Proceedings of the World Congress on Engineering and Computer Science 2010 Vol II
WCECS 2010, October 20-22, 2010, San Francisco, USA

A Two-in-One Device for Air-conditioning and Carbon Dioxide Sequestering for Residential Units

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Abstract—**The paper presents a novel design of a two-in –one unit for air-conditioning (AC) with the provision to sequester carbon-di-oxide by incorporating a roller, coated with modified epomin, cross-linked with epichlorohydrin. The work presents a concept paper on the use of epomin as adsorbent in a residential AC device. The design of the unit has been optimized to show how the sequestration process takes place inside the air conditioner. It is proposed that the desorption of the CO_2 from the adsorbent can be carried out using solar concentrators. The stored carbon-di-oxide can be transported to a secondary storage unit where it can be used for algal growth. The remaining gases are converted to fuel (methanol) using photochemical cell and as mineral carbonates. The method appears to be a 'green friendly' approach and can be applied for household units.**

Index Terms— **Air-conditioner, Carbon-di-oxide sequestration Epomin, Two-in-one unit**

I. INTRODUCTION

"Carbon sequestration" refers to capturing of excess carbon dioxide from the atmosphere, condensing it, and storing it in some benign way. While Carbon_capture and storage (CCSD) technologies are implemented in some limited way in many fossil fuel power plants there is a lacuna between the technology for capturing and technology for storing. Environmentalists feel that Carbon sequestration could play an important role in the fight against greenhouse gases. In spite of many efforts to contain CO_2 emissions, its levels are rising tremendously day by day. The graph in Fig.1 depicts the dramatic rise in CO_2 over the past few years [1]. A study of the global carbon cycle (Fig. 2) has shown that consumption of vegetation by animals & microbes account for about 220 gigatonnes of CO_2 per year. Respiration by vegetation contributes to around 220 gigatonnes. The ocean releases about 332 giga tonnes of CO_2. Fossil fuel burning and changes in land use are other major contributors. However, natural CO_2 emissions (from the ocean and vegetation) are balanced by natural absorptions (again by the ocean and vegetation). Land plants absorb about 450 gigatonnes of CO_2 per year and the ocean absorbs about 338 gigatonnes. This keeps atmospheric CO_2 levels in rough balance. In contrast, human carbon-di-oxide emissions and other metabolic processes upset the natural balance even though they contribute only about 29 gigatonnes per year [2].

Manuscript received July 11, 2010.
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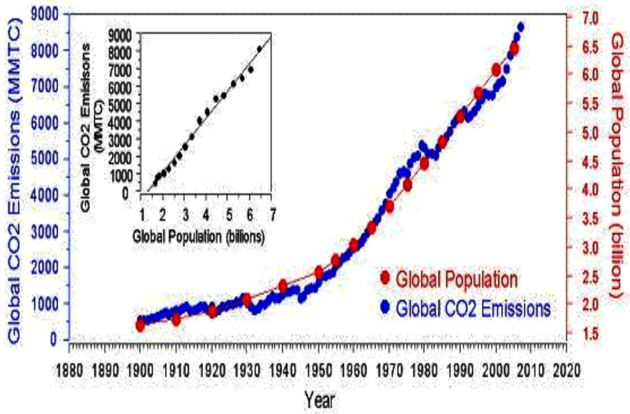

Fig.1 Graph showing dramatic increase in CO_2 over the years [1]

Hence it is necessary to combat the carbon emissions from human activities. The method of carbon sequestration

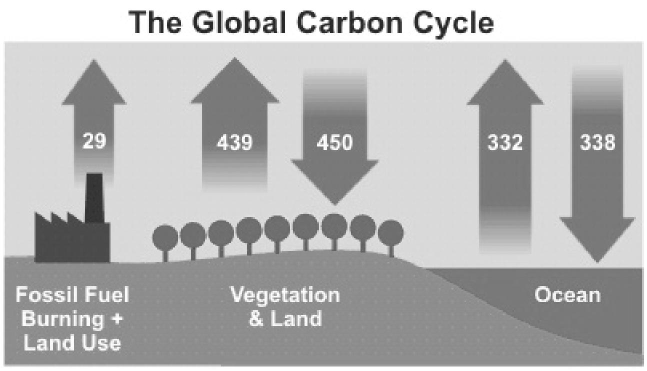

Fig.2. Global carbon cycle pictorially represented [2]

