New technology for customized air purification of toxic gases

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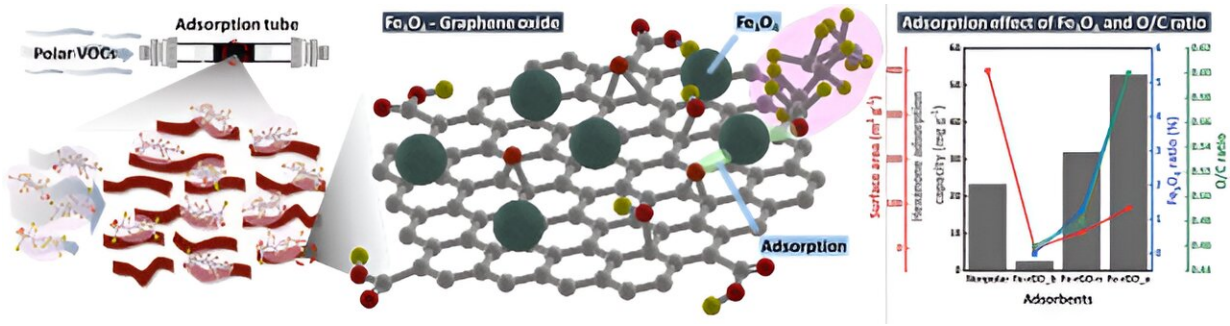

Adsorption mechanism and adsorption performance graph of iron oxide graphene adsorbent for polar VOCs. Credit: Korea Institute of Science and Technology

Volatile organic compounds (VOCs) in daily products such as paints, adhesives, furniture, cosmetics, and deodorants make our lives easier. However, constant exposure can cause serious health problems such as respiratory illness, headaches, dermatitis, and cancer.

Natural ventilation is the most effective way to reduce VOCs in indoor air, but recently, air purifiers have become a common method to maintain indoor air quality due to the frequent extreme outdoor condition (e.g., high concentration of fine dust, heat waves, and extreme cold).

Generally, air purifiers remove VOCs by adsorption using activated carbon, which has a non-polar carbon surface and a large specific surface area. This activated carbon can effectively remove non-polar substances such as toluene and benzene, but cannot remove polar substances such as ketones and aldehydes.

The Korea Institute of Science and Technology has reported that Dr. Jiwon Lee and Dr. Youngtak Oh from the Center for Sustainable Environment Research have developed a new adsorbent technology that can efficiently adsorb amphiphilic VOCs, which have both hydrophilic and hydrophobic properties and are difficult to remove with existing activated carbon technology.

The research was conducted as a major project of KIST (Air Environment Research Program) and was published on October 1 in the *Chemical Engineering Journal.*

The KIST research team synthesized a graphene-iron oxide heterostructure by precisely controlling the surface oxidation of graphite and iron, resulting in a high adsorption capacity for amphiphilic VOCs due to the increase of oxygen functional groups and iron oxide on the surface. This unique adsorbent showed up to 15 times better adsorption efficiency for amphiphilic VOCs than conventional activated carbon adsorbents.

They also found that precise oxygen functional groups and iron oxides control of the adsorbent can offer flexible surface optimization freedom for a desirable nature of the pollutant. By testing four different ketones that are difficult to control with activated carbon adsorbents, the researchers found the correlation between the length of carbon chains and the adsorption efficiency; by optimizing the content of oxygen functional groups and iron oxides in the adsorbent, they were able to bring the maximum removal efficiency for the ketones.

The researchers also analyzed the sub-nanometer electron transfer phenomenon between the adsorbent and VOC molecules; they found a link between the geometric shape of the pollutant and its adsorption trend for the first time. This is expected to enable the development of customized detection and control technologies for various air pollutants in our environment.

"Unlike previous studies that focused on mere improvement of the adsorption performance and regeneration efficiency of adsorbents, we succeeded in developing a breakthrough material that exceeds the limits of existing adsorbents using accessible materials such as graphite and iron, which have high commercialization potential," said Dr. Jiwon Lee.

More information: Seongbin Lee et al, Effect of adsorbate geometry and hydrogen bonding on the enhanced adsorption of VOCs by an interfacial Fe3O4–rGO heterostructure, *Chemical Engineering Journal* (2023). DOI: 10.1016/j.cej.2023.145346

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