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RECOVERY OF CHEMICALS PRODUCED IN AQUEOUS MEDIUM BY ACIDOGENIC FERMENTATION

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Introduction

Molecules such as ethanol and acetic, propionic, butyric and lactic acids are consumed on a very large scale by the industries (millions tons/year). Their esters are also largely used as solvents. Most of these molecules are currently synthesized from oil and gas. Decreasing oil reserves and environmental concerns motivate the use of alternate and renewable sources of energy and commodity chemicals. A more sustainable option could be to derive these molecules via the acidogenic fermentation of biomass. As compared to ethanol fermentation, which requires sugar, the acidogenic fermentation allows to use other, less precious, feedstock's, such as beet leaves. Acidogenic fermentation leads, however, to more dilute and complex aqueous fermentation broths. Hence, the separation of the produced chemicals from the water is challenging. Many recovery processes can potentially be used. Nevertheless, the process which is technically, energetically and environmentally the most efficient is not easy to identify or to develop.

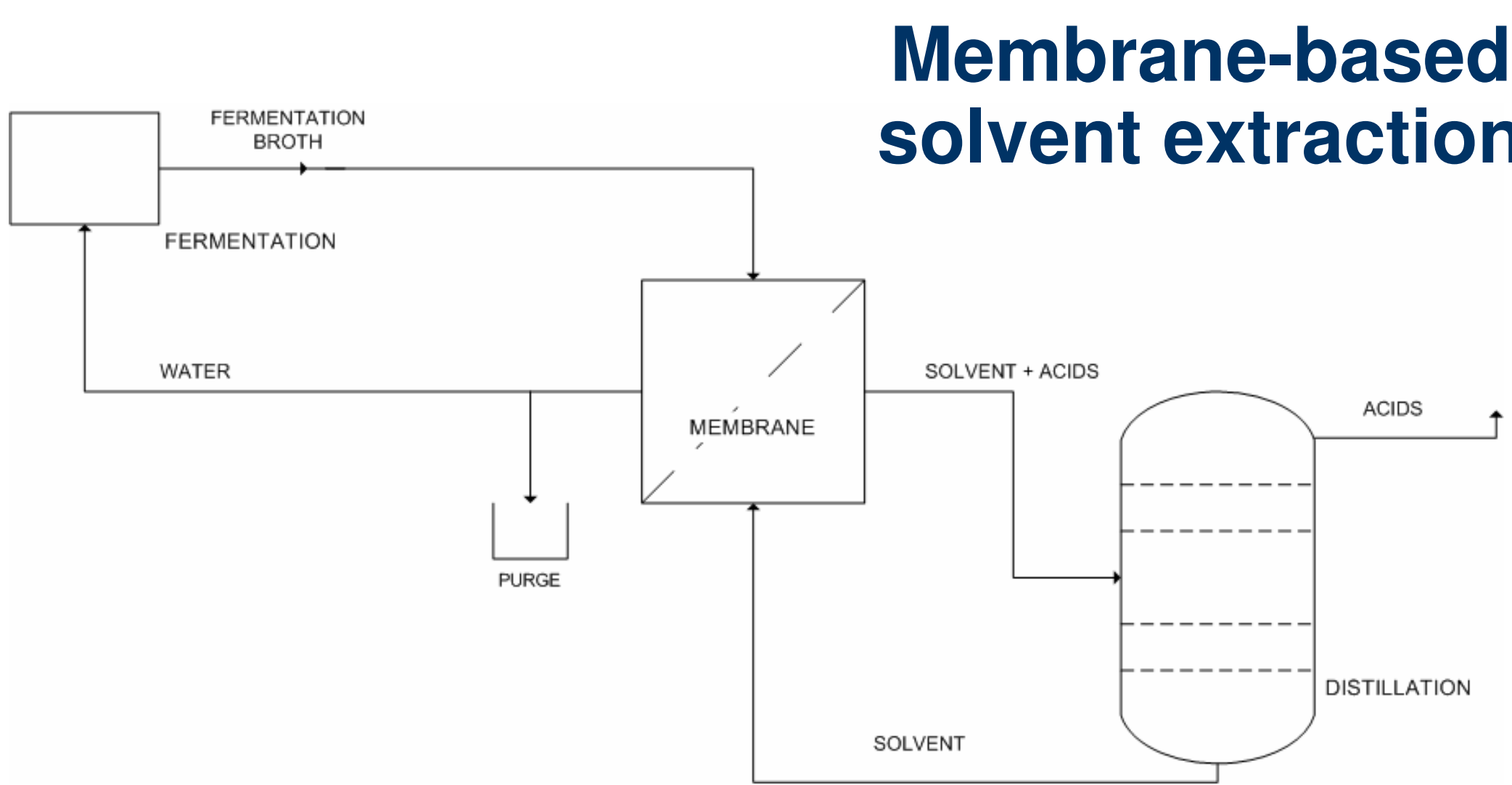
Our research aims at **identifying the most efficient recovery processes** with special attention to technical as well as energy constraints and environmental impacts.

