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A CO2 capture technology using carbon nanotubes with polyaspartamide surfactant

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ABSTRACT

Technologies for the separation of CO_2 from flue gas require a feat of engineering for efficient achievement. Various CO_2 capture technologies, including absorption, adsorption, cryogenics and membranes, have been investigated globally. The absorption technology uses mainly alkanolamine aqueous solutions, the most common being monoethanolamine (MEA); however, further investigation is required to circumvent its weakness due to degradation through oxidation, material corrosion and high energy costs required for regeneration. Attractive advantages in adsorption technology, including the ability to separate the more diluted component in the mixture with a low energy penalty, have been a motivation for many researchers to contribute to the advancement of adsorption technology in CO_2 capture. The challenge in CO_2 adsorption technology is to design a hydrophobic and biodegradable adsorbent with large CO_2 uptake, high selectivity for CO_2, adequate adsorption kinetics, water tolerance, and to require low levels of energy for regeneration processes. The existing adsorbent such as activated carbon, silica gel, zeolites, metal organic frameworks and others, have been ineffective where moisture occurs in flue gas. This work provides an advanced adsorption technology through a novel adsorbent, MWNT-PAA, designed from the non-covalent functionalization of multi-walled carbon nanotubes (MWNTs) by polyaspartamide (PAA) as product of amine grafted to polysuccinimide (PSI). Three types of PAA were prepared using ethylenediamine (EDA), 1, 3 propanediamine (PDA) and monoethanolamine (MEA) drafted to PSI to give PSI-EDA, PSI-PDA and PSI-MEA respectively. The CO_2 adsorption capacity was 13.5 mg-CO_2/g for PSI-PDA and 9.0 mg-CO_2/g for PSI-MEA, which decreased significantly from PSI where the CO_2 adsorption capacity was 25 mg-CO_2/g. PSI-EDA was selected as PAA, because the CO_2 adsorption capacity was 52 mg-CO_2/g which doubled from PSI. The polymer polyethylenimine (PEI), the most commonly polymer used in CO_2 capture, was found to be non-biodegradable, while the polymer PAA showed the presence of CONH as a biodegradable bond functionality, occurring in the MWNT-PAA, as confirmed through Fourier Transform Infrared (FTIR) analysis. The adsorbent MWNT-PAA was demonstrated to have a water tolerance in the temperature range 25-55 ℃, where CO_2 adsorption capacity increased with the increase of water in the adsorbent. The highest CO_2 adsorption capacity recorded was 71 mg-CO_2/g for the moist MWNT-PAA using 100% CO_2 and 65 mg-CO_2/g for the mixture of 14% CO_2 with air. Under the same conditions, the dry MWNT-PAA adsorbed 70 and 46 mg-CO_2/g respectively (100%, 14% CO_2). The

regenerability efficiency of the MWNT-PAA absorbent was demonstrated at 100 ^{o}C; after 10 cycles of adsorption-desorption 99% of adsorbed gas was recovered in the desorption process. The heat flow for the thermal swing adsorption system resulted in the net release of heat over the complete cycle; a cycle includes adsorption (heat release) and desorption (heat absorbance). Thus, this MWNT-PAA adsorbent demonstrates an advantage in terms of overall energy efficiency, and could be a competitive adsorbent in CO_2 capture technology.