Presented in this paper has been designed keeping this in mind. Further it tries to incorporate green energy in the form of solar energy and therefore can be a viable form in the present context. Among the four methods of carbon sequestration – solution absorption, adsorption, membrane diffusion, and cryogenic that are presently being used, adsorption is of great interest for its low energy consumption, low equipment cost, and ease of application. A range of materials have been employed in the research of CO_2 adsorption [3]-[5]. Among these, materials with large surface area, such as zeolites and activated carbon [6]-[9], have been widely investigated. However, applications of these porous adsorbents are limited by the low CO_2 selectivity and adsorption capacity at higher temperature.
In a number of research work, glass fiber has been employed as the matrix due to its high surface area, low price, and ease of use especially with polyethylenimine (PEI) (epomin) coating that offers amine groups. It has been shown

ISBN: 978-988-18210-0-3
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

previously that the adsorbent exhibits a CO_2 adsorption capacity of 2.03 mmol CO_2/g of adsorbent, equal to 6.29 mmol CO_2/g of PEI, with epoxy resin (EP) as the cross linking agent[10].

The present work envisages the use of glass fibers modified with epomin for Carbon sequestration keeping in mind the challenges that are involved generally in the design of an adsorbent:

- The polymer should adsorb CO_2 and subsequently desorbs the same, on heating at preferably low temperature
- The polymer should withstand high temperatures for use in industrial applications.
- The polymer should be as economically viable.

The epomin polymer in a network of primary, secondary and tertiary amines is coated on a glass fiber to enhance the efficiency of its adsorption process and cross-linked with epichlorohydrin. This complex has excellent selectivity and storage capacity for CO_2. The reaction [11] between PEIM and epichlorohydrin is shown in the scheme below

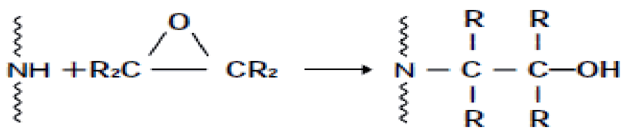

Fig.3. Reaction between PEIM and epichlorohydrin

The new complex formed in Fig.3. Has properties that enhance the carbon capture and has the following advantages as an adsorbent

- Functions at elevated temperatures, thereby increasing the practicality and economic feasibility of using membranes in industries
- Shows superior selectivity and storage capacity for CO_2
- Is completely regenerable at 120ºC.
- Highly porous and shows very high selectivity for carbon capture.
- Mechanically strong
- Thermally stable at high temperatures
- Can be coated as paint.

II. METHODOLGY

The process of sequestering CO_2 inside an air conditioner can be carried out using the set up show in Fig.4. It involves the incorporation of a suitable filter coated with epomin cross-linked with epichlorohydrin inside an air conditioner. This modified air conditioner or "Carbon Conditioner" serves the multiple purposes of decreasing the dust, CO_2 content as well as cooling the air recycled. This setup is feasible as no extra costs are spent on installing a separate machine that sequesters carbon-di-oxide.

III. CONSTRUCTION

The "Carbon Conditioner" is basically a two-in-one unit from

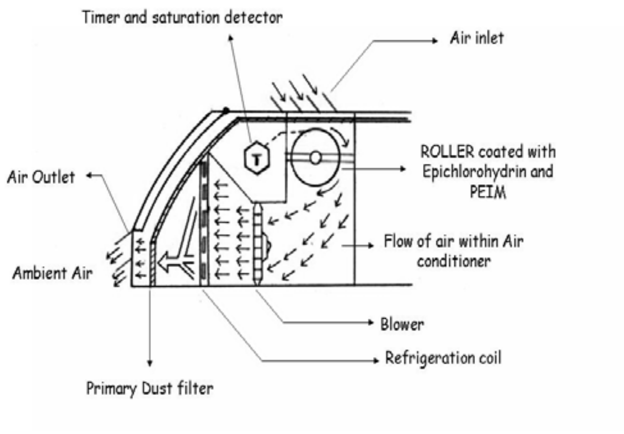

Fig.4. Construction of the "Carbon conditioner"

the conventional air conditioners used in our homes. The only modification comes from the installation of a roller made of

Glass or a suitable filter over which the adsorbent (in this case epomin cross linked with epichlorohydrin) is coated to capture and sequester the CO_2. As most homes use split air conditioners these days, a roller setup is designed to enhance the capture of CO_2 by increasing the surface area for capture. A similar set up can be incorporated for homes using window air conditioners.