Approach

The first step of our research consists in comparing the expected maximal efficiencies of the available technologies. In order to limit the experimental work, a theoretical approach has been developed. Data on the recovery of acids from acidogenic fermentation are either taken from the literature, calculated, or obtained by simulations. In the next phase, laboratory scale experiments will be carried out with the most promising techniques. Separation efficiencies and energy needs will be measured. The experimental data will allow to develop models for scale-up. Finally, the process performances on an industrial scale will be evaluated and be used to assess the energy and environmental balances.

Separation techniques

Presently, one of the most used techniques for the recovery of acids is precipitation. Precipitation is, however, shown to be very expensive and not environment friendly (Wasewar, 2005). Another commonly used technique is distillation. Since water is more volatile than the acids to be recovered, distillation requires considerable amounts of energy to vaporize the water. Membrane technologies emerge as separation techniques for organics compounds (Gaikwad, 2004) and can be considered as a promising alternative for extraction by solvent.



In membrane-based solvent extraction, the dilute target molecules in the fermentation broth are transferred preferentially through the membrane to a downstream solvent. Depending on the solvent, it remains to be investigated if this process is really more pertinent than the direct extraction by solvent, i.e. if the use of a membrane really allows to improve the separation.

References

[1] Gaikwad, A. G. (2004), Transport studies of lactic acid through supported liquid membrane, Chem. Biochem. Eng. Q., 18 (3), p 285-293
[2] Wasewar, K. L. (2005), Separation of lactic acid: recent advances, Chem. Biochem. Eng. Q., 19 (2), p 159-172

