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A comparative review between amines and ammonia as sorptive media for post-combustion CO_2 capture

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HIGHLIGHTS

- Only a few reagents are available to facilitate the capture CO_2 on a large scale.
- CCS is basically employed for both pre-combustion and/or post-combustion.
- We focused on CCS technologies available for both pre- and post-combustion stages.
- The common sorption methods used for CCS are amines and aqueous ammonia.
- In our review, each method for CCS is analyzed and compared on parallel basis.

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ABSTRACT

In recent decades, the accelerating economic and social developments have led to exponentially increasing emissions of carbon dioxide (CO_2) into the atmosphere. As a result, much research efforts have been directed toward more effective measures for the carbon capture and storage (CCS). In this review, we first briefly described the general background on the various techniques available for the abatement of CO_2 emissions worldwide. Then, we provided an in-depth discussion regarding the two comparable control technologies, i.e., the amine- vs. ammonia-based capture approaches; ammonia has lower energy costs than monoethanolamine (MEA). The applicability of each method was described further with an emphasis on their advantages and disadvantages. We also briefly discussed the available options for post-absorption processing such as recovery of absorbed CO_2, compression, and storage. Many immobilized amines as adsorbents can only be regenerated a few times or are a 'once-through process'. This may deplete the global supply of those materials if CCS is scaled up in excess of Mton CO_2 captured per year. Ideally, the captured CO_2 should be isolated from the atmosphere indefinitely and/or photochemically reduced (either biologically or industrially). Finally, we explored future challenges in this field of study to envision and suggest more optimized solutions.

Abbreviations: ACR, acrylonitrile; AEAPDMS, N-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane; AEPD, 2-amino-2-ethyl-1,3-propandiol; AMP, 2-amino-2-methyl-1-propanol; AMPD, 2-amino-2-methyl-1,3-propandiol; APTES, 3-(aminopropyl)triethoxysilane; ASC, advanced supercritical pulverized coal; BET, Brunauer–Emmett–Teller; CCS, carbon capture and storage; CESAR-1, aqueous solution of AMP and PZ; DEA, diethanolamine; DETA, diethylenetriamine; DFT, density functional theory; DGA, diglycolamine; DRIFTS-IR, diffuse reflectance infrared Fourier transform spectroscopy; E-100, ethyleneamine; ESA, electric swing adsorption; E-SNTs, ethane-silica nanotubes; FOB, Free on board; FTIR, Fourier transform infrared spectroscopy; GtC, Gigatonne of carbon; IE, interaction energy; IGCC, integrated gasification combined cycle (e.g., coal to syngas); IPCC, Intergovernmental Panel on Climate Change; KS-1, a commercial amine product from Mitsubishi Heavy Industries; LT, less than; MDEA, methyldiethanolamine; MEA, monoethanolamine; MIL-53(Al), aluminum terephthalate; MOFs, metal–organic frameworks; MW, megawatt; MWt, molecular weight; NFC, nanofibrillated cellulose; NGCC, natural gas combined cycle; PEI, polyethylenimine; PZ, piperazine; RTIL, room-temperature ionic liquid; SBA-15, mesoporous nanoparticles silica; SEM, scanning electron microscope; SFBR, single-fluidized-bed reactor; STP, standard temperature and pressure; TEPA, tetraethylenepentamine; TGA, thermogravimetric analysis; THAM, tri(hydroxymethyl) aminomethane; TVS, temperature vacuum swing; XPS, X-ray photoelectron spectroscopy.

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