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The Capture of Atmospheric Carbon Dioxide

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Abstract

The stability of the global climate is threatened by rising atmospheric carbon dioxide (CO_2) levels, necessitating creative methods for carbon capture and sequestration. This research analyzes alternative strategies for harvesting atmospheric CO_2, concentrating on both upcoming technology and established procedures. Metal-organic frameworks (MOFs), zeolites, and carbon-based materials are examples of very effective sorbents that have recently been developed because to advancements in materials science. These materials demonstrate remarkable selectivity and capacity for CO_2. This review emphasizes the significance of optimizing these materials for practical applications by going over their characteristics, performance metrics, and scaling possibilities. Furthermore, the article examines the significance of natural processes in sequestering carbon, highlighting the complementing techniques of soil carbon sequestration, afforestation, and reforestation. To create a comprehensive strategy for lowering atmospheric CO2 levels, technical innovation and natural solutions must work together. Large-scale carbon capture projects' economic feasibility and potential policy ramifications are also covered. Potential motivations for investing in carbon capture systems are outlined, along with implementation barriers including prices, energy usage, and regulatory frameworks. Case studies of effective carbon capture initiatives offer important insights into best practices and lessons discovered. It may be possible to greatly lower atmospheric CO2 levels by fusing cutting-edge technology with organic processes concentrations, supporting international climate objectives. In order to solve this pressing issue, future research topics are suggested, such as investigating hybrid systems, enhancing material efficiency, and assessing long-term storage solutions. It is emphasized that cooperation between the scientific, industrial, and governmental sectors is required.

Keywords: Carbon Dioxide, Carbon Capture, Chemical Absorption, Soil Carbon Storage, Renewable Energy

Introduction

Since carbon capture is a difficult and costly endeavor, more nations are combining their efforts to advance existing technologies [1-3]. These demonstrations will involve businesses from both countries and will improve trade and commerce." According to the statement, the nations will also cooperate to lower greenhouse gas emissions from heavy vehicles, enhance greenhouse gas data gathering, and promote building energy efficiency. The announcement states that the plans for achieving such targets will be available in October. This will lead to major environmental issues including ocean acidification and global warming. Technologies such as carbon capture and storage can be used to cut down on CO2 emissions from human activity and keep it out of the atmosphere. Additional CO2 conversion to energy-dense compounds will essentially resolve the conflict between the world's need for energy and the depletion of fossil fuels. Capturing CO2 at its source necessitates separating it from other gases generated by industrial operations, and this is the first step in using CO2 [4]. It was claimed that the surface-synthesised 1D and 2D organ o metallic nanostructures could adsorb CO2, and surface-sensitive methods revealed the microscopic processes.

Using 1,4-phenylenediisocyanide (PDI) units coordinating with Au atom substrates, the 1D organ o metallic chains were produced. The first evenly scattered chains may become compact bundles with the adsorption of CO2 on Au-PDI chains maintained on gold surfaces at 90 K, therefore auto catalyzing their own capture. The extraction of carbon dioxide (CO2) from gaseous streams has attracted a lot of attention and is now a significant procedure in a lot of industrial regions. [5,6]. Natural gas's heating value rises, its transported gas volume falls, and its purity is improved when CO2 is removed. The inclination to corrode lessens. Before being discharged into the environment, carbon dioxide in a gasification system can be removed using commercially available technologies like the water gas shift reaction. It is more cost-effective to convert carbon monoxide to carbon dioxide and capture it prior to combustion rather than eliminating carbon dioxide after combustion, so "de carbonizing" or at the very least lowering the carbon content of the gas. Carbon dioxide is usually captured as a byproduct of gasification facilities that produce chemicals, ammonia, hydrogen, or fuels [7]. In comparison to emissions from other technologies, the Environmental Protection Agency claims that the IGCC process's higher thermodynamic efficiency decreases carbon dioxide emissions [8]. An affordable substitute for removing carbon dioxide from coal-fired power plants is an IGCC facility [9]. Furthermore, IGCC-using facilities will have a less energy-intensive than alternative methods in the event that carbon dioxide collection is necessary [10]. All kinds of electricity generation will become more expensive as a result of carbon dioxide capture and sequestration; however, an IGCC plant can compress and collect carbon dioxide for half the price of a conventional pulverized coal plant.

