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The SYNFERON project

DTU

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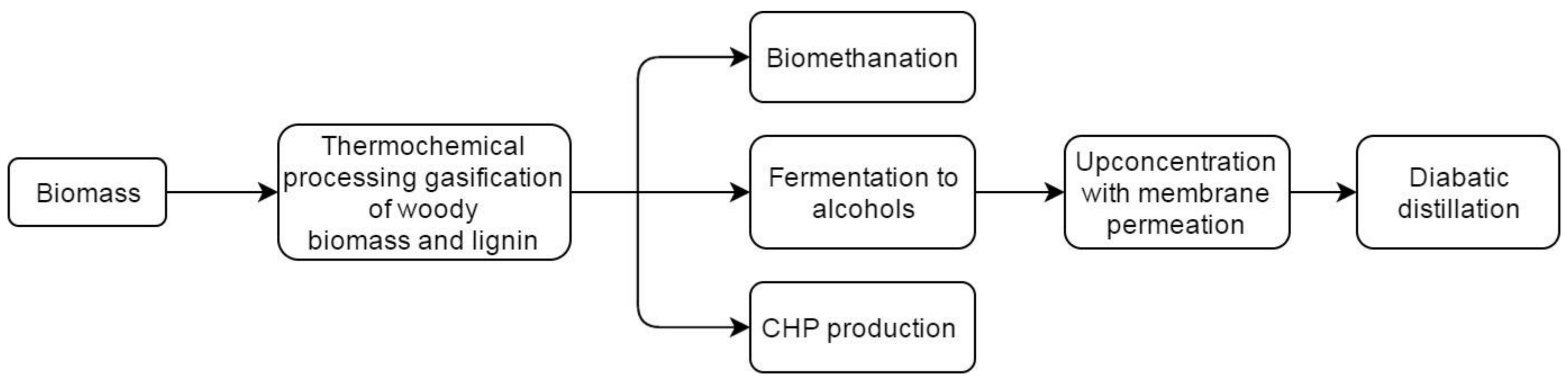
Introduction

Biofuels production for use as liquid motor fuels or for blending with conventional gasoline is increasing worldwide. Ethanol alone makes up the largest share of such biofuels. Conventionally, ethanol is produced from readily fermentable carbohydrates such as sugars and starches. The availability of such agricultural feedstocks is limited, because of competition with food and feed production, arable land usage, water availability. Consequently, forest residues, trees from plantations, straws, grasses and other agricultural residues may become viable feedstocks for bio fuel production. However, the very heterogeneous nature of lignocellulosic materials makes them inherently recalcitrant to bioconversion. An alternative technology is biomass gasification to syngas and then ferment it with anaerobic microorganisms to produce biofuels such as ethanol, n-butanol or chemicals such as acetic acid, butyric acid and the like.



Gasification combined with CHP, syngas fermentation to gaseous and liquids fuels with liquid products upconcentration and separation.

