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सत्यमेव जयते

क्रमांक : 044121521
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भारत सरकार
GOVERNMENT OF INDIA

पेटेंट कार्यालय
THE PATENT OFFICE

पेटेंट प्रमाणपत्र
PATENT CERTIFICATE

(Rule 74 Of The Patents Rules)

पेटेंट सं. / Patent No. : 343314

आवेदन सं. / Application No. : 201841031076

फाइल करने की तारीख / Date of Filing : 20/08/2018

पेटेंटी / Patentee : INDIAN INSTITUTE OF TECHNOLOGY MADRAS (IIT Madras)

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 20th day of August 2018 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF as disclosed in the above mentioned application for the term of 20 years from the 20th day of August 2018 in accordance with the provisions of the Patents Act,1970.

अनुदान की तारीख : 04/08/2020
Date of Grant :

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, **20th day of August 2020** को और उसके पश्चात प्रत्येक वर्ष मे उसी दिन देय होगी।

Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on 20th day of August 2020 and on the same day in every year thereafter.

FORM 2
THE PATENTS ACT, 1970
(39 OF 1970)
&
The Patents Rules, 2003
COMPLETE SPECIFICATION
(Refer section 10 and rule 13)

TITLE OF THE INVENTION:

AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF

2. APPLICANT:
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3. Preamble to the Description

COMPLETE SPECIFICATION

The following specification particularly describes the invention and the manner in which it is to be performed.

COMPLETE SPECIFICATION

TITLE OF THE INVENTION

AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF

FIELD OF THE INVENTION

The present invention relates to the field of air purification or air filtration, more specifically relates to a material that adsorbs CO_2 at ambient room condition and desorbs it at near ambient temperature.

BACKGROUND OF THE INVENTION

Rapid increase in the CO_2 concentration in the air in the recent past and its alarming consequences such as global warming, are some of the most important environmental issues facing the planet. This significant increase in CO_2concentration is caused due to industrial actions, largely from combustion. Increased CO_2 levels have undesirable consequences on metabolism and neuronal activities. Due to the need to have protection from insects, dust, and such other local disturbances, enclosed environments are desired for living. However, the CO_2 levels in such closed enclosures increase due to biological activities of the inhabitants. Therefore, it is necessary to control the concentration of CO_2 in such environments for healthy living.

It is well known from the literature that, there are many CO_2 scavenging materials including calcium oxide, hyper branched amino silica, as well as amines (primary, secondary, and tertiary). In order to maintain the CO_2 concentration below 450 ppm, compatible to global average concentration of 300 – 500 ppm (ANSI/ASHRAE Standard 62.1-2010) in a closed room of 20 cubic meters volume with one occupant for a period of two hours, it is necessary to remove approximately 75 g or 1.704 mol of CO_2. In the ambient condition of 25°C and 90 % relative humidity, removal of such amount of CO_2 is possible by using 0.1910 kg of the best available CO_2 removal media such as amino silica monolith (Harshul Thakkar et. al., ACS Appl. Mater. Interfaces 2017, 9, 7489–7498). Other available media, metal organic frameworks (MOF) -177 (Hussein RasoolAbid et. al., Journal of Colloid and Interface Science 2012, 120-124), requires

0.051 kg of material to maintain CO_2 concentration in the above-mentioned case. However, for commercial feasibility, regeneration of silica monolith requires an optimum ambient temperature of 115 ℃ and, adsorption process of MOF-177 requires an optimum pressure of 4500 kPa. Since, regeneration of the media with best sorption capacity is not possible near ambient conditions, developing a device with a minimum quantity of working sorbent material with efficient cycling capacity near ambient conditions with regeneration is necessary. This will reduces the physical size of the device as well as cost and power requirements.

Though there are many adsorption media for CO_2 removal in recent years, still there is a need for a better and efficient sorbent material for removing CO_2 in ambient conditions. Thus the present invention provides a new material of composite fiber that adsorbs CO_2 at room temperature and desorbs CO_2 at near ambient temperature.

SUMMARY OF THE INVENTION

This invention relates to the field of air purification or air filtration, more specifically relates to a material that adsorbs CO_2 at room temperature and desorbs it at near ambient temperature.

In one embodiment the invention relates to the fabrication of nanofiber membrane by electrospinning an aminoethyl-aminopropyl trimethoxy silane/polyacrylonitrile (AEAPTMS/PAN) composite, with large surface area, having a 100% recyclable CO_2 adsorption capacity of $\geq$ 0.77 mmol/g functioning at 24 ^{o}C, with complete regeneration at near room temperature of 45 ^{o}C, with an adsorption cycle of 120 minutes and desorption cycle of 30 minutes. CO_2 is adsorbed by forming ammonium bicarbonate and ammonium carbamate at room temperature, in the presence and absence of humidity, respectively and desorbed by decomposing the formed ammonium bicarbonate and ammonium carbamate at 55 ^{o}C, preferably at 50 ^{o}C,more preferably at 45 ^{o}C or lower.

