Carbon dioxide absorption through ceramic membrane in ~~different water~~different water

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Abstract

~~An attempt has been made to assess t~~The efficiency of clay alumina based ceramic membrane for the absorption of Carbon ~~D~~dioxide (Co_2) in various types of water was investigated~~.~~ The dissolutions of Co_2~~carbon dioxide~~ are observed for three different types of water – tap ~~water~~and simulated water of Central Glass and Ceramic Research Institute (CGCRI) Kolkata, and ~~simulated sea water prepared in the CGCRI laboratory~~ and milli-Q water (resistance of 18.2 Ω). The absorption of Co_2~~Carbon Dioxide absorption set up~~ was with porous tubular ceramic membrane module having a contact surface area 6329.86 mm^2 ~~is used for the experiment~~. The objective of this work is to present experimental data that would show absorption efficiencies of different types of ~~the above mentioned three different types of~~ water, their compositions after absorption, physical and chemical nature, the effect of temperature, rate of dissolution, and pH. ~~etc~~.

Key words, CO_2 dissolution, absorption~~, membrane~~, membrane contactor, Henry's law, natural water

Introduction

Due to the industrial revolution, there is a continuous emission and absorption of greenhouse gases in the atmosphere which resulted in ~~Global warming or~~ the continual and significant rise in the average temperature of the earth[12]. ~~is mainly caused by the emission of greenhouse gases into the atmosphere.~~~~[1]~~ ~~The greenhouse gases absorb and radiate harmful infrared rays and radiate them into the atmosphere, increasing the earth's temperature by significant amount~~.~~[2]~~ Co_2 was found to be ~~O~~one of the most hazardous greenhouse gases on the earth's atmosphere ~~is Carbon Dioxide. The emission of Carbon Dioxide into the earth's atmosphere has increased manifold over the past three decades because of the industrial revolution. It is estimated that the concentration of Carbon Dioxide~~ which has increased from 290 ppm in 1900 to about 400 ppm at present.[3] Approximately 60% of Global emissions of gas was due to Co_2. ~~Carbon Dioxide gas contributes to more than 60% of global emissions because of the large of gas that is produced~~.[4] Figure 1 show~~s~~ the global emissions of Co_2~~CO2~~ emission by sector. In order to mitigate global climate change concern, researchers in the past made an attempt to capture and sequestrate the emission of Co_2 before it released into the atmosphere. This approach would capture Co_2 from large sources, such as unmineable coal seams, saline formations, depleted oil and gas fields. ~~alleviate the effects of global warming caused by the emission of carbon dioxide, it is necessary to capture and store~~

Comment [CR1]: To Author, Both the first and second para discusses about the same. Hence both are combined. Hope you agree.

~~the gas before it is released into the atmosphere.~~ Several ~~There are several~~ technologies such as chemical[5], and physical absorption[6], biological[7] and geological sequestration[8], and catalytic conversion ~~that can be~~ are applied for Co_2 ~~Carbon Dioxide sequestration~~ sequestration. ~~or the capture and storage of Carbon Dioxide~~. ~~They are Chemical Absorption of Carbon Dioxide,[5] Physical Absorption of Carbon Dioxide,[6] Biological Sequestration of Carbon Dioxide,[7] Geological Sequestration of Carbon Dioxide8 and Catalytic Conversions of Carbon Dioxide.[9]~~