SYNFERON

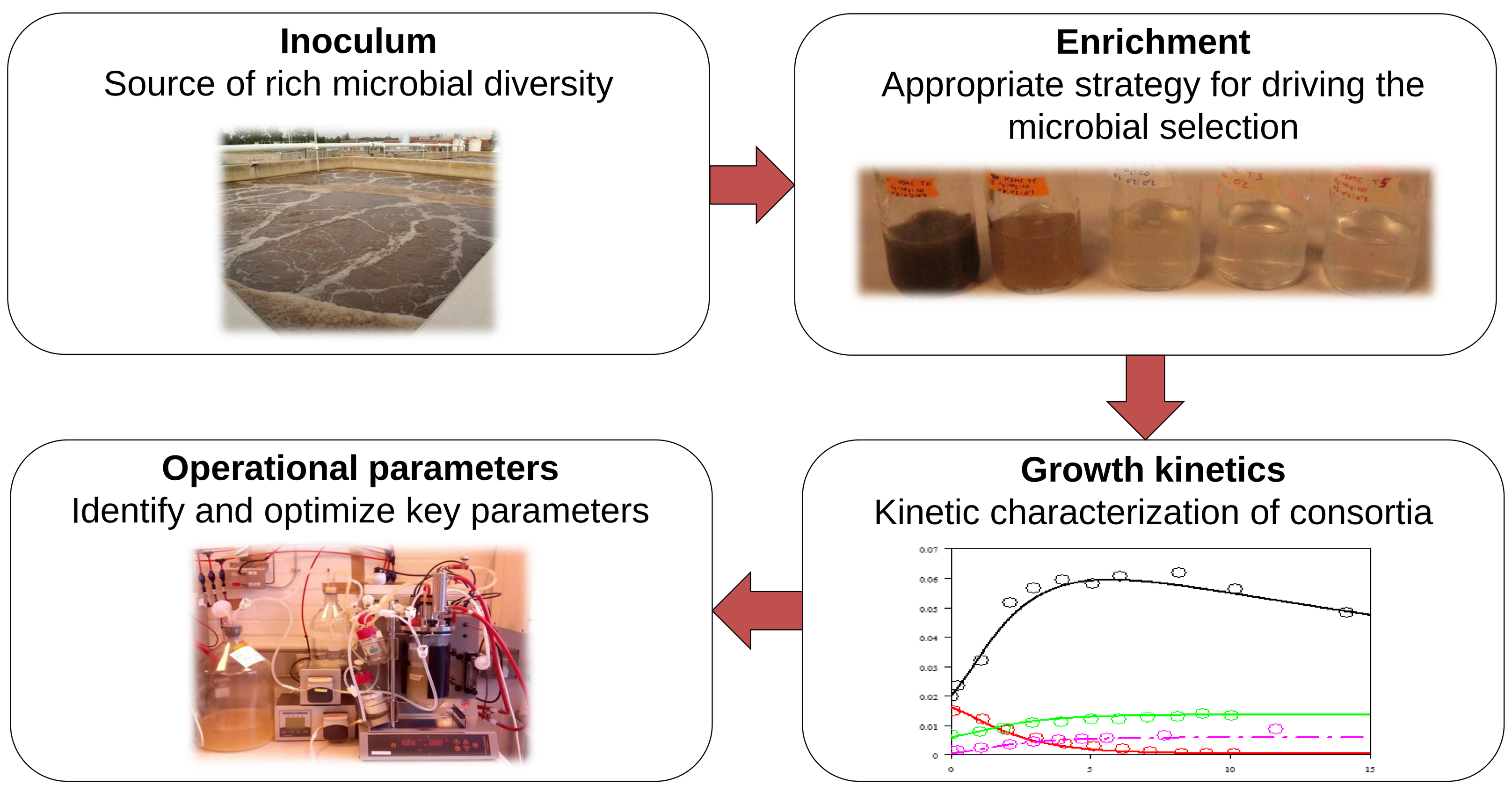
The technological focus and scientific objectives within SYNFERON are:

1. Fermentation of syngas to liquid (alcohols) and gaseous (methane) biofuels
2. Design of novel bioreactors, pressure control and use of suitable surfactants for increasing the gas/liquid mass transfer efficiency
3. Use of biomimetic membranes and development of diabatic distillation for gentle and cost-efficient purification of liquid biofuels and
4. Development of an optimized process design and comparison with existing technologies

Differently from the current commercial technologies, which mainly focus on liquid biofuels production, a more flexible layout will be considered, merging Combined Heat and Power (CHP) production with the fermentation of syngas. When the heating demand is high, the syngas will mainly be exploited through CHP but when the heating demand is low, the syngas will be fermented to storable liquid or gaseous biofuels, thus matching the energy markets requirement

