CO_2 capture using porous structured adsorbents

M. Rombouts, Y. De Vos, B. Sutens, S. Mullens

Coating and Shaping Technologies, Flemish Institute for Technological Research (VITO NV), Boeretang 200, 2400 Mol, Belgium

Solid adsorption based carbon capture is recognized as a promising approach because of its potential energy savings with respect to the commercial amine-based absorption capture technology. Moreover, it has a high flexibility towards CO_2 stream, like the ability to capture CO2 from very dilute flue gases or even from air. Typically in solid adsorption processes, packed beds of adsorbents, which are shaped in the form of pellets, beads or extrudates, are used. More recent developments include porous structured adsorbents in the form of monoliths or sheet laminates. An overview will be given of developed structured adsorbents, including sorbent coated honeycombs and 3D printed monoliths. The beneficial properties of such porous structured adsorbents compared to packed beds of beads in terms of lower pressure drop, better mass and heat transfer will be presented. These characteristics are especially beneficial when considering the operational and capital cost of the carbon capture process. The development of a new CO2 capture pilot for post-combustion carbon capture based on porous structured sorbent monoliths will be presented.

3D-printed hybrid zeolite structures constructed by a phase inversion process

B. Sutens, Y. De Vos, M. Rombouts , S. Mullens

Flemish Institute for Technological Research – VITO, Sustainable Materials Department, Boeretang 200, 2400 Mol, Belgium

Email for correspondence: ben.sutens@vito.be

Additive manufacturing is gaining increasing interest in the field of catalysis and gas separation applications due to the geometric flexibility for a wide range of materials. However, this process typically demands the use of a combination of organic and inorganic binders such as clays, silica or alumina to ensure mechanical integrity. As a result, these types of structures often are extremely brittle and require several post-processing steps involving thermal decomposition of the organic content which could lead to poor adhesion between the various components.

In this work, hybrid organic-inorganic composites were developed using the 3D micro-extrusion technique in combination with a phase inversion process. Due to the combination of the capture efficiency of the inorganic materials and the flexibility or toughness of a polymer matrix, a non-brittle hybrid composite adsorbent composed of a polymer skin encapsulating the uniformly distributed inorganic particles could be developed. Moreover, the ability to eliminate the required thermal treatment in conventional binder systems enables the direct shaping of a wide range of materials that are susceptible to oxidation or thermal decomposition including carbon-based materials, metals and various types of metal-organic frameworks (MOFs).

As a model case, zeolite 13X was used for H_2O and CO_2 adsorption while three different polymers were compared to evaluate the effect of the polymer nature on the porosity and zeolite accessibility. Extensive characterization was performed in terms of N_2, Ar and Hg porosimetry as well as static isotherm measurements and dynamic breakthrough curves. The developed polymer composites were compared with a 3D-printed zeolite-clay structure and other conventional structured zeolites, including pellets and wash coated honeycombs, to show the promising potential of this approach and the industrial applicability.