Summary of results and outputs delivered from the project

In the project (01.12.2017-31.01.2022), the following key-scientific results have been obtained by our international Korea-Visegrad (Czech, Polish, Hungarian) consortium:

Batch biohydrogen fermentations with respect to optimal hydrogen gas yield and production rate using mixed culture inoculum in the presence of ionic liquids (IL) were studied. The ILs are considered as chemicals for efficient lignocellulose biomass pretreatment and could therefore be adopted to increase the digestibility of algal biomass, which is a key-feedstock in our investigation. It turned out from the experiments on model substrate glucose (a carbohydrate present in algal biomass) that ILs such as [bmim][Cl] and [bmim][Ac] could contribute to process enhancement in terms of biohydrogen yield, if their concentrations are adequately chosen. The kinetic analysis based on the modified Gompertz-model has revealed however that excessive concentrations of ILs inhibited the fermentation [1]. The most important characteristics of a continuous biohydrogen fermenter where membrane technology is used for reactor off-gas purification were assessed. Such system, being in the core of this project, is referred as the Gas Separation Membrane Bioreactor (GS-MBR). As the innovative, continuous mode GS-MBR is formed by the direct integration of membrane gas separation to dark fermentative hydrogen-producing reactor, its establishment should be concerned with the adequate design and operation of membrane modules as well as the efficient cultivation and use of algae [2]. Additionally, the potential of gas separation membrane technology for enhancing the dark fermentative biohydrogen production process was analyzed. The perspectives for this research direction were enlightened to indicate how the bioreactor off-gas could be exploited (e.g. after purposefully adjusting its quality by a membrane) for the intensification of liquid-to-gas phase mass transfer conditions, resulting in the improved recovery of biohydrogen [3]. Theoretical considerations and modelling aspects of the integrated membrane gas separation process towards hydrogen/carbon dioxide separation were duly evaluated, as well [4]. For sufficient hydrogen/carbon dioxide separation, a polyetherimide (PEI) membrane module (designed by the Czech collaborators of the project) was tested. The feed gas composition in terms of H_2 (54.8 vol%) and CO_2 (45.2 vol%) concentrations was selected based on operating the continuous biohydrogen fermenters (in South Korea). The PEI module installed to the gas separation process was characterized by gas permeability and selectivity values, obtained under various driving forces, stage-cuts and temperature. It was found that at 2.55 bar transmembrane pressure difference, stage-cut of 0.79 and temperature of 28 ^{o}C, 79.2 vol.% CO_2 could be reached in the retentate. Thus, the suitability of the membrane for the enrichment of carbon dioxide was concluded. A retentate stream with such a high CO_2 content seems to be promising for subsequent utilization in algae-cultivating photobioreactor according to the core idea of our proposed, integrated gas separation membrane bioreactor system [5]. The appropriate publicity of the results has been provided during the project, for instance in the frame of the PERMEA international conference [6].

In total, from our Hungarian side, we have contributed to and published 5 high quality (D1/Q1 ranked) journal articles [1-5] with a cumulative impact factor of 26.505, receiving already a nice number of (50) independent citations (based on Scopus database as of 14.02.2022).

Hence, in the opinion of the principal investigator, despite the Coronavirus pandemic, the goals of the international project have been achieved well. The importance of findings is justified by the quality/quantity of publications as well as the notable number of independent citations. All journal items listed below [1-5] in the Reference list contain the acknowledgement dedicated to the funding agency (National Research, Development and Innovation Office, Hungary) for supporting the project under grant number NN 126995.

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