A Review on Solid Carbon Formation from CO_2

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Abstract –

The need to stop the emissions of greenhouse gases are needed more than ever now. Carbon emissions are one of the biggest contributing factors to the increasing global warming, pollution and climate change in the world. The Carbon emissions led to an increased amount of Carbon Dioxide in the atmosphere, and it gets trapped in the ozone layer, resulting in less protection from UV rays and Solar Radiation. This paper examines the method of Carbon capture and utilization, reducing anthropogenic emissions and providing us with the all- important, Carbon Fiber. Carbon Fiber, a very strong material known for its high tensile strength, low weight to strength ratio, low thermal expansion etc. which makes it an ideal material for the manufacturing industry. Traditionally, Carbon Fibers were manufactured using petroleum-based materials, but advancements in technology have made it feasible to produce carbon fibers from alternative carbon sources, including captured carbon dioxide (CO_2).

Keywords – Emissions, Global Warming, Anthropogenic, Carbon Fiber

I. Introduction:

The Nature and Environment are very precious things for the entire co-existing species. It is providing us with life for countless centuries. But as the time has passed, humans have been on the path of development and thus have been inventing things that have proved to be a boon and at the same time a bane in the long run. While the use of fossil fuels has revolutionized the era (and will continue to do so), the Carbon emissions from such uses have caused a great negative impact on the environment. These anthropogenic emissions need to be reduced if we are to meet the goals set in the 2015 UN Climate Change Conference of limiting global temperature rise to 2 degrees Celsius by the end of this century. Considering the growing population, the energy supply demand is expected to rise significantly over the coming decades and for that renewable energy sources are required.

With this in mind, the concept of Carbon Capture and Utilization is commonly used in maintaining pollution from carbon discharge and the production of carbon fiber. The process involves the selective removal of CO_2 emission from industrial point sources or ambient air and its conversion of the captured CO_2 to carbon-rich feedstock via chemical processes. This carbon feedstock can then be used as a precursor material to produce carbon fibers. The production of carbon fiber from carbon capture sources holds promise for creating sustainable and low-carbon alternatives to traditional carbon fiber production. However, the cost of Carbon Fiber produced through CCU processes is generally higher compared to traditional Carbon fiber produced from petroleum-derived materials. The capture and compression alone make up as much as 75% of the total cost of CCS. However, with further advancements and economies of scale, the cost may decrease in the future, making it potentially more affordable. The CCU technology has recently garnered more attention for using captured carbon dioxide's renewable carbon feedstock and using it to produce valuable materials instead of permanently sequestering it.

In this paper, we examine the previous research, different methods known for obtaining Solid Carbon, recent advancements in the CCU technology, and the current scope and future of the CCU.

Discovery of these processes

The concept of carbon capture and utilization (CCU) has been under development for several decades. The precise dates of discovery or early research efforts in this field can vary depending on specific techniques or approaches.

However, as concerns about climate change, global warming, ozone layer depletion and carbon emissions grew, these ideas gained more compelling attention and research investment in the late 20th century and early 21st century.

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Carbon Capture technologies gained prominence in the 1970s and 1980s as researchers explored ways to lessen greenhouse gas emissions. It was during this time that the idea of capturing carbon dioxide from industrial processes and power plants and storing it underground, gained traction. Since then, the ongoing advancements and research have expanded our understanding of Carbon Capture techniques and their potential applications. Efforts to develop and refine these technologies continue today, with the aim of achieving more efficient and economically viable carbon capture solutions.

Methods to Extract Solid Carbon from CO_2

1) Carbon Mineralization – Reacting Carbon Dioxide with certain minerals to form stable carbonate compounds then trapping the Carbon in its solid state.
2) Direct Air Capture – Using specialized collectors or filters, Carbon Dioxide can be directly captured from the atmosphere. Then the capture CO_2 gets purified and undergoes various chemical processes resulting in the formation of Solid Carbon.

3) Bio-energy with Carbon Capture and Storage (BECCS) – The process which involves capturing Carbon Dioxide emissions from industries that use biomass as a fuel or from biomass powerplants. The captured CO_2 can then be converted into solid carbon materials or can be stored in underground reservoirs.

These techniques show promise in decreasing carbon emissions and potentially producing valuable products from CO_2, such as building materials or fuels. However, further research and development are needed to improve their efficiency and scalability.

How co2 extracted carbon is useful/friendly in nature

Carbon capture and utilization (CCU) and carbon capture and storage (CCS) processes are beneficial for us and the environment in several ways:

1. Climate Change Mitigation: These processes help to reduce greenhouse gas emissions, specifically carbon dioxide (CO2), which is a major contributor to climate change. By trapping and storing CO2 or converting it into useful products, CCU and CCS contribute to reducing the overall carbon footprint.

2. Sustainable Energy: CCS can be applied to power plants and industrial facilities that produce significant amounts of CO2. By capturing and storing the CO2 emissions from these sources, it enables the continued use of fossil fuels while minimizing their environmental impact. This provides a transitional approach as we shift towards renewable energy sources.

3. Negative Emissions: CCU and CCS can result in negative emissions, wherein more CO2 is removed from the atmosphere than emitted. This can help in achieving carbon neutrality and potentially reversing the effects of climate change.

4. Resource Utilization: CCU involves transforming captured CO2 into valuable products. This promotes resource utilization by converting a greenhouse gas into useful materials such as construction materials, plastics, chemicals, or even fuels. It helps to reduce the reliance on traditional resource extraction and promotes a circular economy.

5. Environmental Benefits: By capturing CO2 from industrial processes, CCU and CCS also help reduce other harmful pollutants released into the environment. This leads to cleaner air, improved air quality, and potentially mitigating negative health impacts.