In other embodiment, the invention illustrates the use of the fabricated nanofiber membrane in air purification by integrating it within a device comprising air purifier, air conditioner and heater, with adsorption and desorption cycles.Wherein, the nanofiber works in a cycle with 40 minutes of adsorption and 20 minute of desorption or preferably 20 minutes of adsorption and 10 minutes of desorption.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 SEM image of AEAPTMS/PAN composite electrospun material.

Figure 2 depicts CO_2 sorption capacity of electrospun AEAPTMS/PAN (composite-1).

Figure 3 depicts cyclic CO_2 sorption capacity of electrospun AEAPTMS/PAN (composite-1).

Figure 4 depicts ambient temperature and relative humidity during CO_2 sorption by electrospunAEAPTMS/PAN (composite-1).

Figure 5 depicts % relative humidity dependence of CO_2 adsorption capacity of electrospunAEAPTMS/PAN (composite-1).

Figure 6 depicts temperature dependence of CO_2 adsorption capacity of electrospun AEAPTMS/PAN (composite-1).

Figure 7 depicts the rate of desorption at different ambient temperature for AEAPTMS/PAN (composite-1).

Figure 8 depicts the FTIR spectrum of electrospun AEAPTMS/PAN (composite-1) before adsorption, after CO_2 adsorption and after CO_2 desorption.

Figure 9 depicts the Raman spectrum of electrospun AEAPTMS/PAN (composite-1) before adsorption, after CO_2 adsorption and after CO_2 desorption.

Figure 10 depicts the schematic diagram of proposed device for CO_2 adsorption and desorption process using electrospun APAETES/PAN membrane.

Referring to the drawings, the embodiments of the present invention are further described. The figures are not necessarily drawn to scale, and in some instances the drawings have been exaggerated or simplified for illustrative purposes only. One of ordinary skill in the art may appreciate the many possible applications and variations of the present invention based on the following examples of possible embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As required, detailed embodiments of the present invention are disclosed herein. However, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various forms. The figures are not necessary to scale exemplary of the invention that may be embodied in various forms. The figures are not necessary to scale; some features may be exaggerated to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention.

The present invention shows the possibility of using the well-known carbamate and bicarbonate chemistry of amines in scavenging CO_2 by a suitable combination of amines and polyacrylonitrile polymer. The nanofiber membranes of large surface area are produced by electrospinning the composite and this composite material can also be processed into fibrous membrane using melt-spinning process. Due to the inherent curvature and exposed functionalities, large CO_2 uptake is possible resulting in a CO_2 scavenger functioning at room temperature and ambient pressure.Homogeneous distribution of CO_2 scavenging sites leads to the uniformly ordered formation of carbamate and bicarbonates. This electrospinning induced homogeneity in carbamate and bicarbonate formation on AEAPTMS/PAN structure leads to sharp desorption of CO_2. The saturated material desorbs CO_2 in the temperature window of 47-50°C enabling complete regeneration. This process can be repeated several times. Even with the comparatively poor adsorption capacity of AEAPTMS/PAN material, room temperature adsorption and near complete desorption close to ambient conditions, make it possible to design a system for CO_2 sequestration with a reduced quantity of the material. A device incorporating such materials with reduced energy input requires 1.64 kg of AEAPTMS/PAN composite material for maintaining CO_2 concentration below 450 ppm in a room of 20-meter cube volume with one active adult occupant. The adsorption happens at 25 °C, preferably at 22 °C with 60% relative humidity and desorption occurs at 50°C, preferably at 47 °C.

This invention describes a method for CO_2 control in closed environments to enhance the quality of human life.

Properties of all the best-known materials for CO_2 sorption as of today and their performances are listed in Table 1.

Table 1 Adsorption capacity of various adsorbents and theiroperational parameters

Material name	**Base/support material**	**Adsorption temperature (°C)**	**Desorption temperature (°C)**	**Adsorption pressure (bar)**	**Pick up (mmol/g)**	**Cycling capacity**	**Reference**
(N-[3-(Trimethoxysilyl)propyl]ethylenediamine)	Electrospun PAN fiber	**23**	**50**	ambient	**0.77**	**100 %**	**This Work**

