Membranes for sustainability

Clean air

The 2°C climate target can only be achieved by strictly avoiding CO_2 emissions. Separating CO_2 from exhaust gas streams and processing H_2 are separation tasks that are essential for a future industrial society in order to reduce CO_2 pollution on the one hand and produce valuable substances on the other.

Clean water

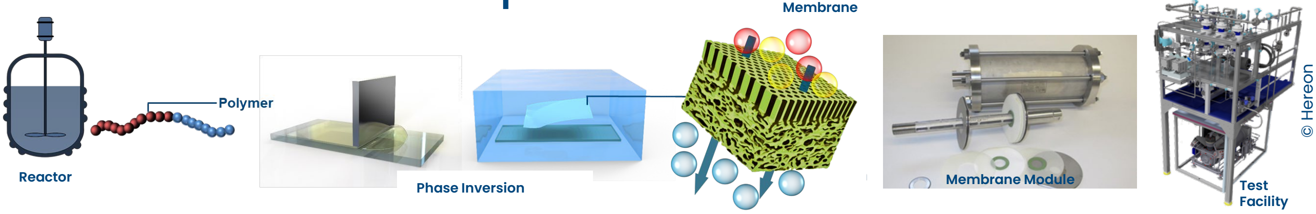
Millions of people worldwide have little or no access to clean water. Regions that are already suffering from water shortages due to climate change are particularly affected. Therefore, the sustainable supply of drinking and process water is one of the major challenges of the coming decades.

Institute of Membrane Research:

Our contribution to problem solving

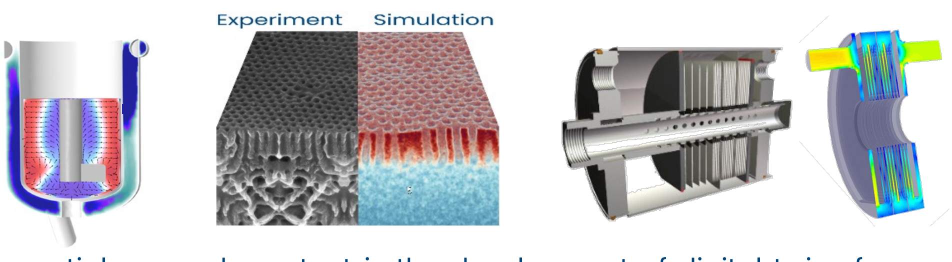
Water shortage, climate change and the energy transition - material separations play a central role in these challenges. In order to contribute to solving these global problems, the Institute of Membrane Research develops innovative membrane processes for both liquid phase and gas phase applications. In doing so, it follows a holistic, interdisciplinary approach.

Holistic membrane development



Our membrane research covers the entire research and development chain. Interdisciplinary teams synthesize new polymers on a laboratory and pilot scale and test their suitability as membrane materials. The next step is to develop the production of membranes on a square meter scale and to design apparatuses, i.e. membrane modules, that enable their technical use. These modules are then examined in test facilities for various separation tasks.

Digital Twin



$$\frac{d\dot{n}''_{R,i}}{dz} + \varepsilon_R \cdot a_R \cdot \dot{n}''_{M,i} = 0$$

$$\frac{d}{dz}\left(\tilde{H}_R \cdot \sum_{i=1}^{nc} \dot{n}''_{R,i}\right) + \varepsilon_R \cdot a_R \cdot \dot{e}''_M = 0$$

$$\dot{n}''_{M,i} = L_i \cdot \left(f_{RM,i} - f_{PM,i}\right)$$

An essential research content is the development of digital twins for our experimental activities. They allow us to gain a deep understanding of the fundamental scientific relationships and enable the development of new separation processes. We simulate chemical reactions and model the formation of membrane structures. Experimental data are digitally recorded and evaluated using artificial intelligence methods. In parallel, systems of equations are set up that describe substance separation and flow in membrane modules and thus enable the simulation of separation processes.

