Technique captures and separates benzene air pollution

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Led by scientists at the University of Manchester, a series of new stable, porous materials that capture and separate benzene have been developed. Benzene is a volatile organic compound (VOC) and is an important

feedstock for the production of many fine chemicals, including cyclohexane. But it also poses a serious health threat to humans when it escapes into the air and is thus regarded as an important air pollutant.

The research published today (Feb 24) in the journal *Chem*, demonstrates the high adsorption of benzene at low pressures and concentrations, as well as the efficient separation of benzene and cyclohexane. This was achieved by the design and successful preparation of two families of stable metal-organic framework (MOF) materials, named UiO-66 and MFM-300.

These highly porous materials are made from metal nodes bridged by functionalized organic molecules that act as struts to form 3-dimensional lattices incorporating empty channels into which volatile compounds can enter.

VOCs such as benzene are common indoor air pollutants, showing increasing emissions from anthropogenic activities and causing many environmental problems. They are also linked with millions of premature deaths each year. Benzene is one of the most toxic VOCs, and is classified by the World Health Organization as a Group 1 carcinogen to humans.

"The really exciting thing about these materials is that they allow us not only to capture and remove benzene from the air, but also to separate benzene from cyclohexane, which is an important industrial product often prepared from benzene," says Professor Martin Schröder, lead author of the paper published in *Chem*.

"Because of the small difference in their boiling points (just 0.6 °C) the separation of benzene and cyclohexane is currently extremely difficult and expensive to achieve via distillation or other methods."

Conventional adsorbents, such as activated carbons and zeolites, often suffer from structural disorder which can restrict their effectiveness in capturing benzene. This new research also reports a comprehensive study of the adsorption of benzene and cyclohexane in these ultra-stable materials to afford a deep understanding of why and how they work.

"The crystalline nature of MOF materials enables the direct visualization of the host-guest chemistry at the atomic scale using advanced diffraction and spectroscopic techniques," says Professor Sihai Yang, another lead author on the paper.

"Such fundamental understanding of the structure-property relationship is crucial to the design of new sorbent materials showing improved performance in benzene capture."

More information: Martin Schröder, Control of the Pore Chemistry in Metal-Organic Frameworks for Efficient Adsorption of Benzene and Separation of Benzene/Cyclohexane, *Chem* (2023). DOI: 10.1016/j.chempr.2023.02.002. www.cell.com/chem/fulltext/S2451-9294(23)00066-9

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