Polyethylenimine	Silica	25	85	NA	1.705	NA	Alain Goeppert et. al., J. Am. Chem. Soc., 2011, 133 (50), 20164–20167
N-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane	Nanofibrillated cellulose	25	100	NA	1.39	50 %	Christoph Gebaldet.al.,Environ. Sci. Technol. 2011, 45, 9101–9108
1°,2°,3° amines	Mesoporous silica	25	100	NA	1	NA	Stephanie A. Didas et. al., ChemSusChem 2012, 5, 2058 – 2064
Polyethylenimine	Fumed silica	NA	85	NA	NA	NA	Alain Goeppert et.al., ChemSusChem 2014, 7, 1386 – 1397
Hyper branched amino silica	Mesoporous SBA - 15 silica	Ambient	70-120	NA	NA	NA	Stephanie A. Didas et. al., Acc. Chem. Res. 2015, 48, 2680−2687
Amines (1°, 2°, 3°)	SBA 15	25	NA	NA	0.289	NA	GuoShiou Foo et. al., ChemSusChem2017, 10, 266 - 276
Dentriticstructure with 1°and 3° amine	SBA 15	35	110	NA	0.21	NA	Simon H. Pang et. al., J. Am. Chem. Soc. 2017, 139, 3627−3630
3D printed amino silca monolith PD-APS (AP – 4)	Silica	25	110	NA	2.23	100 %	Harshul Thakkar et. al., ACS Appl. Mater. Interfaces 2017, 9, 7489−7498
Zeolite	NA	0		1		NA	Brandon. ITO et. al., Thesis,Metal oxide sorbents for carbon dioxide capture prepared by ultrasonic spray pyrolysis, 2011
Activated carbon		15-55		1	3.1- 1.3		
CaO		600			17.8		
Lithium zirconates		400-750	780		4.5		
Poly amines	SBA- 15	75	NA	NA	4.43	NA	Chin-Te Hung et. al., Microporous and Mesoporous Materials , 2017, 15,2-13
$NaNO_3$	CdO	230	380	NA	5.68	NA	Kang-Yeong Kim et. al., ACS Appl. Mater. Interfaces

							2017, 9, 21563−21572
Polyethylenimine	Commercial silica	25	NA	NA	2.36	NA	Choi S et.al., *ChemSusChem.*, 2011, 4, 628– 635
Poly(allylamine)	MCF silica mesocellular foam	25			0.86		Chaikittisilp W. et.al., Ind. Eng. Chem. Res. 2011, 50, 14203– 14210
Polyethylenimine	SBA 15	25			1.05		
Tetraethylenepentamine	Commercial silica	25			2.5		Brilman W. et. al., Energy Procedia 2013, 37, 6070–6078
Polyethylenimine	Fumed silica	25			2.44		Goeppert A. et. al., ChemSusChem 2014, 7, 1386–1397
Ethylenediamine	Silica gel	25	90		0.44		Wurzbacher J. A. el. al., Energy Environ. Sci. 2011, 4, 3584– 3592
Linear amine	Porous polymer networks	22	NA	1	1.3	NA	Lu, W. et. al., Angew. Chem., Int. Ed. 2012, 51, 7480–7484
MOF 177	NA	24.85	NA	45	33.5	NA	Mohammad Songolzadeh et. al., The Scientific World Journal 2014,8281, 31-34
Molecular basket MCM-41 (50% PEI)	NA	74.85	NA	1	2.5	96 %	
Molecular basket PE-MCM-41 (TRI)	NA	24.85	NA	1	1.8	94 %	
Molecular basket PE-MCM-41 (DEA)	NA	24.85	NA	1	2.9	96 %	
Mesoporous (MgO)	NA	24.85	NA	1.01	1.8	100 %	
CaOnanopods	NA	599.85	NA	1.01	17.5	60 %	
N-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane	NFC hydrogel	30	90	NA	1.33	68 %	Christoph Gebald. et. al., Environ. Sci. Technol. 2013, 47, 10063−10070

The present invention relates to the development of electrospun AEAPTMS/PAN fibrous membranewith a high surface area for CO_2 adsorption. The electrospun fiber's surface contains numerous uniform amine sites for CO_2 capture. Figure 1 shows the SEM images of the surface. According to the invention, the composite-1 comprises of the electrospun material, N-[3-(Trimethoxysilyl) propyl]ethylenediamine (AEAPTMS) functionalized polyacrylonitrile (PAN/AEAPTMS) as the adsorbent surface which has a higher surface area with a nanofiber diameter of 1µm, preferably 0.5µm, more preferably 0.1µm. Figure 1 shows that the fibers are 0.359±0.065µm in diameter. The electrospun polymeric material does effective adsorption of CO_2 at room temperature and desorption at 50 °C enabling complete regeneration of the adsorbent material.

Further, this invention demonstrates the CO_2 sorption capacity of the AEAPTMS/PAN and solvent composition. The adsorbent surface was prepared by the electrospinning technique. Amine loaded nano-fibrous material, composite-1 was prepared by dissolving 12wt% PAN in dimethylformamide (DMF) with 1 ml AEAPTMS in use. In another aspect, amine loaded nano-fibrous material, composite-2 was prepared by dissolving 14 wt% PAN in DMF with 2.0 ml of AEAPTMS. Figure 2 shows an adsorption capacity of 0.77mmol/g CO_2 for composite-1, nanofiber material in an ambience having 70 % relative humidity, 24 °C temperature and 3400 ppm CO_2 concentration.

