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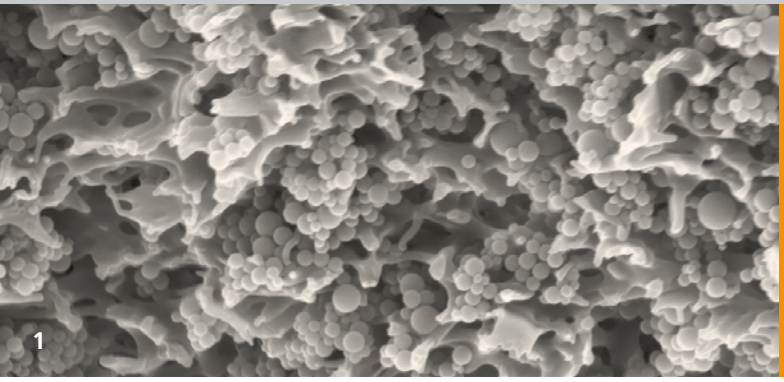

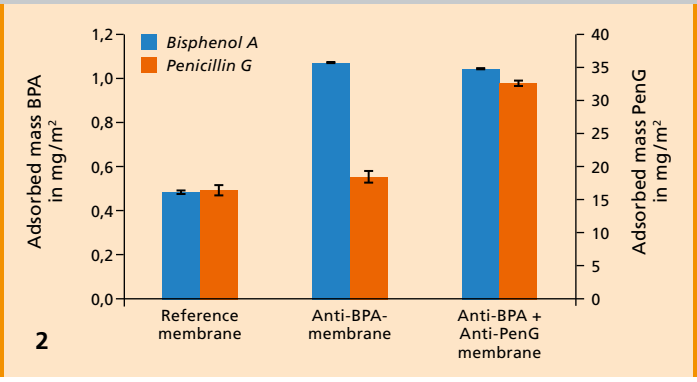

1 *SEM image of a particle-filled polyethersulfone flat membrane.*

2 *Simultaneous adsorption of hydrophobic Bisphenol A and negatively charged Penicilin G at IGB membrane adsorbers.*

MEMBRANE ADSORBERS – SEPARATION OF VALUABLE MATERIALS AND POLLUTANTS

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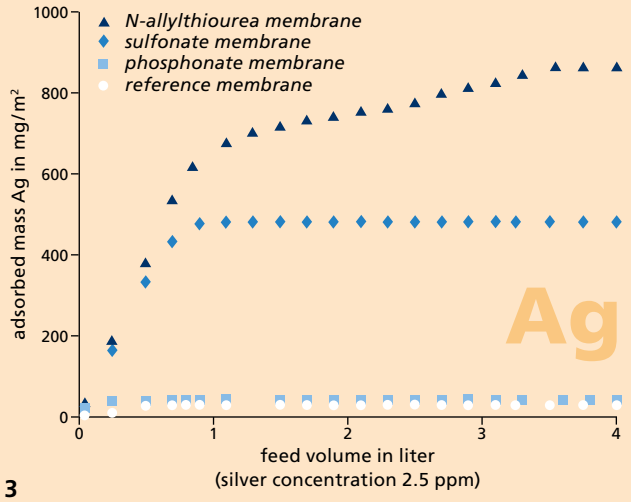
Nowadays various types of membranes for water filtration are already available through commercial channels. A common feature of these membranes is that substantially different separation cut-offs are used for size exclusion. On the other hand, the underlying porous structure, which provides a highly specific surface, remains unused. Membranes for nanofiltration (NF) and reverse osmosis (RO) can in fact partially retain molecular and ionic substances. However, high pressures are necessary for this, which pushes up both the investment and the operating costs.

In principle adsorbers can be used to remove molecular contaminants. Typical adsorber materials are microporous, so as to provide a large specific surface for adsorption. A disadvantage of these materials is the limited mass transport, since the micropollutants have to diffuse into the inner porous structure of the adsorbents. This leads to low dynamic adsorption capacity at high flow rates which are needed for the treatment of large volume streams.