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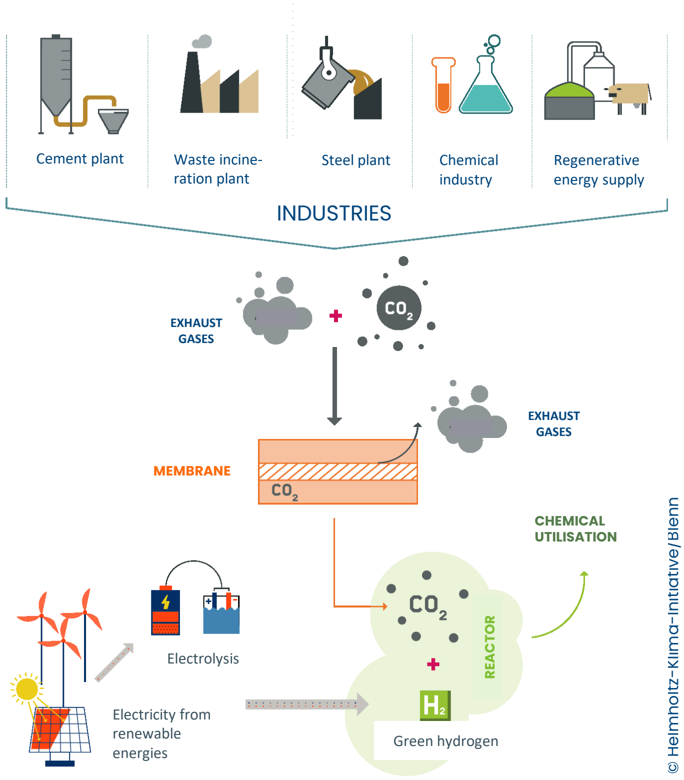
Applications

Power-to-X

New valuable substances are created from CO_2 and regeneratively produced hydrogen.



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CO_2-Separation

For the separation of CO_2, we use thin-film composite membranes: these are CO_2-selective separation layers up to 70 nm thin, embedded in a supporting structure that provides stability. These membranes are in turn located in membrane modules that are connected in such a way that streams with 95 vol.-% CO_2 are obtained from exhaust gases containing 15 vol.-% CO_2. The energy required for this of 230 kWh/t_{CO_2} is significantly lower than with other processes.

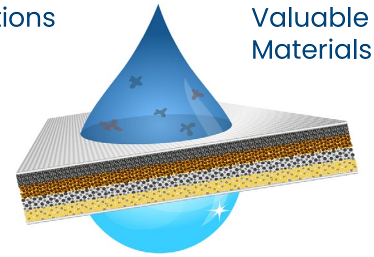
H_2-Processing

Similar membranes are used for the separation or purification of H_2: e.g. H_2 can be separated from the natural gas grid with membranes or dried after electrolysis and is thus available for further use. It can serve either directly as a fuel or via membrane reactors to produce new substances (power-to-X). Here, the combination with metal hydride storage systems for hydrogen developed by Hereon plays an important role.

Separation of pollutants and recovery of raw materials from water

There are many applications for membrane technology in water treatment, and the energy requirement is often lower than for conventional processes. Membranes can be used, for example, for the separation or recovery of

- Industrial waste (e.g. dyes)
- toxic salts (e.g. arsenates)
- agricultural residues (e.g. nitrate)
- strategically important components (e.g. lithium salts)



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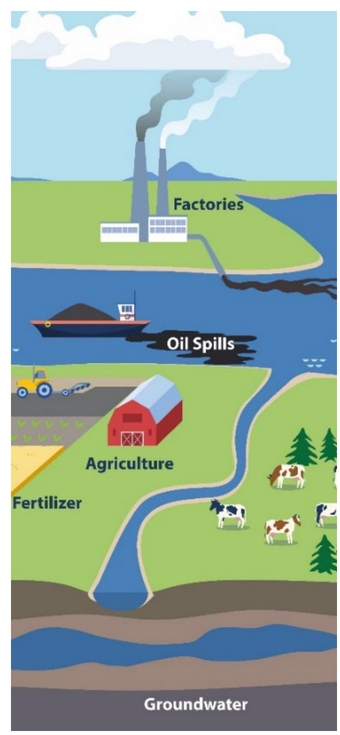

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