Mixed microbial consortia for syngas fermentation

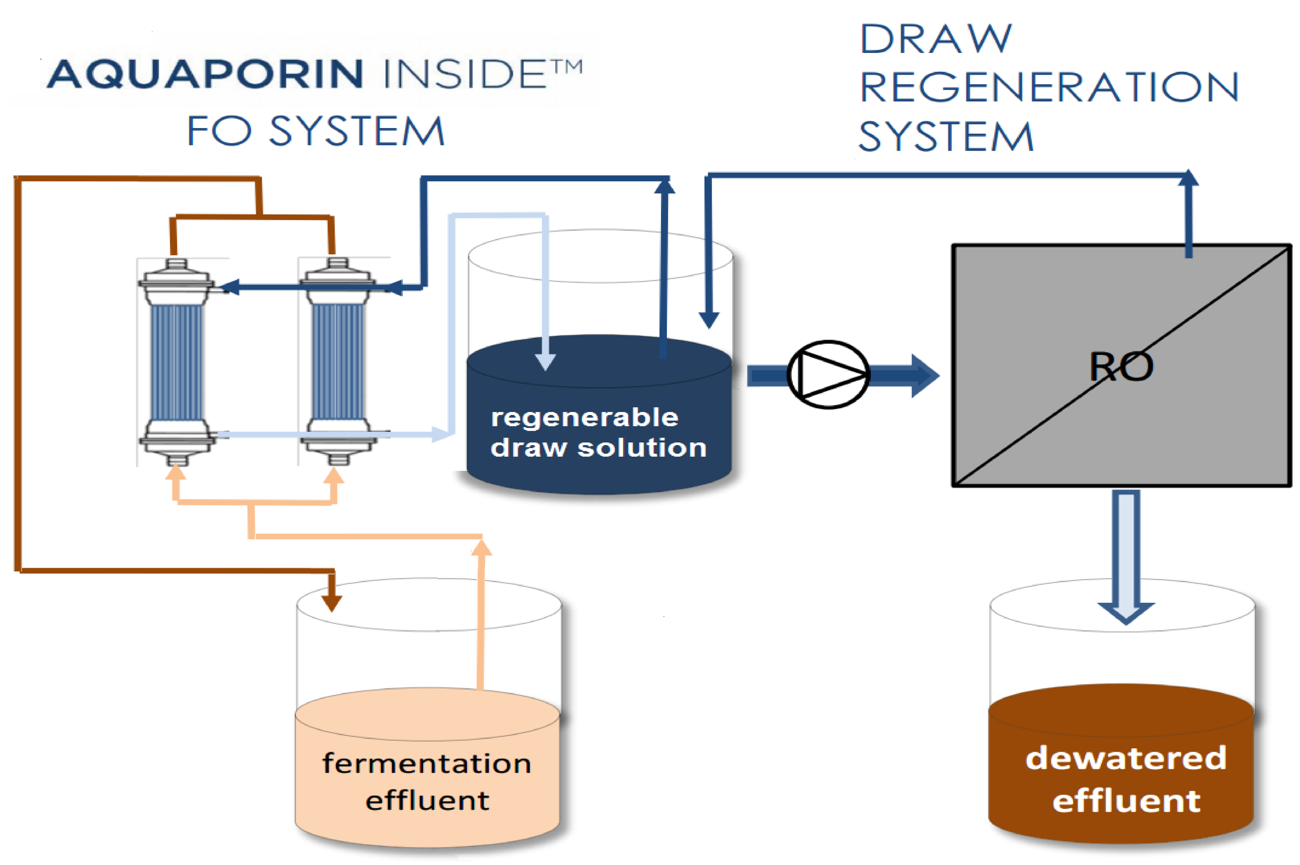
SYNFERON targets the challenging aspect of eliminating the need of maintaining sterile conditions during syngas fermentation by applying open mixed culture fermentation (MCF). The big asset of MCF is the lower operation cost compared to pure wild and/or genetically engineered microbial strains.



Operational framework of MMC bioconversions: the key factor for developing MMC based bioprocesses is to selectively enrich the desired metabolic activities by applying a suitable selective pressure and microbial enrichment strategy

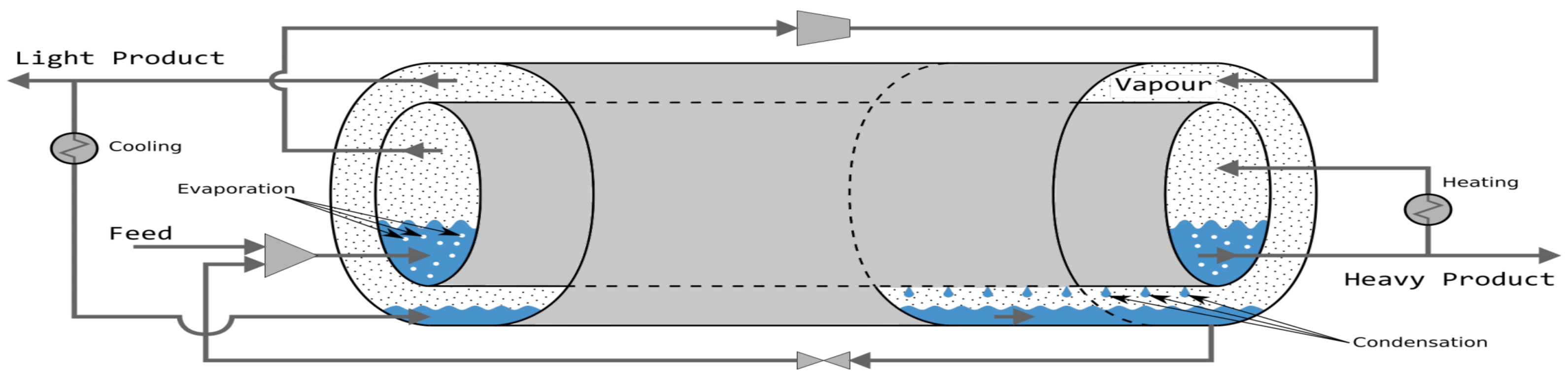
Concentrating and separation of liquid alcohols