The adsorption-desorption experiments were performed in an air-tight desiccator having pre-determined humidity and concentration of CO_2 andAEAPTMS/PAN fibrous material sheet and CO_2 measuring meter kept in it. Relative humidity, temperature and CO_2concentration in the desiccator were monitored and logged each minute. Adsorption experiments were done at an average temperature of 25°C and desorption tests were performed at 50°C. Desiccator was kept in a hot air oven for high temperature studies and air-conditioned roomfor low temperature studies. Three adsorption – desorption cycles in Figure 3shows 100% cycling capacity of 0.8 g of composite-1material with an initial CO_2 concentration of 2304 ppm. The graph shows the uptake of CO_2 by the fibers when the composite-1fiberswere exposed to the gas in an enclosure. The adsorption experiment was repeated after desorption of the adsorbed CO_2 at 50 °C.Figure 4 shows the corresponding changes occurred in temperature and % relative humidity during three adsorption–desorption cycles. Electrospuncomposite-1shows an average of 0.347mmol/g CO_2 adsorption capacity for initial 30 minutes of adsorption cycle and 100% desorption capacity when the material was heated up to 50 °C. The rate of CO_2 desorption increases as the temperature of the material increases.

The CO_2 sorption capacity of the developed composite material is dependent on ambient humidity and temperature. The higher value of humidity and lower value of temperature will favor enhanced rate of adsorption. Table 2 shows the amount of CO_2 adsorption for each cycle with a maximum of 0.55mmol/g at 70 % relative humidity and 25 ℃.

Table 2 CO_2 concentration in the chamber after each sorption cycle for electrospun AEAPTMS/PAN (composite-1)

Material	Cycle	Initial CO_2 concentration (ppm)	Final CO_2 concentration (ppm)	CO_2 pick up (ppm)	CO_2 pick up (mmo1/g)
Composite-1	1	2304	636	1668	0.5
	2	2380	616	1764	0.54
	3	2388	597	1791	0.549

Bicarbonate and carbamate chemistry based CO_2 adsorption capacity is dependent on initial CO_2 concentration, ambient temperature and % relative humidity. CO_2 adsorption capacity increases with increase in initial CO_2 concentration, decrease in ambient temperature and increase in % relative humidity. Presence of water vapor enhances bicarbonate formation and increases the CO_2 adsorption capacity. CO_2 desorption rate increases at higher temperature.

Increase in CO_2 adsorption rate with increase in % relative humidity at 25 ℃ temperature is shown in Figure 5. At ambient temperature, bicarbonate formation is the dominant mechanism for CO_2 adsorption, than by carbamate formation. As temperature increases, formation rate of bicarbonate decreases and carbamate formation becomes the more dominant mechanism for CO_2 adsorption. As temperature increases, the CO_2 adsorption rate further decreases because of an aggregate decrease in the rate of formation of ammonium bicarbonate and ammonium carbamate, hence saturation uptake is delayed. The same phenomenon is shown in Figure 6.

Desorption tests were performed at a fixed temperature of 50 ℃, with different temperature ramp rates. To obtain the different temperature rate of 1.11, 1.25 and 1.85 °C/minute, oven temperature was set to 60, 70 and 80 °C, respectively. Once oven temperature reaches 50 ℃, it was maintained the same. At three different ramping rates of 1.11, 1.25 and 1.85 °C/minute, composite-1, takes 45, 40 and 27 minutes, respectively for full desorption of adsorbed

0.308 mmol of CO_2. The rate of desorption is high with a high-temperature ramp rate. Rate of desorption at different temperature windows is given in Figure 7.

FTIR analysis shows the formation of ammonium bicarbonate and ammonium carbamate on composite-1after CO_2 adsorption in humid ambience with 60 % relative humidity and 24 ℃ temperature. Figure 8 A), B) and C) shows the ATR - FTIR spectra of composite-1before adsorption, after adsorption and after desorption, respectively. The difference spectrum B-A shows the difference between the spectrum after CO2 adsorption and before CO_2 adsorption and C-A difference spectrum shows the difference between the spectrum after CO_2 desorption and before CO_2 adsorption, respectively.

Upon CO_2 adsorption, various surface species are readily formed and the spectrum shows IR features in the range of 1600 to 500 cm^{-1}. The IR bands in the region, 1600-500 cm^{-}1 are due to carbamate, bicarbonate and carbamic acid species. Adsorption of CO_2 with H_2O molecule present in the humid air on the uniformly distributed homogeneous sites leads to the formation of bicarbonate peaks at 816, 1318 and 691cm^{-1}. Chemisorption of CO_2 on amine groups present on the surface results in carbamate and carbamic acid peaks at 1478, 1561 and 593 cm^{-}1. The peak at 2245 cm^{-1}can be attributed to unreacted polyacrylonitrile. Assignments are summarized in Table 3. The available transmittance peak intensities in the difference spectrum B-A confirms the formation of bicarbonate and carbamate after CO_2 adsorption whereas the absence of corresponding peak intensities in the difference spectrum C-A, suggests reversal of the formed bicarbonate and carbamate and re-availability of homogeneous adsorption sites.