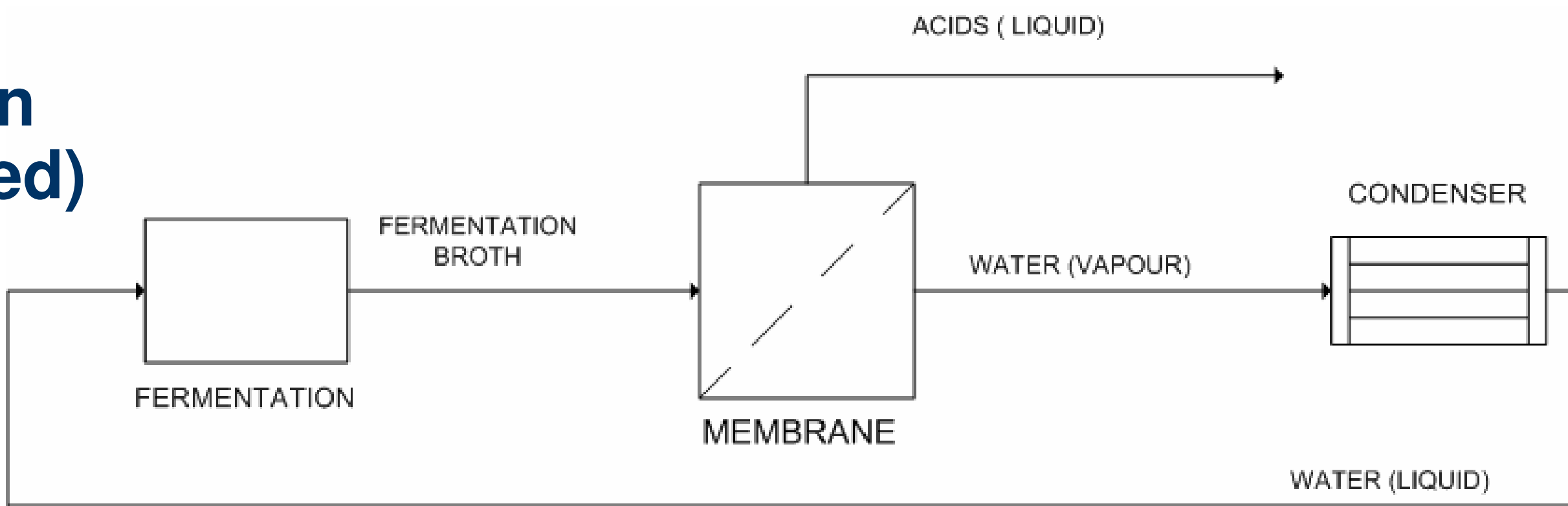
Acidogenic fermentation

The main difficulty in the separation of the target molecules lies in their low concentration in the water. Indeed, acidogenic fermentation leads to very dilute and complex aqueous solution. The concentration of the acids in the water is then less than 1%.

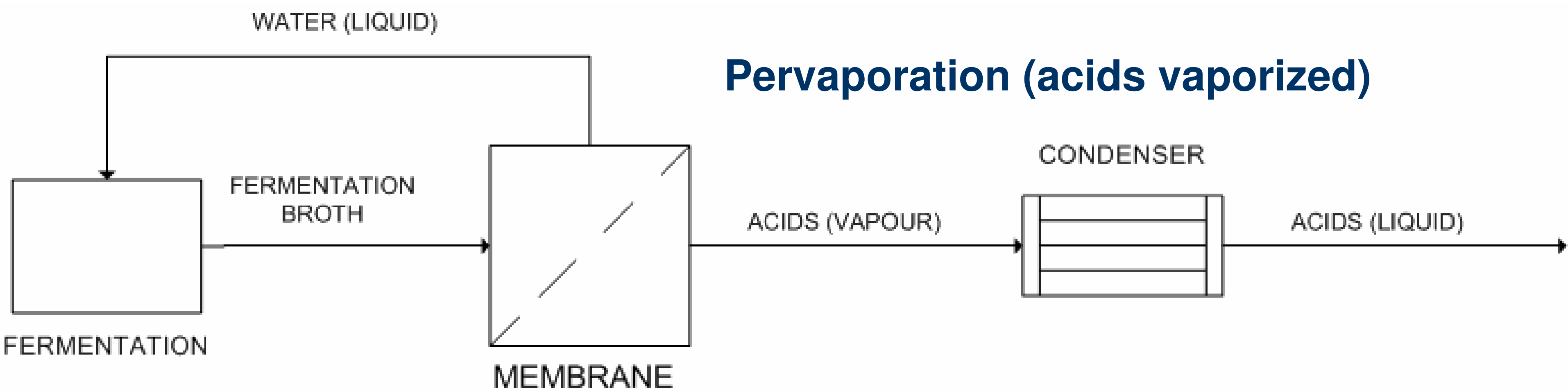
Typical composition of target molecules

Molecules	Concentration
Ethanol	0.5 – 5 g/l
Acetic acid	1 – 10 g/l
Propionic acid	0.1 – 1 g/l
Butyric acid	0.5 – 5 g/l
Lactic acid	1 - 10 g/l

Pervaporation (water vaporized)



In case of water pervaporation, important water flow rates will have to be vaporized and transferred through the membrane. As such, pervaporation of the water does not seem more interesting than distillation and very expensive from the energy point of view. Furthermore, it needs considerable investments.



When applying acid pervaporation, only the small concentration acids have to be vaporized, avoiding the vaporization of important water amounts. So far, no membrane both permeable for the acids and impermeable for water exists. In view of the extremely low concentration in acids of the solution to be separated, a high selectivity for the acids is crucial.

A new membrane is to be developed that is permeable for acids and impermeable for water.