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Reduction of Carbon Dioxide in the Environment Using Calcium Oxide as an Adsorbent

Pavan Kumar A[1], Jaysurya K[2], Revanasiddappa M[3]

[1]Department of Computer Science and Engineering, PESIT, Bangalore South Campus, Bangalore, India
pavank830@gmail.com

[1]Department of Computer Science and Engineering, PESIT, Bangalore South Campus, Bangalore, India
Jaisurya.1234@gmail.com

[2]Department of Engineering Chemistry,PESIT,Bangalore South Campus, Bangalore, India
revanasiddappam@pes.edu

Abstract: ***There is a growing concern that anthropogenic Carbon Dioxide (CO2) emissions, are contributing to global climate change. Therefore, it is critical to develop technologies to mitigate this problem. Carbon storage and capture is the major strategy that can be used to reduce the greenhouse gas emission. One very basic approach to reduce the Carbon Dioxide gas from the atmosphere is by adsorption on a chemical substance. The advantages of using Calcium oxide as adsorbent are safe handling, rate of adsorption and its easy availability. Current efforts cover the experimental work done in order to find the levels of Carbon Dioxide that is adsorbed on Calcium oxide over a period of time with specified external conditions and the best uses that can be made from the Carbon Dioxide captured. The reversible adsorption of carbon dioxide by calcium oxide is a promising method for capturing and removing carbon dioxide from the atmosphere. The main challenge faced in this method is the deterioration of carbon dioxide adsorption capacity when the method is applied over a large number of adsorption/desorption cycles. Adsorption data obtained from experiment will be used to determine the efficiency and external conditions required for maximizing the same. This paper further leads to investigations in improving the adsorption efficiency of carbon dioxide on calcium oxide and maximizing the recycling capacity of the adsorbent used. Therefore, this paper will focus on the experimental research of Carbon Dioxide adsorption in calcium oxide with various determining factors.***

Keywords: Carbon dioxide; Calcium oxide; adsorbent; greenhouse gas; adsorption/desorption;

1. Introduction

[1.1] Greenhouse gas mitigation technology, particularly with respect to Carbon Dioxide (CO_2) is assuming increasing importance, taking into consideration of rigorous climate change fears. There are seven primary greenhouse gases including Water vapour (H_2O), Carbon Dioxide (CO_2), Methane (CH_4), nitrous oxide (N_2O), Per fluorocarbons (C_2F_6), Sulfur hexafluoride (SF_6), and Hydro fluorocarbons (CHF_3). Water vapour is the most important, dominant and abundant greenhouse gas, and carbon dioxide is the second most important one. Over the past 36 years there has been a growing concern on the global temperature. Figure 1-1:shows the increase in the annual mean surface temperature of the earth due to greenhouse gases.

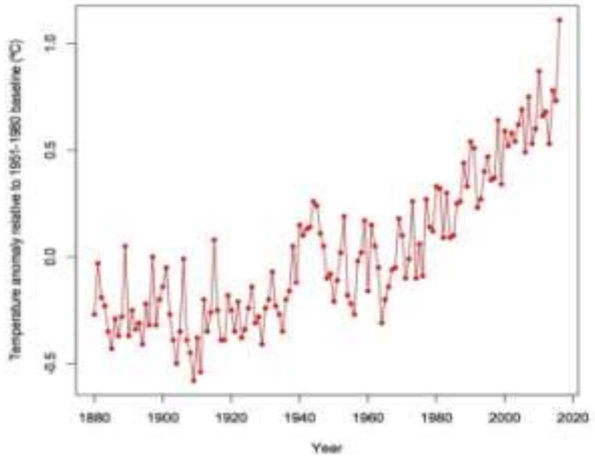

Figure 1.1: Annual mean temperature Vs Year

Due to carbon dioxide emissions from anthropogenic activities there is an increase estimate of 2 degrees by the year 2020.[1.2]Carbon Dioxide which is misinterpreted as a pollutant has the tendency to play a crucial role in maintaining the earth's temperature if mishandled or not treated with suitable measures may lead to severe global warming issues. The percentage of carbon dioxide can be reduced by lowering the usage of fossil fuels and planting more trees, but in this research we have used a sophisticated method to reduce the amount of carbon dioxide from the atmosphere.

Adsorption operation can reduce energy and cost of the capture or separation of CO_2 from the atmosphere. To achieve this goal, it is necessary to find adsorbents with suitable properties. In general, CO_2adsorbent must have high selectivity and adsorption capacity and adequate adsorption/desorption kinetics, remain stable after several adsorption/desorption cycles, and possess good thermal and mechanical stability.