Despite several technologies, ~~M~~membrane separation is one of the key chemisorptions processes used for the capture and sequestration~~storage~~ of Co_2 ~~carbon dioxide~~.[10] The membrane processes used include membrane gas-separation,[11] and sequestration through membrane contactors[12], ~~etc~~. Several researchers in the past ~~A lot of researchers~~ have carried out Co_2~~Carbon Dioxide~~ sequestration using polymer membranes due to its reliability, scalability, easy operation and low costs membranes[13]. ~~because the membranes are easy to operate and give reliable performances. Moreover polymeric membranes are easy to scale up and are low cost membranes, thus making them desirable among many~~. ~~[13]~~ In comparison to other conventional technologies, ~~M~~membrane contactors are advantageous ~~compared to other conventional technologies~~ because of their high interfacial contact area, their ability to withstand unlimited load, and enabl~~ing~~ed mass transfer free of dispersion.[14] Polymeric hollow fiber membrane contactors have been used by ~~R~~ Naim et al (2012) for stripping Co_2~~Carbon Dioxide~~ using diethanolamine solution.[15] However, ~~But~~ fouling of polymeric membranes was~~is~~ common that lead to ~~leading to~~ low flux through the membrane. In addition, ~~T~~the ~~polymeric~~ membrane~~s~~ lack sufficient mechanical strength and are mostly hydrophobic in nature.[16] Due to these limitations, ~~Because of these disadvantages,~~ other types of membranes and membrane contactors were considered for effective sequestration of Co_2~~Carbon Dioxide~~. Ceramic membrane contactors ~~,~~are found to be cost effective, ~~and have~~ withstand very high temperature, pressure, ~~and~~ high chemical stability, and ~~high~~ durability. As a result, the probability of corrosion was less and resists ~~they do not corrode easily and can resist very~~ high temperatures, ~~and~~ pressures and strong chemicals. They are an excellent alternative to polymeric membranes when it comes to Co_2~~Carbon Dioxide~~ capture.[17]

Given this advantage, ~~In the present study~~the aim of this study was to investigate ~~,~~the efficiency of a ceramic membrane contactor to capture Co_2~~Carbon Dioxide~~ by the phenomenon of physical absorption ~~is tested.~~ The~~is study aimed to~~ ~~aim of the work is to~~ prepare a water saturated with Co_2 (medium saturated), which has ~~medium saturated with Carbon Dioxide. Water saturated with Carbon Dioxide has~~ several useful applications. For example, carbonated water injected into oil ameliorates oil

Materials used and Apparatus description

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Water from various sources was used for the experiment: a) Tap water taken from CGCRI, b) Milliq water with a resistance of 18.2 Ω taken from CGCRI laboratory, c) simulated~~Simulated~~ sea water prepared in the CGCRI ~~laboratory G~~gas containing 99.9% Carbon Dioxide and 99.9% Nitrogen is purchased from BOC. Table 1 ~~shows~~show the weight compositions and physical characteristics of water used in the study while ~~. T~~the schematic diagram for the ~~e~~ experimental setup is ~~xperimental set-up is~~was shown in **Figure 1.** The gas-liquid contactor module made of tubular ceramic membrane (three in number) in line ~~is~~ was connected to a feed water tank with a capacity of 2.5 liters and a pump ~~which is~~was fitted for circulating feed through the membrane module. The flow rate through the magnetic drive chemical process pump ~~is~~ was 750 ml/min. The ceramic membranes are made from 80% and 20% clay,~~m 80%~~ alumina with an ~~and 20% clay and they have an~~ outer (O.D) ~~-~~and inner diameter (O.D.) of 10 mm ~~and an inner diameter (I.D.) of~~ and 7 mm respectively. The average pore size of the membranes ~~i~~was~~s~~ 0.5 to 1.5 micron with ~~. The membranes have~~ a contact area of 5.3298*103 mm^2 and a ~~and a~~ packing density of 41.52443 m^2/m^3 (total contact surface of the module~~ace area~~ /total volume of module). Effective length of each membrane ~~is~~was 125.6 mm, ~~and~~ thickness of the wall ~~of each membrane is~~was 2.58 mm and the ~~. The~~ total volume of the module ~~is~~was 152435.6 mm3. The membranes are manufactured by the ~~Central Glass and Ceramic Research Institute~~CGCRI.

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A display of the experimental set-up used and details of the apparatus are shown in Figure 2. A source line from gas cylinders that constitute~~s~~ pressure reducer valves, pressure gauge, flow meters and ~~is~~ are connected to a mixing chamber in turn ~~which is connected~~ to the membrane module. The feed tank made of stainless steel has a rectangular cubic structure with a capacity of 2.5 liters. It is connected to the membrane module and a magnetic drive chemical process pump. The two ends of the three-membrane Perspex cylindrical module are connected to the feed tank and pump respectively.