In a world with limited resources, other gasification-based possibilities, such as the generation of motor fuels, chemicals, fertilizers, and hydrogen, would significantly assist the economy and ecology due to their much lower carbon dioxide collection and compression costs carbon [11-13]. It is well recognized that the enzyme ribulose 1,5-bisphosphonate carboxylase/oxygenase (RubisCO) and the Calvin-Benson-Bas sham (CBB) cycle are crucial to the worldwide fixation of CO2. A major increase in the enzyme's CO2 selectivity is also predicted, along with the use of several CO2-fixing enzymes for capture. This carbon capture approach explores a variety of electrode biocatalysts, including acetogenic bacteria, and prepares the way for single- and multi-enzyme bio fuel cells. To lower CO2, the electrocatalyst might be paired with microbes or other multi enzymes [14-16]. Because of these advantages, it has been suggested that ILs be used in place of conventional sorbents during the CO2 extraction process. This domain is contingent upon both performance and cost [17].

Carbon Dioxide

Liquid carbon dioxide was the most common mode of sale in the mid-1900s. Allowing the liquid to expand at atmospheric pressure causes it to cool and partially freeze into dry ice, a solid that resembles snow and sublimates (goes straight into vapor (without melting) under standard pressure and -78.5°C (-109.3°F). environment [18].

Chemical Absorption

When the gaseous component and the liquid come into contact, the gaseous component is absorbed into the liquid phase. It's common to refer to the liquid used for absorption as an absorbent or solvent. In this text, both words shall be used interchangeably. When selecting an adsorbent, two factors need to be taken into account. This implies that an acidic solution will arise when absorbed using an absorbent based on water. As a result, an alkaline absorbent is preferred for the absorption of acid gasses. It is chemical absorption. As of right now, it is estimated that their combined CO_2 collection capability in commercial facilities is 860 MtCO_2/year. Mono ethanolamine (MEA), diet hanolamine (DEA), N-methyl diethanolamine (MDEA), and di-2-propanolamine (DIPA) are among the most often utilized solvents. Temperature increases during regeneration cause the intermediate molecule to break down into the main solvent and CO_2 stream. CO_2 recovery is contingent upon the particular circumstances and the type of chemical reaction involved. According to recent scientific literature, the method's benefit is that chemical absorption effectively removes CO_2 at low concentrations from the exhaust gas combination at a relatively low pressure. Among the drawbacks is the requirement to purge the flue gases of SO_2, O_2, dust, and hydrocarbons because these materials may cause issues for the absorbent column's functionality.

The solvent regeneration process's high energy consumption and caustic nature are other drawbacks. The favored method for post-combustion capture is chemical absorption. Chemical and physical absorption separation techniques are often employed in the oil and gas and chemical sectors to extract CO_2 from gas streams. The interaction of the liquid absorbent—typically an amine aqueous solution—with CO_2 is the main focus of chemical absorption [19].

Carbon Capture

The purpose of carbon capture and storage (CCS) is to sequester carbon dioxide (CO_2) before it is discharged into the environment. Next, what should be done with the CO_2 that has been captured? Deep CO_2 injection is necessary for the majority of CCS methods in use today. There has also been a lot of attention lately in using CCS technology to eliminate atmospheric CO_2. One choice is bio energy with CCS (BECCS), in which photosynthesis occurs in biomass (like grass or wood) to remove CO_2 from the atmosphere. After that, the biomass is gathered, burned, and the CO_2 is collected and stored in a power plant to create electricity. As a result of removing and storing CO_2 from the atmosphere, this produces "negative emissions." Direct air capture (DAC) is an additional technique for reducing emissions; it involves removing CO_2 from the atmosphere chemically. Nevertheless, the air's CO_2 content is around 300 times lower than that of industrial or power plant chimneys, meaning that CO_2 extraction is far less effective. As a result, DAC is now rather costly [20].

