Carbon Capture and Storage using Amine Absorption

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1 Overview and Background

1.1 Brief background

Questions to be answered: (1) What is carbon capture? (2) Why is it important? (3) What is Amine Adsorption? (4) What are the pros and cons? (5) Why is the Amine absorption method specifically good for carbon capture? (6) Research status of using Amine Adsorption for carbon capture.

(1) What is carbon capture? Carbon capture and storage (CCS) tackles global warming challenges by first capture CO2 from power generation and then store it underground[1]. (2) Why is it important? Coal is still the largest fuel source for power generation taking up to 38%. Although there is an urgent necessity to address the primary contributors to climate change, emissions from the power sector in 2019 were merely slightly lower than their record-setting peak in 2018, totaling 13.6 gigatons of carbon dioxide.[2] Presently, the CCS initiatives are annually sequestering close to 45 million tons of CO2, approximately equivalent to the emissions generated by 10 million passenger cars. The capturing process is typically implemented at significant stationary CO2 sources, such as power plants or industrial facilities involved in cement, steel, and chemical production.[3] Leading companies in the energy sector like ExxonMobil has already lay out more than 1,500 miles of CO2 pipeline owned

[1]Source from National Grid
[2]Source from IEA Reports.
[3]Source from MIT Climate Portal.

and operated – largest network in the U.S.[4] (3) What is amine absorption? Four primary technologies for CO2 capture exist, namely chemical absorption, adsorption, membrane separation, and cryogenic distillation. Regarding the chemical absorption, five major absorbent groups prevail: amine-based absorbents, carbonate absorbents, hydroxide absorbents, ionic liquids (ILs), and amino acid salts. [3]

1.2 Benefits & challenges

(5) Benefits? Amine-based absorbents have garnered significant attention in research, primarily because of the early commercialization of monoethanolamine (MEA) for CO2 capture in the 1970s. This early adoption popularized MEA as a promising absorbent, driving extensive studies in this domain. As of now, the primary amine system, specifically the use of monoethanolamine (MEA), remains the most widely employed CO2 capture technology. [3] (6) Challenges? While primary amines present an effective CO2 capture capability, they come with drawbacks, and the most common one is their susceptibility to degradation. Alkanol amines, including primary amines, can undergo two types of degradation: thermal degradation and oxidative degradation. [1, 3, 4] The deterioration of these materials can exacerbate additional issues, including solvent loss, fouling, heightened viscosity, and corrosion of downstream equipment. (6) General Research Status: In a review by Hamdy et al. [6], they reviewed the chemical reaction mechanism of amine absorption: The process begins with the initial creation of a C–N bond, resulting in the formation of carbamic acid. The amine proton of the carbamic acid is then transferred to a free base, such as a second amine or water, leading to the generation of the carbamate salt. In the work of computational modeling with molecular simulations by Bahamon et al. [2], they compared different solvents for absorbing CO2. Their results show that non-aqueous amine solvents exhibit a 5–10% reduction in cyclic working capacity and a 10–30% decrease in the energy index compared to their aqueous counterparts, all while maintaining the same total amine mass concentration. They attribute the difference to the lower heat of vaporization and specific heat capacity of non-aqueous amine solvents. Danaci et al. [5] analyzed the amine absorption from the techno-economic perspective, and very interestingly, they state that reducing the cost of capital (i.e., interest rate) has a minor impact on the capture cost but it would be more beneficial to reduce steam requirements.

[4] Source from ExxonMobil Website

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