Method

The experiment ~~is~~ was carried out with milli-q water, tap water from CGCRI, Dhakuria lake water, Ichamati river water and simulated sea water. The simulated sea water ~~is~~ was prepared in CGCRI laboratory by mixing 3.5 % sodium chloride with milli-q water. The feed tank ~~is~~ was filled with 2.2 liters of feed (for each type of water) and ~~. The feed is~~ circulated at 750 ml/min through the tube side of the module via the magnetic drive chemical pump. Simultaneously CO_2 ~~Carbon Dioxide~~ gas (15%, 20% and

100% CO_2 ~~Carbon Dioxide~~ in a mixture of CO_2 ~~Carbon Dioxide~~ and Nitrogen gas) ~~is~~was passed through the shell side at the rate of 200 ml/min. The partial pressure of CO_2 ~~Carbon Dioxide~~ in the gas mixture ~~is~~ was 0.10 Kg/cm2. For each type of water, samples are collected at regular intervals of time and the various parameters such as pH, conductivity, turbidity, TDS, and alkalinity ~~etc. are~~are measured. The total dissolved ~~Carbon Dioxid~~CO_2 ~~e~~ in the aqueous solution was~~is~~ calculated by sample titration with ~~titrating the samples with~~ sodium hydroxide to estimate ~~and~~ the amount of ~~estimating the amount of~~ $HOCO_2^-$ ions ~~.~~

Figure 2

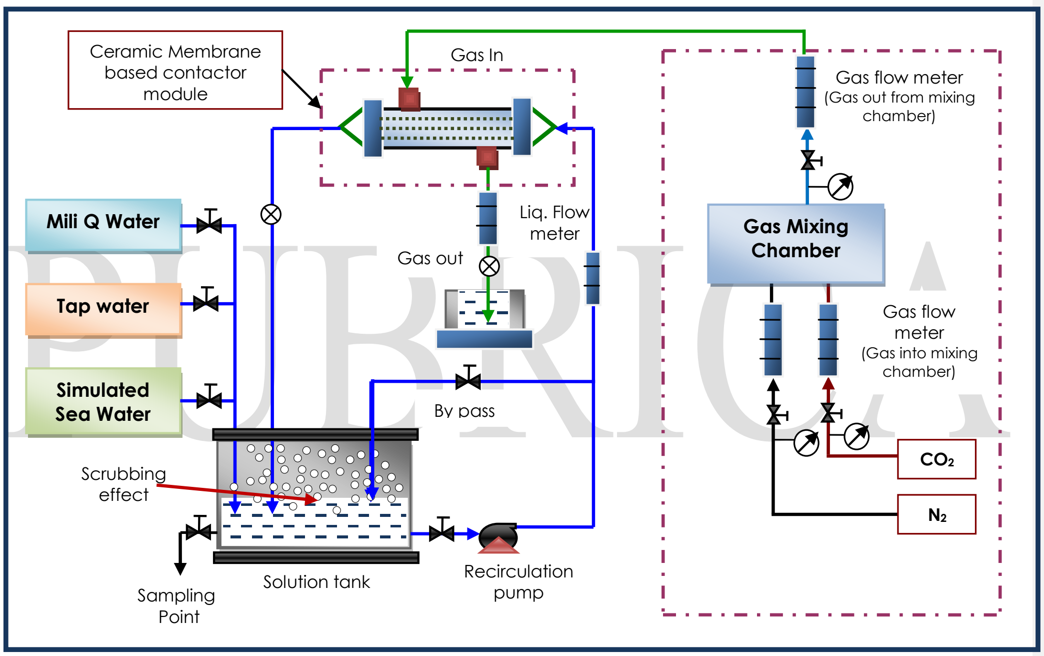

Fig 2.

Figure 2 : Ceramic Membrane based Contactor setup for CO_2 capturing

Characterization of tubular ceramic membrane elements

Tubular ceramic membranes with 10mm ~~od~~ OD 7mm id ~~i~~was~~s~~ used in this CO_2 ~~carbon dioxide capture~~ sequestration experiments. Characterizations of these elements are done by XRD, FESEM, Chemical analysis and porosity, and pore size distributions,