[1.3] The adsorbents used for CO_2 separationare placed into two main categories: physical and chemical adsorbents. Chemisorption is a subclass of adsorption, driven by a chemical reaction occurring at the exposed surface. Adsorption capacities vary taking into consideration different chemical adsorbents.Figure1-2: summarizes the adsorption capacities of various chemical substances.

Sorbent	Operating temperature (K)	Operating pressure (kPa)	CO_2 capture capacity (mol CO_2/kg sorbent)	Regeneration cycles, n	CO_2 capture capacity remained after n cycles (%)
Mesoporous (MgO)	298	101	1.8	3	100
CaO nanopods	873	101	17.5	50	61.1
CaO derived from nanosized $CaCO_3$	923	101	16.7	100	22.2
CaO-$MgAl_2O_4$ (spinel nanoparticles)	923	101	9.1	65	84.6
Nano CaO/Al_2O_3	923	101	6.0	15	61.7
Lithium silicate nanoparticles	883	101	5.77	n.a.	n.a.
Nanocrystalline Li_2ZrO_3 particles	843	101	6.1	8	100
CaO/Al_2O_3	923	101	6.02	n.a.	n.a.
Lithium silicate	993	n.a.	8.18	n.a.	n.a.
Lithium zirconate	673	100	5.0	n.a.	n.a.
Lithium orthosilicate	873	100	6.13	n.a.	n.a.
Calcium oxide	873	100	17.3	n.a.	n.a.
Magnesium hydroxide	473	1034	3.0	n.a.	n.a.
Mesoporous magnesium oxide	373	100	2.27	n.a.	n.a.
Lithium Silicate nano particles	873	101	5	n.a.	n.a.
HTI-HNa	573	134	1.109	50	93.3

Figure1-2: Adsorption Capacities of chemical substances

Calcium oxide which is commonly known as quick lime or burnt lime is a white crystalline, caustic, alkaline solid at room temperature. Calcium is the fifth most abundant element on the earth surface by mass. Hence, it is economically viable.

2. Methodology

[2.1] In this research we have taken weighed amount of dry calcium oxide on a watch glass and placed it in a closed room. The process of chemisorption takes place on the surface of the adsorbent, Calcium Oxide. The adsorption of carbon dioxide on the adsorbent is been competed with other gases such as CO,SO2 and water vapour. When the results are analyzed it is observed that the concentration of other gases adsorbed is negligible, and carbon dioxide has its superiority in the competitive adsorption. The adsorption of carbon dioxide takes place according to the following chemical reaction.

$$CaO + CO_2 \rightarrow CaCO_3 \quad (1)$$

[2.2] In the experiment carried out the sample is weighed every day, and the values are documented. Increase in the weight is noted until the saturation point of Calcium oxide is reached where no more adsorption of Carbon Dioxide takes place. In this case, we have recorded the saturation point to be on the ninth day to attain complete stability. Figure2-1: shows the increase in weight of the sample on day to day documented data.

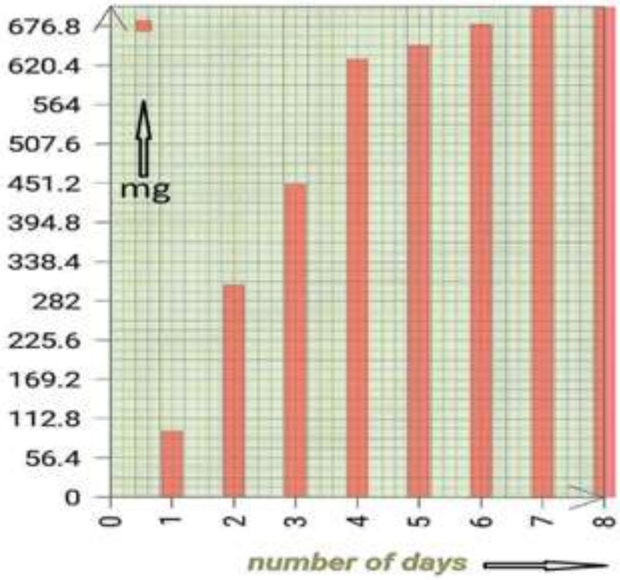

Figure 2-1: Increase in weight of the sample vs. number of days

[2.3]Cross verification test is performed on the final product collected on the ninth day in order to check for the presence of Calcium carbonate with respect to the equation [1]When conc. HCl is tested with the final product brisk effervescence is observed which confirms the presence of Carbon Dioxide in the Adsorbent according to the following equation.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g) \quad (2)$$

3. Result

[3.1] Sample of 2g of calcium oxide was taken which resulted in the increase to 2.715g of calcium carbonate. For the process of removing water vapour the final product is heated to a temperature of 100^0 C - 120^0 C. This led to loss of 25mgof weight which further brought down the weight of the final product to 2.690g.Hence,
2g of CaO→690mgofCO$_2$

So**,** 1g of CaOadsorbs 345mg of CO2 [practical]

But according to the equation:1g of CaO adsorbs 440mg of CO_2 [theoretical]

Hence, there is difference of 95mg of CO_2 in practical observation and theoretical observation. The 440mg can be achieved practically by providing exact conditions. Hence, in this project 1gof CaO adsorbs345mg of CO_2 is proved practically.