The Raman spectrum of AEAPTMS functionalized fiber before CO_2 adsorption, after CO_2 adsorption and after CO_2 desorption are shown in Figure 9. Similar to FTIR, Raman analysis corroborates the formation of ammonium bicarbonate and ammonium carbamate on composite-1 after CO_2 adsorption in humid ambience with 60 % relative humidity and 24 ℃ temperature.

The Raman shift in the region 1000-3000cm^{-1} is due to bicarbonate andcarbamte species. Adsorption of CO_2 from humid air on the uniformly distributed homogeneous sites leads to the formation of bicarbonate peak at 1075 cm^{-1}. Chemisorption of CO_2 on the amine groups present on the surface results in amide peak at 1465 cm^{-1} and the peak at 1687 cm^{-1}can be attributed to secondary carbamate (CHN group), carbonyl group of acid and antisymmetric CO stretching of bicarbonate. The peak at 2260cm^{-1} is due to unreacted nitrile which also gets intensified after adsorption of CO_2 due to overlap of NH^+ group vibration. The peak at 2900 cm^{-1} is due to CH stretching vibrations, vibrations of $O–CH_3$ group and shift of alkane stretching to higher wave number due to the protonation of amines through CO_2 adsorption.

Table 3 IR band assignments after CO2 adsorption on AEAPTMS/PAN (composite-1).

Frequency (cm^{-1})	Assignation and group
691	OH out of plane bending of bicarbonate
816	Stretching of bicarbonate
1318	C-O symmetric band of bicarbonate
1478	NH deformation of carbamate
1561	COO asym stretching of carbamate
593	COO twist of carbamic acid
1414	Symmetric starching of NCOO of ammonium carbamate

A schematic diagram of device with AEAPTMS/PAN membrane and inbuilt heater is shown in Figure 10. During the operation of device, air enters through particulate filter where suspended &micro-particles are removed. After the particulate filter, air goes through filaments of heater and then subsequently through electrospun AEAPTMS/PAN membrane, where CO_2 from ambient air is removed. This provides best efficiency when operated in air-conditioned room without causing any energy inefficiency to existing air-conditioning system. Heater is kept on and off for CO_2 adsorption and desorption cycle, respectively. During desorption, temperature of inlet air increases to temperature above 45°C or preferably 55°C.

It may be appreciated by those skilled in the art that the drawings, examples and detailed description herein are to be regarded in an illustrative rather than a restrictive manner.

We Claim:

1. A nanofiber membrane fabricated by electrospinning an aminoethyl-aminopropyl trimethoxy silane/polyacrylonitrile (AEAPTMS/PAN) composite, with large surface area,having a 100% recyclable CO_2 adsorption capacity of ≥ 0.77 mmol/g functioning at 24 ^{o}C, with complete regeneration at near room temperatureof 45 ^{o}C, with an adsorption cycle of 120 minutes and desorption cycle of 30 minutes.
2. The membrane as claimed in claim 1, wherein the nanofiber is fabricated bymelt spinning, or melt electrospinning, or electrospinning.
3. The membrane as claimed in claim 1, wherein the diameter of the nanofiber is in the range of 1µm to 0.1µm.
4. The membrane as claimed in claim 1, wherein the CO_2 is adsorbed and desorbed in ambient air with adsorption cycle time not greater than 120 minutes and desorption cycle time not greater than 30 minutes.
5. The membrane as claimed in claim 1, wherein the CO_2 is adsorbed on homogenous uniformly distributed amine sites.
6. The membrane as claimed in claim 1,wherein CO_2 is adsorbed by forming ammonium bicarbonate and ammonium carbamate at room temperature, both in the presence and absence of humidity.
7. The membrane as claimed in claim 1,wherein CO_2 is desorbed by decomposing the formed ammonium bicarbonate and ammonium carbamate at 55 ^{o}C, preferably at 50 ^{o}C, more preferably at 45 ^{o}C or lower.
8. The membrane as claimed in claim 1,wherein the CO_2 adsorption leads to homogenous uniformly distributed bicarbonate and carbamate sites.
9. The membrane as claimed in claim 1, wherein re-adsorption and re-desorption occurs for multiple cycles with 100% regeneration capacity.
10. The membrane as claimed in claim 1, wherein the nanofiber is integrated within a device comprising air purifier,air conditioner and heater, with adsorption and desorption cycles.
11. The membrane as claimed in claim 10,wherein the CO_2 is adsorbed after particulate removal from ambient air.

12. The membrane as claimed in claim 10, wherein the nanofiber works in a cycle with 40 minutes of adsorption and 20 minute of desorption or preferably 20 minutes of adsorption and 10 minutes of desorption.