Soil Carbon Storage

An essential component of soil that influences its chemical, biological, and physical characteristics and is crucial to human civilizations' ability to operate properly is organic matter. Improved soil quality through greater water and nutrient retention is one of the advantages of soil organic matter (SOM), which raises plant production in both agricultural and natural situations. SOM increases food security and lessens adverse effects on ecosystems by reducing erosion and improving soil structure. This also leads to better surface and groundwater water quality. Societies have recognized that human activity may reduce soil productivity and the capacity to generate food since the dawn of time. Understanding the relationship between soil productivity and SOM levels has only recently emerged, and the Depletion of SOM reserves frequently has significant effects on whole ecosystems, if not the planet itself. For instance, the loss of tropical forests, which store a large quantity of carbon in terrestrial ecosystems, is a major factor in the rise in atmospheric carbon dioxide (CO_2) levels associated with climate change, whereas the decrease in SOM levels Because mining disturbs the soil, it can have an impact on soil moisture storage and rainfall infiltration, both of which are crucial for reducing flood damage. Functions of terrestrial ecosystems can be restored with the use of suitable restoration strategies.

When land-hungry pioneers drove their wagon trains west across the United States in the 19th century, they came across a wide area of tall grasses that fed rich, deep soils. These days, the tall grass grasslands of North America are reduced to just 3%. The geography and ecology of the United States have changed dramatically as a result of their extinction, but a significant side effect that has gone mostly unnoticed is the enormous loss of carbon from the soil to the atmosphere. There is a growing body of study on the significance of soil carbon, including how it leaches from the earth and how that process might be stopped. These findings have significant ramifications for efforts to slow the rapidly rising levels of carbon dioxide in the environment. With the understanding of soil carbon sequestration growing at a rapid pace, scientists are now investigating how land restoration initiatives may contribute to the return of carbon to the soil in regions such as the North China Plain, the ancient North American grassland, and even Australia's patchy interior. The process of soil degradation, which has spread around the world, reduces soil to plain dirt in the absence of carbon and vital bacteria. Regenerative farming techniques, according to many experts, can reverse the carbon clock and lower atmospheric CO_2 levels while enhancing soil fertility and strengthening drought and flood resistance. Agro forestry, which blends agriculture, forestry, and animal husbandry, is one of these regenerative practices. Another is sowing crops or other cover crops on fields all year round. Acknowledging the critical role that soil carbon plays may signal a significant, if subtle, change in the global warming discourse, which has mostly centered on reducing emissions from fossil fuels. However, examining the soil helps us concentrate more on potential carbon sinks. Reducing emissions is vital, but soil carbon retention must also be part of the equation, Lal adds. He states that the restoration of damaged and degraded areas, together with avoiding deforestation and the development of peat lands—which are a significant carbon reservoir and quickly decompose—should be the top goals [21].

Conclusion

A comprehensive strategy for carbon capture and sequestration is necessary due to the pressing need to address the increasing amounts of carbon dioxide (CO_2) in the atmosphere. This study demonstrates how both traditional and novel technologies may effectively reduce CO2 emissions, emphasizing the importance of natural solutions and advancements in materials science as key elements of an all-encompassing approach. Direct air capture (DAC) and metal-organic frameworks (MOFs) are two emerging technologies that provide promising ways to selectively and very efficiently extract atmospheric CO2. In the meanwhile, utilizing organic processes like forestry and soil carbon sequestration can yield significant extra advantages, enhancing biodiversity and ecosystem health. However, overcoming a number of obstacles, such as those related to profitability, scalability, and regulations, is necessary for the successful use of these techniques. Researchers, legislators, and industry stakeholders must work together in order to produce integrated solutions that mix technical innovation with natural techniques [22].