Hence we can say that the efficiency is 34.5%.
As we know that reaction of calcium oxide with Carbon Dioxide is a reversible reaction and the equation is given below

$$CaCO_3 \rightarrow CaO + CO_2 \; (3)$$

There by when we heat the final product formed on the ninth dayto a temperature of 900^0C - 950^0C and in 1atm pressure in a muffle furnace the adsorbed Carbon Dioxide is released back from the Calcium carbonate sample. Equilibrium pressure of Carbon Dioxideover Calcium carbonate is as shown in the following Figure3-1.

Equilibrium pressure of CO2 over CaCO3 (P) vs. temperature (T).[37]

P (kPa) 0.055 0.13 0.31 1.80 5.9 9.3 14 24 34 51 72 80 91 101 179 901 3961

T (°C) 550 587 605 680 727 748 777 800 830 852 871 881 891 898 937 1082 1241

Figure 3.1: Equilibrium pressure of CO2 over CaCO3 Vs temperature

4. Conclusion

[4.1]Adsorption is one of the promising mechanisms of carbon capture. In this work, we have mainly focused on removal of CO_2 from the atmosphere. Calcium oxide is used as an sorbent material to adsorb CO_2. Industries have their own CO_2 absorption plants, but in metropolitan cities due to increase of vehicular emissions CO_2 levels are increasing .So, in this work we have mainly focused on removal CO_2 in the cities.

The main advantages of this method are adsorbent used is fifth most abundant element on earth's crust and hence economically viable and by this method it leads to reduction one of the most important greenhouse gas, CO_2.

5. Applications

The Carbon dioxide thus captured can be used for the following applications-

[5.1] It is used as a coolant in waste water treatment devices and is also used as a supercritical fluid for removing photo resist from wafers to avoid the use of organic solvent.

[5.2] High concentration of carbon dioxide is used to kill pesticides and it is used in manufacturing of medicines as 5% of CO2 is added to pure oxygen for stimulation of breathing after Apnea and to stabilize O2/CO2 balance in the blood.

[5.3]It is also used in the generation of electricity with the help of gas turbines and it can be used in production of urea, carbonates, bicarbonates, and sodium salicylate.

[5.4] Carbon dioxide is used on a large scale as shield gas in MIG/MAG welding, where the gas protects the weld puddle against oxidation by surrounding air and carbon dioxide in solid and in liquid forms is used for refrigeration and cooling.

[5.5] Carbon dioxide is used in oil wells for extraction of oil.

6. Acknowledgments.

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References

[1] AnushaKothandaraman,B. Chem. Eng.Institute of Chemical Technology, University of Mumbai, 2005M.S. Chemical Engineering Practice Massachusetts Institute of Technology, 2006 submitted to the department of the department of chemical engineering in partial fulfillment of the requirements for the degree of doctor of philosophy in chemical engineering practice at the Massachusetts institute of technology© 2010 Massachusetts Institute of Technology
[2] www.uigi.com/carbondioxide.html,
[3] www.online-sciences.com/earth-and-motion/the-importance-and-uses-of-carbon-dioxide-gas/,
[4] www.power-eng.com/article/2014/11/Toshiba-to-supply-supercritical-carbondioxide-turbine-to-texas-power-project.html

Author Profiles

Pavan Kumar Ais currently pursuing her B.E in Computer Science and Engineering at PESIT South Campus, Bangalore. His interests lie in the field of material science and technological applications.

K Jaysuryais pursuing B.E Computer Science and Engineering in PESIT South Campus.His field of interests are sensors and its technologies.

Dr. Revanasiddappa M, Professor in the Department of Engineering Chemistry, PESIT-Bangalore South Campus, Bangalore, he obtained M.Sc., degree from Department of PG studies in Chemistry Gulbarga University, Gulbarga and secured "Gold medal" in the year 1999. He got his Ph. D degree in Inorganic Chemistry from Department of PG studies in Chemistry Gulburga University, Gulbarga in 2006. He has 12+ years of Teaching and Research experience. His current research interests include conducting polymer composites, coordination metal complexes, fabricating devices, Pharmaceutical active ingredients, microwave and EMI studies of materials, Fly ash, Life member Indian Society of Technical Education (ISTE).