MemFast" - Separation, fractionation and valorisation of fusel oils towards pharmaceuticals, cosmetics, thinners and automotive ingredients (lubricants)

1.1. Project goals

This is a part of the HORIZON MSCA DN project "Membranes as Enablers for Future Biorefineries: from Fabrication to Advanced Separation Technologies – MemFast" (3 years project).

The main goals of the project are following – identification, separation, fractionation and valorisation of the components of fusel oils (a by-product of ethanol fermentation), by using the membrane separation and classical separation techniques.

1.2. Outline

Fusel oils are by-products of bioethanol production and they are mostly the aqueous mixture of C2-C5 alcohols, constituting 0.10-0.15wt.% of raw ethanol. Owing to the expanding production of bioethanol, there is an expanding need for the processes enabling the utilisation of these side streams. Various research show that fusel oils can contain even up to 150 different compounds and that is considered as raw material for various value-added products. The condition for effective management of fusel oils is their full or partial dehydration, separation and further processing towards the desired products. The main goal of the project is to develop an innovative method for dewatering of fusel oils, using a membrane separation technique (PV in liquid or vapor phase) followed by their separation and further processing (esterification, catalytic dehydration) towards products possessing high market potential (solvents, thinners, biodegradable lubricants, active pharmaceutical ingredients). Chemometrics methods will be utilized for the optimization of the separation process. During the industrial secondment at Membrain company novel PV membranes will be developed and tested.

The successful candidate will sign the 3 years contract as the research assistant at NCU in Torun. The candidate will join Membranes and Membrane Techniques Research Group at Faculty of Chemistry NCU in Torun under the supervision of prof. Wojciech Kujawski. The group is also a part of Emerging Field project "Applied Polymers, Nanomaterials, Membranes, and Composites" formed within Excellence Initiative – Research University. More information about the group can be found here:

https://sites.google.com/view/membranesncu/

The detailed information regarding this PhD, HORIZON MemFast project, and Membranes and Membrane Techniques Research Group can be provided upon the request to prof. Wojciech Kujawski (wkujawski@umk.pl).

1.3. Work plan

- preparation of the review paper related to the main subject of the PhD project (M1-M3)
- identification of the components of fusel oils by using selected analytical techniques (M1-M5)
- dehydration, separation and fractionation of fusel oil components by using various separation techniques, e.g. pervaporation, nanofiltration, extraction (M2-M12)
- processing of the selected components towards pharmaceuticals, cosmetics, thinners and lubricants (M10-M24)
- application of chemometrics methods for the processes optimization (M13-M24)
- secondments (M25-M36)
- dissemination of the project results as JCR papers and during conferences and schools – M3-M33
- preparation PhD Thesis followed by the thesis defence – M27 - M36

1.4. Literature *(max. 10 listed, as a suggestion for a PhD candidate)*

1. .W. Kujawski, W. Capała, M. Palczewska-Tulińska, W. Ratajczak, D. Linkiewicz, B. Michalak, *Application of Membrane Pervaporation Process to the Enhanced Separation of Fusel Oils, Chemical Papers 56 (2002) 3*
2. N. Nemestóthy, T. Bányai, K. Bélafi-Bakó, L. Bartha, L. Gubicza, *Biotechnological Utilisation of Fusel Oil for Biolubricant Production, in Food Industrial Processes – Methods and Equipment, ch. 8, Dr. Benjamin Valdez (Ed.), 2012, ISBN: 978-953-307-905-9, www.intechopen.com.*
3. N. Dormo, K. Belafi-Bako, L. Bartha, U. Ehrenstein, L. Gubicza, *Manufacture of an environmental-safe biolubricant from fusel oil by enzymatic esterification in solvent-free system, Biochemical Engineering Journal 21 (2004) 229*
4. C. Vauclair, H. Tarjus, P. Schaetzel, *Permselective properties of PVA-PAA blended membrane used for the dehydration of fusel oil by pervaporation, Journal of Membrane Science, 125 (1997) 293*
5. L. Ferreira, M. Kaminski, A.J. Mawson, D.J. Cleland, S.D. White, *Development of a new tool for the selection of pervaporation membranes for the separation of fusel oils from ethanol/water mixtures, Journal of Membrane Science 182 (2001) 215*
6. A. Guvenc, N. Kapucu, H. Kapucu, O. Aydogan, U. Mehmetoglu, *Enzymatic esterification of isoamyl alcohol obtained from fusel oil:Optimization by response surface methodolgy, Enzyme and Microbial Technology 40 (2007) 778*
7. L. Padilha de Lima et al., *From waste to raw chemicals: Catalytic transformation of fusel oil by mixed metal oxides, Applied Catalysis B: Environment and Energy 351 (2024) 123985*
8. J. Serrano-Jimenez et al., *Electrochemical reforming of a fusel oil stream from the winery industry: New insights for a circular economy based on renewable hydrogen, Fuel 350 (2023) 128728*
9. P. Szczepański, W. Kujawski, J. Kujawa, *Application of selected chemometric methods to*

describe and predict the properties of grafted ceramic membranes, Separation Purification Technology, 323 (2023) 124468

10. *J. Mendoza-Pedroza et al., Recovery of alcohol industry wastes: Revaluation of fusel oil through intensified processes, Chemical Engineering and Processing - Process Intensification 163 (2021) 108329*

1.5. Required initial knowledge and skills of the PhD candidate

MSc studies in Nature Sciences (preferred: chemistry , biology).

Good bases of physical chemistry, inorganic and organic chemistry, and analytical chemistry.

Good working knowledge of membrane separation processes (e.g., membrane preparation /polymeric, mixed matrix membranes, ceramic membranes/, pervaporation, nanofiltration, membrane distillation, ultrafiltration), analytical techniques (e.g., GC, HPLC, GC/HPLC – MS), membrane characterization techniques (e.g., SEM, TEM, AFM, TGA, contact angle, zeta potential, DLS).

Knowledge of English language – B2 level

1.6. Expected development of the PhD candidate's knowledge and skills

During the education in AST doctoral school, student will acquire learning outcomes corresponding to level 8 of the Polish Qualifications Framework with regards to knowledge, skills and social competences.