Dated at Chennai this Aug 20, 2018,

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AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF

ABSTRACT

An AEAPTMS (N-[3-(Trimethoxysilyl) propyl] ethylenediamine)/aminoethyl-aminopropyltrimethoxysilanepolyacrylonitrile (PAN) based electrospun nanocomposite material for CO_2 adsorption and air purification is proposed. The material has CO_2 capture capacity of 0.77 mmol/g at 24℃ and 70% relative humidity or in air-conditioned environment with 100% regeneration capacity at near ambient temperature.

AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF

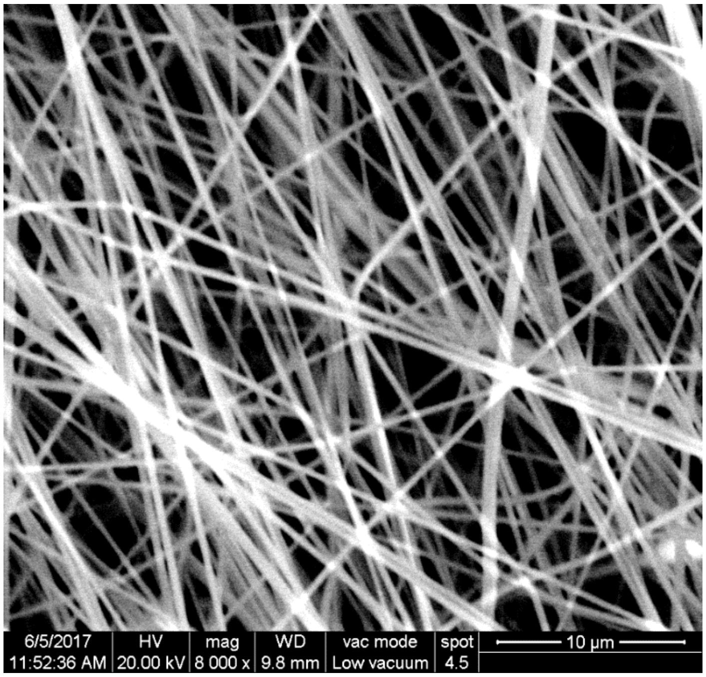

FIGURE 1

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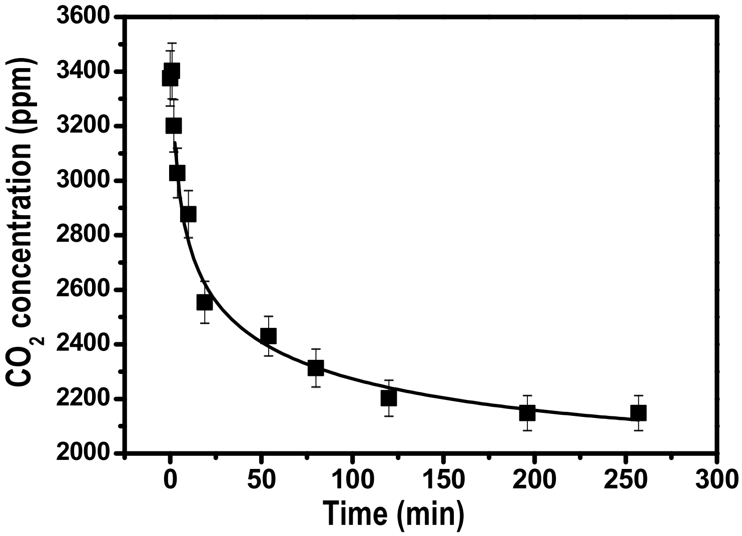

FIGURE 2

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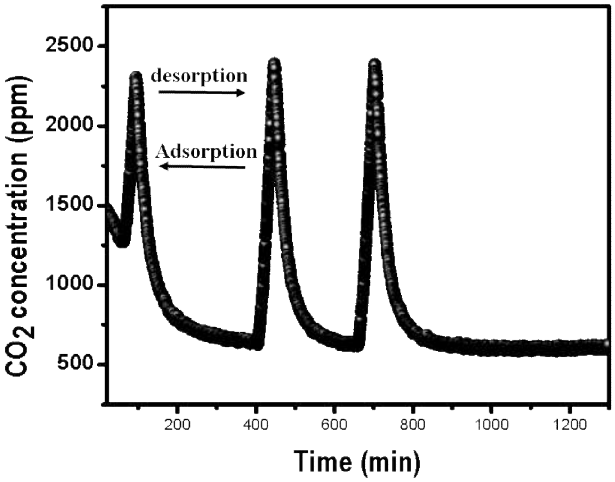