Biomimetic (aquaporin) membranes will be applied for concentrating the liquid products based on forward osmosis.



Aquaporin-like biomimetic membranes, which have the ability to separate water by forward osmosis with very low energy requirements and a huge application potential in relation to up concentrating the bioreactor effluent stream and thus substantially decreasing the cost of the subsequent separation/purification technologies

The target in SYNFERON is a more energy-efficient downstream separation method, to meet these challenges an horizontal distillation systembatic distillation for separation of alcohols will be investigated.

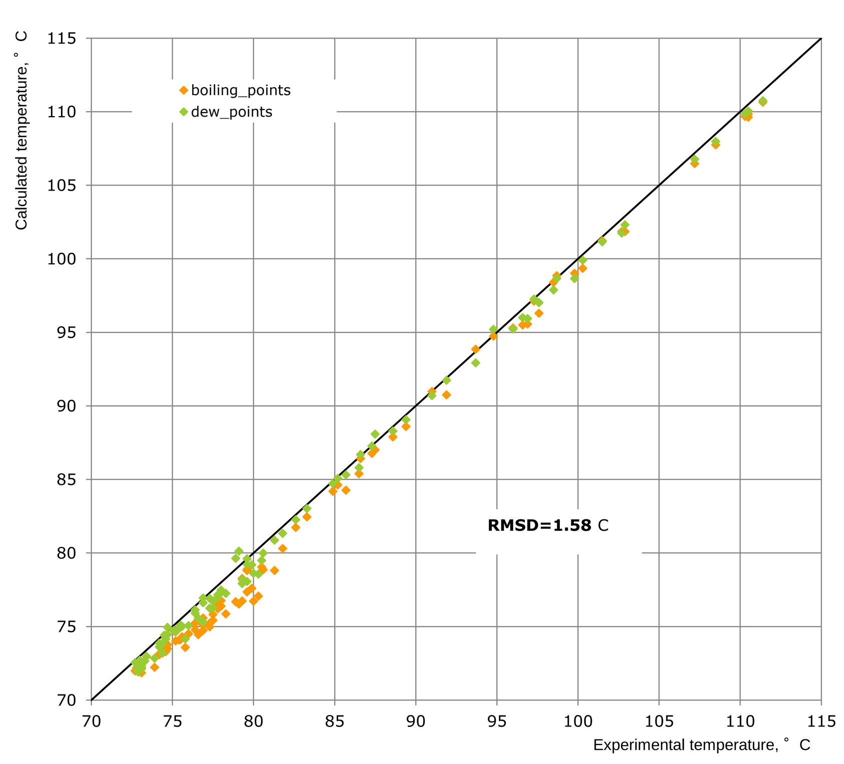


Diabatic distillation approach and new horizontal distillation system will offer energy savings over 40-60% of the energy consumption of a traditional adiabatic column

Process simulation

In the contest of WP4, regarding engineering analysis of the existing platforms, after the identification of the most probable products and side-products from the fermentation, a thermodynamic consistency study was conducted in order to verify the reliability of the models available in Aspen Plus in explaining equilibrium data found in literature for similar systems.

Prediction of quaternary system: Ethanol-Acetic Acid-Ethyl Acetate-Water



For highly non-ideal and strongly associated mixtures and moderate pressures: an activity coefficients model coupled to a modified virial equation of state have been found appropriate. UNIQUAC model for the liquid phase, and O'Connell modified virial equation for the gas phase

LanzaTech waste gas to fuel demonstration plant at Shougang Steel Mill

An example of commercial scale facility is the LanzaTech process. Differently from its competitors the process does not consider any gasification, indeed all its commercial scale plats exploit a waste gas obtained as by-product of steel production. Two of their facilities are located in Shougang Steel Mill in Beijing and BaoSteel Steel Mill in Shanghai

References

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