While CCU and CCS are not standalone solutions to the climate crisis, they are viewed as important tools in the larger portfolio of strategies for mitigating greenhouse gas emissions and transitioning towards a more sustainable and low-carbon future. Solid carbon formation from carbon dioxide (CO2) is a crucial process in the fight against climate change. It involves various methods and processes that have the potential to significantly reduce greenhouse gas emissions. Two prominent strategies in this field are carbon capture and utilization (CCU) and carbon capture and storage (CCS). CCU focuses on capturing CO2 emissions from industrial sources and converting them into valuable products. This approach not only helps in reducing greenhouse gas emissions but also creates economic opportunities by producing useful materials. In some cases, the conversion process results in the formation of solid carbon materials as byproducts. These solid carbon materials can be used in various applications, such as construction materials, carbon fibres, or even as a substitute for fossil fuels. On the other hand, CCS primarily aims to capture and store CO2 emissions for long-term storage in a solid form. The captured CO2 is often stored in geological formations deep underground, where it can be securely stored for thousands of years. This method prevents the CO2 from entering the atmosphere and contributing to global warming. CCS is particularly useful for industries that produce large amounts of CO2 emissions, such as power plants or cement factories. In addition to CCU and CCS, there are ongoing research efforts into carbon mineralization and direct air capture (DAC) methods. Carbon mineralization involves the conversion of CO2 into stable carbonate minerals, which can be stored permanently. This process mimics natural geological processes and has the potential to provide a long-term solution for carbon storage. DAC, on the other hand, involves capturing CO2 directly from the air and converting it into solid carbon. This method has the advantage of being able to capture CO2 from any source, including diffuse emissions, making it a promising technology for addressing climate challenges. However, these technologies are still in the early stages of development and require further optimization to become economically viable and scalable globally. The cost of capturing and storing CO2 is currently high, and more research is needed to improve efficiency and reduce costs. Additionally, the infrastructure for transporting and storing captured CO2 needs to be expanded to accommodate large-scale implementation. In conclusion, solid carbon formation from CO2 offers promising solutions for reducing greenhouse gas emissions and mitigating climate change. CCU and CCS are leading strategies that focus on capturing and utilizing or storing CO2 emissions, respectively. Ongoing research into carbon mineralization and DAC methods further expands the possibilities for solid carbon formation. However, further development and optimization are necessary to make these technologies economically viable and scalable on a global scale.

II. Conclusion:

Solid carbon is a promising solution to address environmental issues and sustainable carbon management. The creation of solid carbon from carbon dioxide can be achieved through innovative processes that reduce CO2 emissions and convert them into a solid form. Carbon capture and utilization (CCU) and carbon capture and storage (CCS) are two leading technologies that are driving these efforts involves converting CO2 emissions into valuable products, which can sometimes result in the creation of solid carbon materials. This process not only reduces greenhouse gas emissions but also creates new opportunities for green technologies and products. For example, solid carbon can be used as a building material, a fuel source, or even as a substitute for traditional plastics, on the other hand, involves capturing and storing CO2 in geological formations or similar environments. Over time, the stored CO2 can become solid carbon. This process not only helps to reduce greenhouse gas emissions but also provides a way to safely store carbon dioxide, which can help to mitigate the effects of climate change. While there are challenges associated with the creation of solid carbon, ongoing research and development of these technologies promise a brighter, more sustainable future. By transforming carbon dioxide from a pollutant into a valuable resource, we can help to address environmental issues and create new opportunities for green technologies and products.

By harnessing the power of carbon mineralization, direct air capture (DAC), and carbon capture and storage (CCS), we have the potential to revolutionize our approach to climate change. These methods allow us to not only capture and convert carbon dioxide (CO2) into solid carbon, but also create valuable materials and products in the process. Carbon mineralization involves the natural process of converting CO2 into solid carbon through chemical reactions with minerals. This method has the potential to permanently store carbon in a stable form, reducing its impact on the atmosphere. Additionally, the solid carbon produced can be used in various industries, such as construction materials or even as a substitute for fossil fuels. Direct air capture (DAC) takes a more proactive approach by directly capturing CO2 from the atmosphere. This captured CO2 can then be converted into solid carbon through various processes, such as chemical reactions or electrolysis. This method not only reduces greenhouse gas emissions but also provides a valuable resource that can be utilized in different sectors. Carbon capture and storage (CCS) involves capturing CO2 emissions from industrial processes, such as power plants, and storing them underground or in other secure locations. By converting the captured CO2 into solid carbon, we not only prevent it from entering the atmosphere but also create a valuable resource that can be utilized in various industries. These approaches offer a promising solution to address climate change and reduce greenhouse gas emissions. By capturing and converting CO2 into solid carbon, we can effectively remove carbon from the atmosphere and prevent it from contributing to global warming. Furthermore, the creation of valuable materials and products from CO2 contributes to a sustainable and circular carbon economy. However, it is important to acknowledge that these technologies are still in the early stages of development and face economic and technical challenges. Further research and development are crucial for their successful implementation and widespread adoption. Governments, industries, and research institutions must collaborate to overcome these challenges and ensure the successful integration of solid carbon formation from CO2 into our efforts to mitigate climate change. In conclusion, the formation of solid carbon from carbon dioxide offers a promising solution to address climate change and reduce greenhouse gas emissions. Through methods such as carbon mineralization, direct air capture, and carbon capture and storage, we can capture and convert CO2 into stable, solid carbon products. These approaches not only reduce carbon emissions but also create valuable materials and products, contributing to a sustainable and circular carbon economy. Although these technologies are still developing and face challenges, further research and development are crucial for their successful implementation and contribution to a more sustainable future.

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