FIGURE 3

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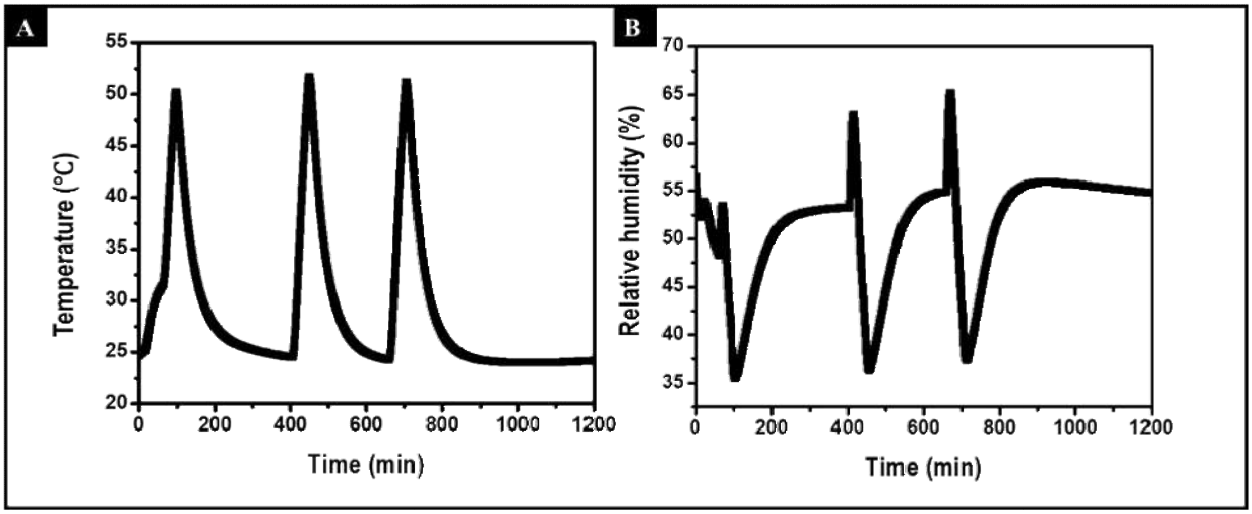

FIGURE 4

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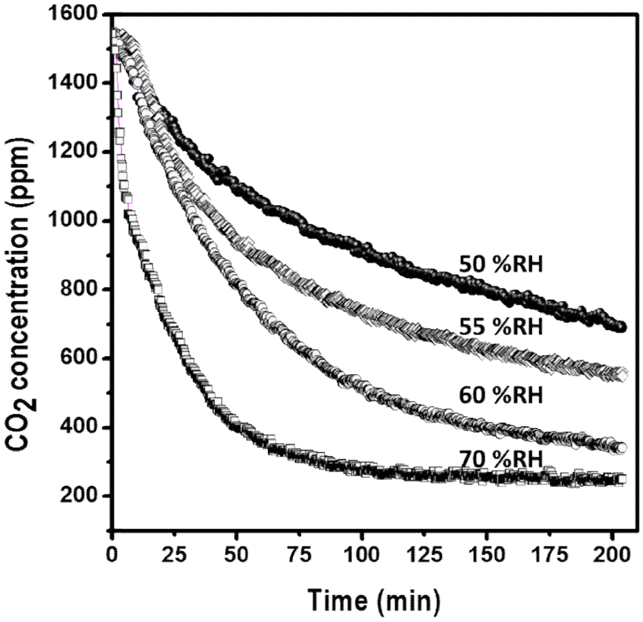

FIGURE 5

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AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF

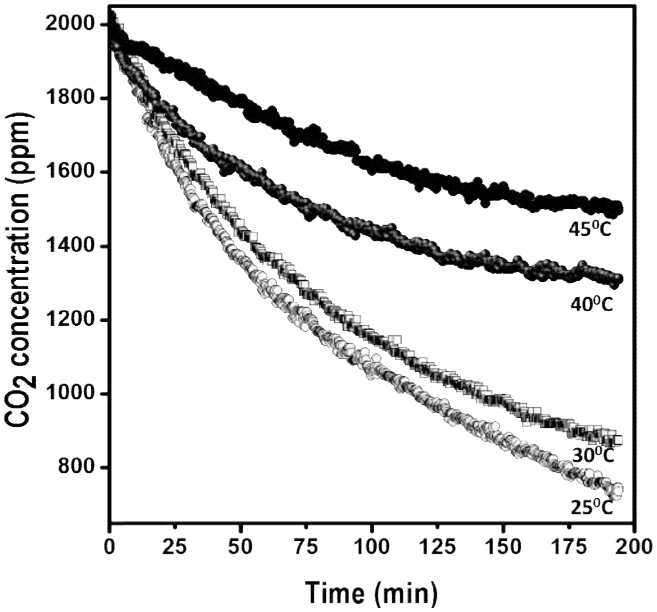

FIGURE 6

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AN ENHANCED CARBON DIOXIDE SORBENT NANOFIBER MEMBRANE AND A DEVICE THEREOF