The construction is an air conditioner, with extra features as follows:

i. A detachable roller made of glass coated with epomin and epichlorohydrin adsorbent, for the capture of CO_2 that can be released and the material regenerated for multiple cycles.

ii. A timer or a saturation sensor setup to sense when the roller needs to be removed and sent for regeneration

The saturation sensor involves detecting the amount of CO_2 adsorbed and then stops the functioning of the roller so that the CO_2 can be released after removal of the roller. However to follow a simpler approach, a timer set for a specific time say one month is used and controls the functioning of the roller for the specified time duration. The roller is then manually changed and regenerated. The functioning of the AC unit is not hindered in the process except some extra power for the motor operating the roller.

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IV. DESCRIPTION

A. Carbon-di-oxide capture

The ambient air enters into the inlet and passes through the primary filter that filters out the dust particles. It then passes to the sequestration chamber where it comes in contact with the constantly rotating roller coated with epomin and epichlorohydrin complex. The roller captures the CO_2 due to its proper pore size for carbon capture and high selectivity for CO_2 [11]. The Roller shown in Fig.4 can be replaced by a double roller conveyor belt system that improves the surface area for capture. The filtered air passes through the blower to the cooling chamber. The refrigeration coil cools the air that again passes through a secondary filter to remove any remaining dust and is recycled back to the room.

B. Conversion of captured carbon-di-oxide

The roller in which the carbon has been adsorbed by the adsorbent is taken out after the saturation is reached as indicated by the timer (which indicates the time for which the device has been used) and subjected to solar concentrators at 120 ºC to regenerate adsorbent completely for re-use. Thus desorbed carbon-di-oxide is stored in a primary storage chamber. It is transported to secondary storage units to laboratories, wherein the CO_2 is used for algal growth, or converted to methanol using photo-electrochemical cells and also to mineral carbonates as shown in Fig 5.

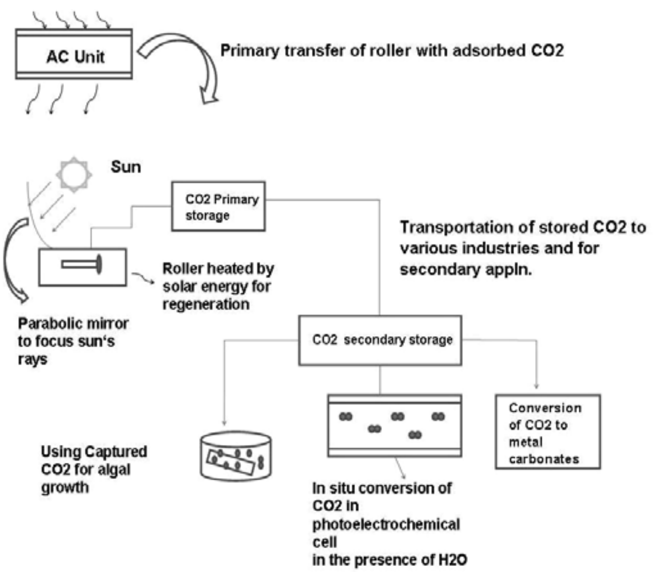

Fig.5. Schematic of the proposed scheme with usage of stored CO_2 in algal growth, conversion of CO_2 into fuel (methanol) and into mineral carbonates

V. MERITS OF THE METHOD PROPOSED

- The method proposed is unique and would help in sequestering carbon in air conditioned rooms with out too much increase in cost of installation at the place of CO_2 generation
- The method would provide comfort to the people occupying such rooms.
- *Cost-effectiveness-* The method optimizes the capture costs by the usage of low-cost membranes capable of regeneration. Since the adsorbent is used inside an air conditioner, no new machine is needed for the carbon sequestration, there by minimizing the cost of construction. The additional cost of installing and powering the roller is also comparatively less and the benefit is more.
- *Wide applicability-* The concept could be employed in industries to sequester carbon-di-oxide.

VI. CONCLUSION

In conclusion, this paper envisages the use of a thin coating of epomin on a membrane to sequester CO_2 and works in tandem with a regular air-conditioner unit in any residential unit. Thus, even a small amount of epomin coated as a thin film on a membrane can be used with air conditioner at ambient temperature. The adsorbent is known to completely desorb all the CO_2 at 120 º C using the solar concentrators. The paper thus presents novel idea of a two-in-one unit that can cost effectively and efficiently work in cooling the room and also sequester CO_2. The stored gas can be transported easily and used for other purposes like growth of algae and also in the preparation of metal carbonates. Combination of air-conditioner with the carbon sequestering unit is an advantage, especially in places where humidity can be around 80%.

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