There is therefore a need for new integrated separation systems. For this purpose we are developing mixed-matrix membranes that, in addition to their filtration function, can adsorptively bind substances dissolved in water at high flow rates with high dynamic adsorption capacities. The variation of the particle surface and the combination of different particles enables us to manufacture membrane adsorbers with separation characteristics that can be adapted flexibly for applications in the areas of:

- Drinking water
- Process water
- Wastewater.



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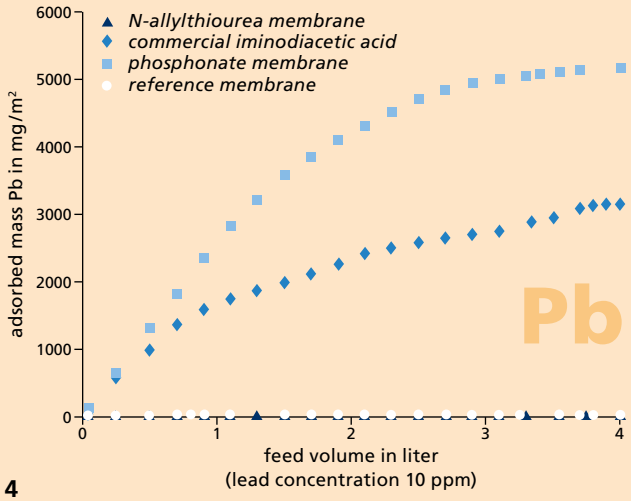

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Functional adsorber particles

We have developed sub-micron particles by advanced polymerization technique. The particles are between 50 nm and 500 nm in size and can be synthesized from a variety of different, commercially available monomers. Such particles offer the best compromise of specific surface, security and functionality and are compatible with the phase inversion process used for the manufacturing of porous membranes.
A large number of particles with different functional surface groups are available. The spectrum of functional groups ranges from the fairly hydrophobic pyridine, by way of cationic ammonium compounds to anionic phosphonates and also thiourea functions.

Membrane adsorber

The adsorber particles were embedded in polyethersulfone flat membranes by means of a phase inversion process which is used in industry for preparation of MF membranes and UF membranes. This showed that, quantitatively, up to 40 percent by weight of the particles can be integrated in the membranes. These membranes show high water flux values in the range of MF membranes and UF membranes. It was also shown that different particles can be combined in one membrane. In this way various micropollutants, for example, can be removed with just one membrane adsorber. So to say we can produce tailor-made membranes for a specific separation problem.

Selective adsorption of valuable materials or (micro-)pollutants

Different tests showed the good selectivity of these membrane adsorbers. If one compares the adsorption behavior of silver on various membrane adsorbers, it can be seen that the reference membrane without particles exhibits practically no unspecific adsorption. On the other hand, the membrane with sulfuric thiourea groups selectively binds over 0.8 g silver per m² (Fig. 3). However, if one tests the adsorption behavior of various membrane adsorbers with aqueous solutions that contain lead ions it is obvious that the phosphonate membrane adsorber adsorbs the highest amounts of toxic lead ions (up to 5 g per m², Fig. 4), even more than a commercially available membrane adsorber. Another membrane adsorber developed at the Fraunhofer IGB is able to bind two molecules with different chemical properties simultaneously. This membrane adsorbs Bisphenol A (BPA) and the antibiotic Penicillin G (PenG) (Fig. 2).

Regeneration of the membrane adsorbers

The regenerability of the systems is important for the cost-effectiveness of the membrane adsorbers. So far we have been able to find suitable solutions for a quantitative desorption in all the adsorptions investigated. Thus copper, for instance, can be completely removed from the membrane adsorber using small amounts of diluted nitric acid. Even membrane adsorbers for micropollutants such as bisphenol A can also be completely regenerated by means of a pH shift.

Services at a glance

- Development and synthesis of specific adsorber particles
- Feasibility studies
- Conception and preparation of selective mixed-matrix membrane adsorbers as flat sheet or hollow fiber membrane
- Characterization of the separation performance

3 *Adsorption of silver ions on membrane adsorbers with different functional groups.*

4 *Adsorption of lead ions on membrane adsorbers with different functional groups.*