References

1. Herzog H (2001) What future for carbon capture and sequestration? Environmental Science and Technology-Columbus 35: 148A.
2. Lampton DM (2019) Reconsidering US-China relations. asia policy 14: 43-60.
3. Carl Baker, Brad Glosserman (2013) Comparative Connections 15.
4. Feron PH, Hendriks CA (2005) CO2 capture process principles and costs. Oil & Gas Science and Technology 60: 451-459.
5. Gao W, Liang S, Wang R, Jiang Q, Zhang Y, et al. (2020) Industrial carbon dioxide capture and utilization: state of the art and future challenges. Chemical Society Reviews 49: 8584-8686.
6. Abas N, Khan N (2014) Carbon conundrum, climate change, CO2 capture and consumptions. Journal of CO2 Utilization 8: 39-48.
7. Lopes JV, Bresciani AE, Carvalho KD, Kulay LA, Alves RM (2021) Multi-criteria decision approach to select carbon dioxide and hydrogen sources as potential raw materials for the production of chemicals. Renewable and Sustainable Energy Reviews 151: 111542.
8. Falcke TJ, Hoadley AF, Brennan DJ, Sinclair SE (2011) The sustainability of clean coal technology: IGCC with/without CCS. Process Safety and Environmental Protection 89: 41-52.
9. Zhang Z (2015) Techno-economic assessment of carbon capture and storage facilities coupled to coal-fired power plants. Energy & Environment 26: 1069-1080.
10. Finney KN, Akram M, Diego ME, Yang X, Pourkashanian M (2019) Carbon capture technologies. InBioenergy with carbon capture and storage pp 15-45.
11. Khandaker S, Das S, Hossain MT, Islam A, Miah MR, et al. (2021) Sustainable approach for wastewater treatment using microbial fuel cells and green energy generation–A comprehensive review. Journal of molecular liquids 344: 117795.
12. Bierbaumer S, Nattermann M, Schulz L, Zschoche R, Erb TJ, et al. (2023) Enzymatic conversion of CO2: from natural to artificial utilization. Chemical Reviews 123: 5702-5754.
13. Renfrew SE, Starr DE, Strasser P (2020) Electrochemical approaches toward CO2 capture and concentration. ACS catalysis 10: 13058-13074.
14. Tan X, Nielsen J (2022) The integration of bio-catalysis and electrocatalysis to produce fuels and chemicals from carbon dioxide. Chemical Society Reviews 51: 4763-4785.
15. Andres RJ, Boden TA, Bréon FM, Ciais P, Davis S, et al. (2012) A synthesis of carbon dioxide emissions from fossil-fuel combustion. Biogeosciences 9: 1845-1871.
16. Lammgård C (2012) Intermodal train services: A business challenge and a measure for decarbonisation for logistics service providers. Research in Transportation Business & Management 5: 48-56.
17. Hoehn JP, Randall A (1987) A satisfactory benefit cost indicator from contingent valuation. Journal of environmental Economics and Management 14: 226-247.
18. Omae I (2006) Aspects of carbon dioxide utilization. Catalysis Today 115: 33-52.
19. Abdeen FR, Mel M, Jami MS, Ihsan SI, Ismail AF (2016) A review of chemical absorption of carbon dioxide for biogas upgrading. Chinese Journal of Chemical Engineering 24: 693-702.
20. Corbeels M, Scopel E, Cardoso A, Bernoux M, DOUZET JM, et al. (2006) Soil carbon storage potential of direct seeding mulch-based cropping systems in the Cerrados of Brazil. Global Change Biology 12: 1773-1787.
21. Dignac MF, Derrien D, Barré P, Barot S, Cécillon L, et al. (2017) Increasing soil carbon storage: mechanisms, effects of agricultural practices and proxies. A review. Agronomy for sustainable development 37: 1-27.
22. Dincer I (2000) Renewable energy and sustainable development: a crucial review. Renewable and sustainable energy reviews 4: 157-175.

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