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Post-combustion carbon capture by membrane separation, Review

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ABSTRACT

The human-induced increase in average global temperature since pre-industrial times (1850–1900 average) has already reached 1.0 °C in 2017 so there is a strong call for effective carbon capture and storage/utilization technology especially in the energy sector where the CO_2 emissions are the largest. Membrane technologies are often declared to be a good option. This work tries to find how the commercially available modules are doing from the economical and practical point of view and if there are some new membrane materials which could be feasible and practically applicable in the power plat post-combustion CO_2 separation. The main conclusion is that membrane technology is potentially suitable for fuel gas purification in the future but there are still some issues to be solved such as for example membrane resistance for humid feed stream, fouling and long-term stability of thin selective layer.

1. Introduction

Combustion is a significant industrial source of air pollution worldwide. Therefore, a variety of flue gas treatment systems are used and they are an essential part of many technologies that include combustion [1–7]. Often, a variety of pollutants have to be removed from flue gas, which affects the extent and complexity of the flue gas treatment system. Some aspects of flue gas treatment have a long history, e.g. the removal of particulate matter. Other problematics are relatively new, such as the reduction of NO_x, or removal of polychlorinated dibenzodioxins and dibenzofurans (PCDD/Fs) and/or mercury.

Because of the global temperature rising of which anthropogenic CO_2 is considered to be the major cause, there is a demand for CO_2 capture technologies. Now, one of the key strategies to achieve lower greenhouse gas emissions is carbon pricing, either in the form of carbon allowances or a carbon tax. The carbon tax can currently (2019) range from a few (e.g. Japan) to over one hundred (e.g. Sweden) €/ton of CO_2 equivalent [8]. The carbon allowance price has reached almost 30 €/ton of CO_2 equivalent (July 2019) within the European Union Emission Trading Scheme (EU ETS). The EU ETS is one of the first and so far the biggest carbon markets worldwide and regulates the greenhouse gas emissions from large scale facilities in the energy (e.g. power plants) and industry sectors [9]. This concerns 31 countries (EU + Iceland, Norway, and Lichtenstein), moreover, additional countries, such as China, South Korea, Canada, Japan, New Zealand, Switzerland, and the United States, have implemented separate national or regional systems within the EU ETS [10]. According to the policy of greenhouse gas control of the EU, the emissions of greenhouse gases should be 21% lower in 2020 and 41% lower in 2030 compared to 2005. The price of a CO_2 emission allowance rocketed to the current price from 4.38 €/ton of CO_2 equivalent in May 2017 [11,12] and may reach 40 €/ton [13] by 2023. Writing such an article in 2017, the main question would have

Abbreviations: [APTMS][Ac], 3-(trimethoxysilyl)propan-1-aminium acetate; Barrer, non-SI unit of gas permability; CA, cellulose acetate; CNG, compressed natural gas; EU ETS, European union emission trading scheme; [emim][BF_4], 1-ethyl-3-methylimidazolium tetrafluoroborate; [emim][Tf_2N], 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide; gen1, gen2, fist generation, second generation; GO, graphene oxide; GPU, gas permeation unit; hum, humid feed flow; IL, ionic liquid; MEA, monoethanolamine; MMM, mixed matrix membrane; MOF, metallic-organic framework; NO_x, nitrogen oxides; LM, liquid membrane; LNG, liquefied natural gas; PA, polyamide; PAN, polyacrylonitrile; PCDD/Fs, dibenzodioxins/dibenzofurans; PDMS, polydimethyl siloxane; PE, polyethylene; PEBA, polyether block amide; PEG, polyethylene glycol; PEI, polyether imide; PEO-PBT, poly(ethylene oxide)–poly(butylene terephthalate); PES, polyether sulofone; PI, polyimide; PIM, polymer with intrinsic microporosity; PIM-1, polymer with intrinsic microporosity of the fist generation; PolyIL, polyionic liquid; ppm, parts per million; PSf, polysulfon; PTMEG, polytetramethylene Ether Glycol; PU, polyurethane; PVA, polyvinyl alcohol; PVC-g-POEM, poly(vinyl chloride)-g-poly(oxyethylene methacrylate); SILM, supported ionic liquid membrane; SO_x, sulphur oxides; STP, standard conditions (i.e. 273.15 K and 101.325 kPa); TRP, thermally rearranged polymers; UF, ultrafiltration; ZIF, zeolitic imidazolate framework

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