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Combining multiple functions to achieve process intensification in adsorptive separations

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There is a tendency in chemical industry to electrify thermal chemical processes in order to reduce carbon footprint [1]. Therefore, electrification of Thermal Swing Adsorption processes is also of interest. Alternative heating methods such as Joule heating (Electrical Swing Adsorption - ESA) [2], Microwave heating (Microwave Swing Adsorption - MSA) [3] and Magnetic Induction heating (Magnetic Induction Swing adsorption –MISA) [4] have been considered by various researchers to heat and regenerate the adsorbent bed. These methods have a number of advantages, such as the direct, contactless and localized heating of the bed, resulting in reduced heat losses; high heating rates and an on/off behavior, offering perspectives for improved process control and reduced cycle time.
Nevertheless, these electrified regeneration methods require materials that are compatible with the respective heating method. Joule heating requires an electrically conductive path, microwave heating requires dielectric properties for the adsorbent material and induction heating requires an adsorbent with magnetic properties. Obviously, common porous solids don't have all of these properties. Therefore, composite materials have to be developed such that the resulting hybrid adsorbent becomes susceptible to the applied heating method. Such materials can be shaped as beads, extrudates, 3D-printed materials or monoliths. This does not only affect the separation performance, but also the heating behavior.
In this paper, a number of approaches to prepare hybrid materials for electrified Temperature Swing Adsorption processes will be discussed, from literature and our own work. Examples in the field of carbon capture, direct air capture and solvent recovery will be given.

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