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Editorial corner – a personal view

Where porous polymers can make a difference

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Consider making more from less; to perform their function effectively, do materials have to be non-porous bulk materials? Polymer foams are all around us, they retain warmth and repel noise, provide comfort where we sit and sleep, support supply chains by protecting valuable goods from damage, and are crucial firestop agents.

Porous polymers can be broadly defined as polymers containing a dispersed gas phase. The gas phase can be free to move or may be encapsulated within interconnected or closed-celled polymer networks. The amount of gas phase within the polymer defines the material's density and porosity. The absence of bulk material within pores produces not only 'empty' space but also much more accessible surface area. This increased surface area allows for the vast improvement of processes that occur at surfaces and interfaces, provided the adsorbate has suitable surface chemistry. Exploitation of this effect is beneficial to many applications, such as separation and storage, energy conversion, tissue engineering, mixing, and catalysis.

Porous materials can be categorised by pore size. Pore diameters exceeding 50 nm are macropores, between 2–50 nm mesopores, and those with pore diameters <2 nm are called microporous materials. An array of methods are available for the synthesis of all of these materials, ranging from macropore templating (https://doi.org/10.1002/anie.201801466), over phase separation approaches (https://doi.org/10.1002/ijch.202000003), to the bottom-up molecular design of various microporous polymers (https://doi.org/10.1021/acs.chemrev.9b00399).

The search for effective adsorbent/separation materials has emerged as a crucial research topic due to climate change and the pressing need for ever-more energy efficient separation processes (https://doi.org/10.1038/532435a). Process optimisation alone results in energy savings, however, the development of more effective separation processes, including those utilising porous materials, will allow for more significant improvements. For example, the isolation of propylene and ethylene from their alkane equivalents via cryogenic distillation alone accounts for ~0.3% of the world's energy consumption. Looking forward, distillation may be avoided using adsorbents. It was shown that tailoring the surface properties of porous organic polymer composites via Ag-loading allows for selective adsorption of alkenes over alkanes due to π-interactions with Ag(I) (https://doi.org/10.1016/j.cej.2021.131628).

Catalysis using porous polymers has also emerged as a promising route to low-energy transformations. The coupling of chemically inert frameworks, high temperature tolerance, high surface areas, and effective mass transfer make porous polymers ideal candidates for many catalytic processes. Due to the crosslinked nature of many porous polymers, they are non-soluble in all reaction systems, making them attractive heterogeneous catalysts that are easily recovered and regenerated, post-reaction. Examples of such catalytic processes are vast and include conversion of CO_2 into solar fuels, water splitting, and many organic transformations (https://doi.org/10.1002/adma.201802922).

Combining micro- and macroporosity within one material imparts both high surface area for effective catalysis and improved mixing of reagents, allowing for process miniaturisation and intensification (https://doi.org/10.1016/j.ces.2022. 118151).

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Porous organic polymers are distinguished from other classes of porous materials, such as metal-organic frameworks and zeolites, by their chemical robustness and tailorability. Their future is still unfolding and lends itself to excite the next generation of materials scientists and chemists. In our new Master module comprising 'Porous Organic Materials' and 'Where porous materials can make an impact: 7 chemical separations to change the world' we see this increased curiosity first hand and hope to continue to push the frontier of this class of materials.

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