New membranes for mix gas and flue gas separation

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Keywords: Combustion, Non-porous membranes, SO2 and CO2 removal, Ultrapermeable polymer
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Combustion technology is a significant source of industrial emissions. Along with solid waste, various compounds produced during combustion are emitted in gaseous form. Although current methods for purifying waste gases allow flue gases released into the atmosphere to meet emission standards, these technologies are approaching their maximum separation capabilities. These membranes and the overall CC technology must also address pollutants such as SO2, NOx, and HX. We aim to determine whether our new separation method can be as effective as current polymeric membranes, as evidenced by several academic studies and pilot tests by membrane producers. Developing a process that efficiently removes SO2, NOx, HX, and recovers water without necessarily removing CO2 would be advantageous, especially since CC will be feasible only at sites where further processing is possible. Therefore, there may be a demand for efficient technology without CC, which can be combined with existing flue gas purification systems, particularly on smaller scales. A unique lab-scale apparatus for testing flue gas purification has been constructed. Using the tested flat sheet membrane Toray, we achieved purification of feed gas to levels required by the European Commission's 2021 legislation. Various separation conditions (pressure above and below the membrane, separation temperature, feed and sweeping gas flux) were tested to identify optimal parameters. Our results demonstrate the high separation potential of the "water condensing membrane" for SO2 and CO2 removal from flue gas. Another approach was to use the ultrapermeable polymer of intrinsic microporosity (PIM) based on a tetramethyltetrahydronaphthalene unit coupled with bicyclic triptycene (PIM-TMN-Trip). Permeation tests with a CO2-N2-O2-SO2 mixture, simulating flue gas from power plants, were carried out using an in-house developed permeation unit. The results demonstrated very high permeability of the membrane for sulfur dioxide (SO2) and high permeability for carbon dioxide (CO2), with values primarily between the Robeson upper bound from 2008 and the more recent upper bound reported in 2019. The membrane exhibited moderately high mixed gas selectivity for SO2 and CO2 relative to N2 (21 and 11, respectively), combined with very high permeability (28·10^3 and 30·10^3 Barrer, respectively), indicating its potential for industrial gas separation processes. The SO2/CO2 mixed gas selectivity was relatively low (around 1.8), but comparable to other novel membranes, with both gases being removed simultaneously during the CO2 separation process.

Acknowledgement: Financial support obtained from the Czech Science Foundation, projects 24-10288S, is gratefully acknowledged