Current and Future Trends in Adsorption for Environmental Separations

Journal of Hazardous Materials (JHM) publishes original scientific contributions that address environmental problems. Innovation in the treatment of contaminated liquid and gas phases via adsorption remains paramount to address challenges pertaining to environmental safety and sustainability, and JHM continues to be interested in papers describing associated advances. Adsorption science continues to progress, largely due to the discovery of new materials with unique textural and chemical characteristics that offer great potential to address timely environmental challenges. These new materials might improve adsorption capacity, kinetics, longevity, selectivity, or regenerability. However, it is essential that manuscripts submitted to JHM consider those critical aspects that make a new adsorbent environmentally relevant, including (1) contaminant removal considering environmentally relevant concentrations (e.g., ng L^{-1} to (sub) mg L^{-1} for contaminants of emerging concern in water), (2) removing contaminants from multi-component, competitive matrices, and (3) removing contaminants of emerging concern (e.g., pharmaceuticals, pesticides, microplastics, per- and polyfluoroalkyl substances). Furthermore, the connection between adsorption performance and relevant material characterization must be clearly established in the manuscript to warrant consideration in JHM. Results should be presented with statistical confidence by including relevant qualifiers (e.g. standard deviations in tables, error bars in figures). Method artifacts that are easy to control or correct for should be taken into account in the quality assurance procedures. Adsorption to non-settling phases may be important for compounds that have an extremely high affinity for the adsorbent, such as heavy metals and highly hydrophobic organic compounds with log K_{ow} > ~4. Studies that involve empirically testing an adsorbent performance at unreasonably high concentrations, or using dyes only, or lacking statistical confidence, are not likely to meet JHM publishing expectations.

Regeneration is also an essential criterion when benchmarking adsorbents for multi-cycle operations in water and gas treatment. Regeneration media and conditions should facilitate either reuse of recovered adsorbates (for valuables) or destruction to harmless products (for trace contaminants). In addition, many applications mandate continuous, flow unit operations; transient and dynamic adsorption studies are therefore of utmost importance to elucidate the pertinence of the solid material as a potential adsorbent in those cases. Authors must consider how their material/methodology would be realistically applied in the environment.

JHM continues to welcome efforts in the area of waste reuse to produce adsorbents, provided the work generates new knowledge, beyond what has been learned from studies on traditional adsorbents. It is necessary to consider the above-mentioned criteria when benchmarking this kind of adsorbents. As with other adsorbent studies, waste-based materials must be critically evaluated for their environmental performance and compatibility; *the novelty of such papers should be on controlling a hazardous material, not generating an adsorbent.* Benchmarking a new adsorbent (e.g., based on economics) can improve the impact of an analysis. Similarly, designer adsorbents should offer added value compared to low cost, industry norms. Economics is therefore another important factor to consider as part of the evaluation on adsorption performance. Estimates and analysis on the costs for developing adsorbents relative to those seen in the general state-of-the-art application end are just some examples of how to benchmark performance.

Adsorption and desorption mechanisms should be substantiated with relevant characterization (e.g., spectroscopy, microscopy, and/or chemical analyses). Computational studies (e.g., Density Functional Theory) used to elucidate adsorption mechanisms are appropriate for publication in JHM if accompanied by experimental uptake data that allows readers to make a direct connection with observations. The same should apply for efforts related to the discovery of adsorbents via high throughput computational efforts (e.g., Machine Learning/Artificial Intelligence). Manuscripts solely based on theoretical approaches or computational data to predict or model the adsorption of contaminants and/or new adsorbent formulations should be submitted to a more specialized Journal instead.

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