Separation of lipids, proteins and hydrocarbons from microalgae using a coupled supercritical CO_2 extraction/fractionation device

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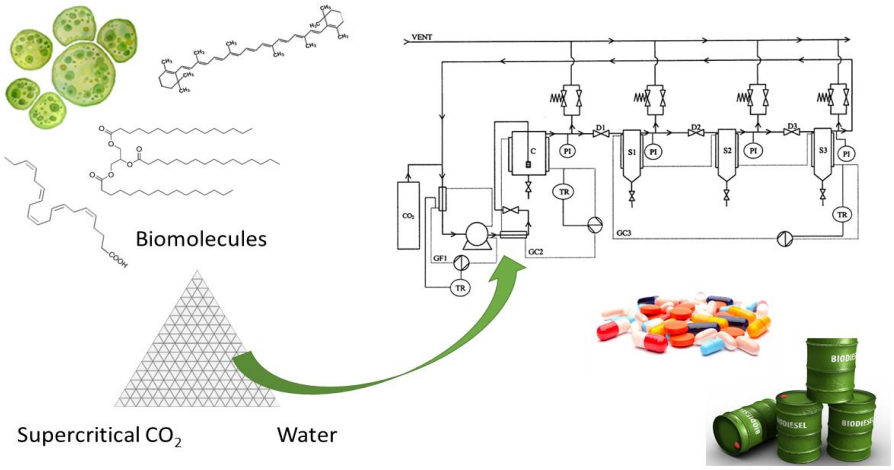

Fossil fuel depletion, one of the biggest challenge of this century, drives the development of alternative energies. Microalgae stand for a potential green and sustainable source of biofuels, as they may produce high levels of lipids and/or hydrocarbons comparable to petroleum fuels. In addition to the direct production of biofuels, microalgae can be processed into fuels instead of first extracting oils and post-processing. These conversion technologies include pyrolysis, gasification, liquefaction or anaerobic digestion [1]. Moreover, algal biomass can also contain valuable biomolecules such as polyunsaturated fatty acid or carotenoids with nutraceutical, pharmaceutical or cosmetic industrial applications.

Conventional extraction process using polar (methanol, ethanol, and acetone) or apolar solvents (hexane, toluene, diethyl ether) has been carried out to separate target molecules from the other algal constituents [2][3]. Supercritical CO_2 may be an attractive alternative, allowing the solvent power modulation in an easy way, while avoiding thermal degradation of valuable extracts and residual solvent traces. However, high water content of algal biomass may hinder the development of competitive supercritical extraction processes.

A coupling between extraction and continuous countercurrent fractionation processes in supercritical CO_2 medium was considered in this study without any microalgae pre-treatment. A mixture of lipids, proteins and/or hydrocarbons, has been considered as representative simulant of microalgae biomass medium. Solubility measurements of lipids, hydrocarbons and proteins will be carried out in suitable pressure (80-300 bar) and temperature (40-100°C) operating ranges. Such data allow to determine operating conditions as the best compromise between extraction yield and selectivity. Moreover, the creation of thermodynamic and flow-balance models will be implemented from these specifications to size and scale-up the fractionation column device form height equivalent to a theoretical stage calculation. The size of the column will be adapted to microalgae production harvesting flows. Last but not least, a pilot scale extraction fractionation process will be built according to previous results so as to consider nominal operating regime guaranteeing highest extraction yield and selectivity, minimizing hydrodynamics instabilities so as validate the proof of concept. The project aims to support the scale-up of the biorefinery concept applied to microalgae, which strives to be more profitable by recovering both biofuel substrate and high-added value biomolecules.

[1]: El Bekadi, Université de Nantes (2009), available on https://core.ac.uk/display/55514857 [2]: Kumar et al., *Fron Energy Res* 2:61 (2015, available on https ://doi.org/10.3389/fenrg .2014.00061; [3]: Lee et al., *Environ Chem Lett (*2020), available on https://doi.org/10.1007/s10311-020-01088-5