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Carbon Dioxide Capture, Utilization and Storage (CCUS)

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SUMMARY

Carbon dioxide being the most anthropogenic greenhouse gas, it needs to be isolated from entering into atmosphere. Carbon capture and storage is a process that captures CO₂ emitted from various sources, separates it from other gases and stores it in a safe place preferably in underground geological formations for a large period of time. It is then purified and monitored so that it can be made to reuse. Monoethanolamine, zeolitic imidazolate framework, microalgae, membranes etc are utilized to capture CO₂. Post-combustion, pre-combustion and oxyfuel combustion along with chemical looping combustion are technologies for scrubbing CO₂. The properties of CO₂ being easily miscible and readily dissolving in oil with impurities makes it capable for numerous applications such as in producing oil by enhanced oil recovery (EOR), Bio CCS Algal Synthesis etc. CO₂-EOR operation is capable to produce million barrels of oil and extend the field's lifetime as in case of Weyburn Oil Field in Canada. The physical storage of CO₂ is technically the most feasible direction provided that the associated safety and sustainability issues can be met and new materials for CCUS process at low cost are urgently found so that fossil based systems with carbon capture are cost competitive.

Introduction

CO₂ produced from the combustion process is the most anthropogenic greenhouse gas leading to global warming. Carbon capture and storage or sequestration (CCS) is the process of capturing waste carbon dioxide (CO₂), transporting it to a storage site in order to isolate it from entering into the atmosphere, preferably in an underground geological formation. CO₂ capture and storage, including its utilization or reuse enables deep reductions in greenhouse gas emissions thereby mitigating global climate change. The long term storage of CO₂ is a relatively new concept and is envisaged either in deep geological formations like oil and gas reservoirs, deep saline reservoirs, or in the form of mineral carbonates. Broadly, three different types of technologies for scrubbing exist which are post-combustion, pre-combustion and oxyfuel combustion. An alternate method under development is chemical looping combustion (CLC).

Combining utilization and storage optimally for CO₂-EOR deals with multiphase flow and miscibility process in three phase CO₂-oil-brine systems. Carbon storage and utilization research is organized into four key focus areas, namely Storage, Monitoring, verification & accounting (MVA), Simulation & risk assessment and CO₂ use & reuse.

Methodology

This paper will also review existing methods of CO₂ utilization and the future scope for utilization as a sink that could prevent the release of anthropogenic CO₂ emissions into the atmosphere. If CCS technique is applied to a conventional power plant, it could reduce CO₂ emissions into the atmosphere by approximately 80-90% compared to a plant without CCS. Liquids such as monoethanolamine (MEA) are commonly employed to capture CO₂ as an acid-base adduct. Moreover, amines can be chemically tethered on silica materials for capturing CO₂ from flue gas. A zeolitic imidazolate framework with high thermal (up to 390 °C) and chemical stability under refluxing organic and aqueous media shows exceptional selectivity for CO₂ capture and storage. Other modern approaches for CCS are Capture by Microalgae, Ocean fertilization, membranes for CO₂ separation etc.

Carbon dioxide (CO₂) utilization efforts focus on pathways and novel approaches for reducing CO₂ emissions by developing beneficial uses for the CO₂ that will mitigate CO₂ emissions in areas where geologic storage may not be an optimal solution. Also, revenue generated from the utilized CO₂ could offset a portion of the CO₂ capture cost. The emerging uses of CO₂ are: enhanced CBM recovery, polymer processing, power generation, algal bio-fixation & bio-fuel production.

Applications

Production from an oil or natural gas reservoir can be enhanced by pumping CO₂ into the reservoir to push out the product, which is called enhanced oil recovery. CO₂ has two characteristics which make it a perfect fit for EOR are that it is miscible with crude oil and is less expensive than other similar miscible fluids. The United States is the world leader in enhanced oil recovery technology, uses about 32 million tons of CO₂ every year for this purpose.

Instead of depressurizing the Coal bed methane in order to produce CH₄, an alternative approach is to inject CO₂ into the bed which has adsorption rate twice of methane and can remain stored in bed. Also, Bio CCS Algal Synthesis, that utilize CO₂ as a useful feedstock input to the production of oil-rich algae in solar membranes to produce oil for plastics and transport fuel (including aviation fuel).