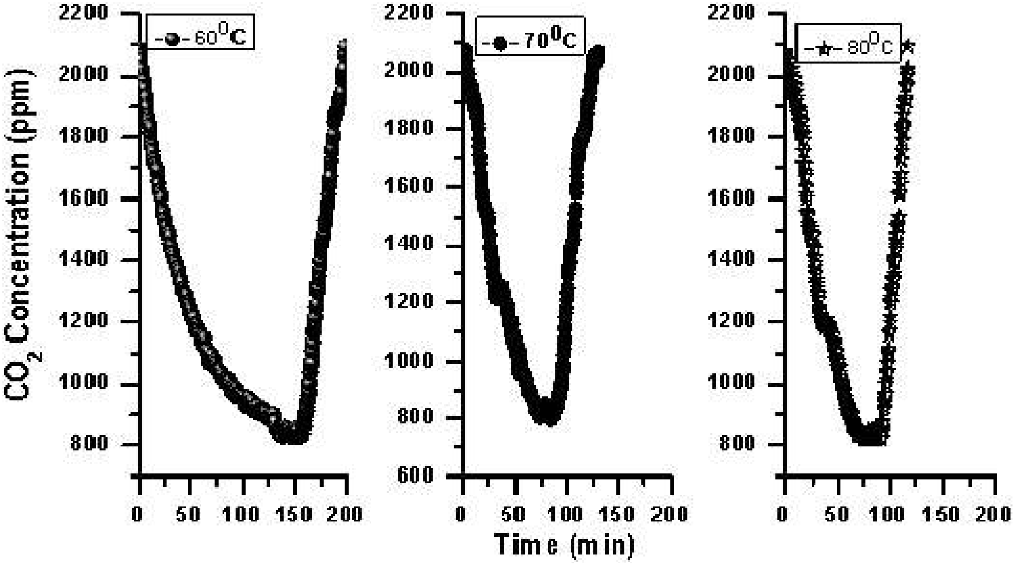

FIGURE 7

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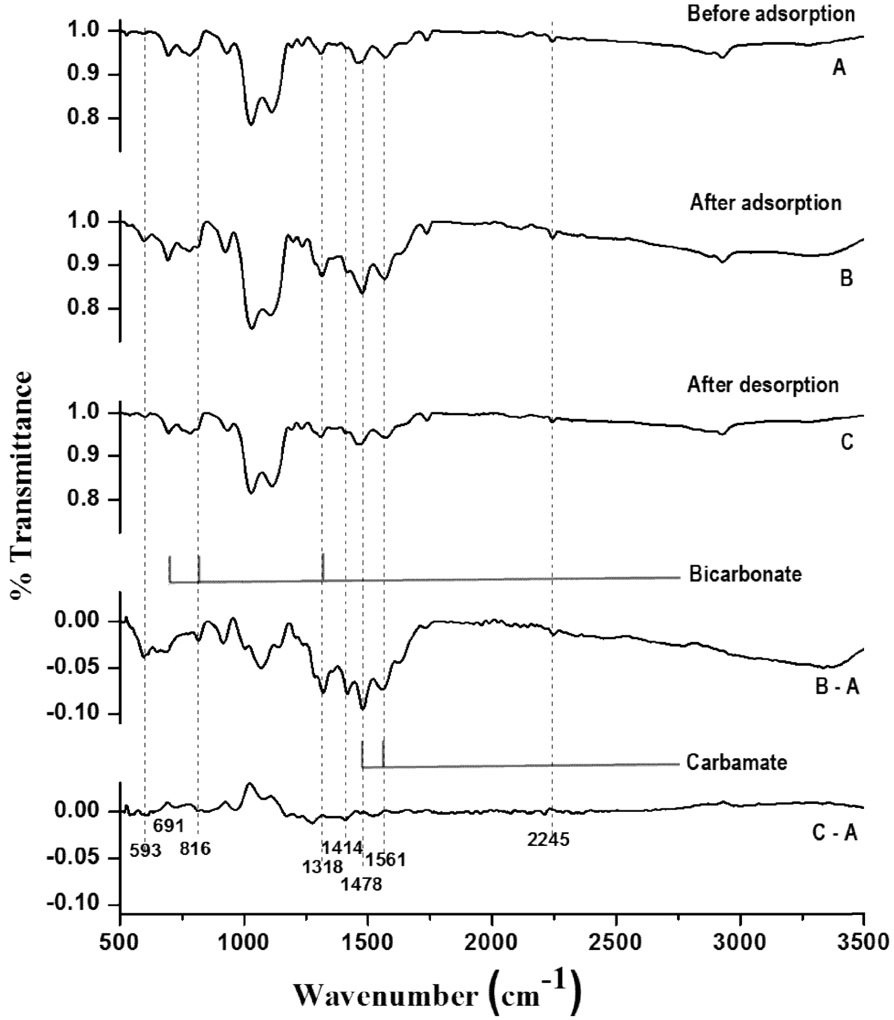

FIGURE 8

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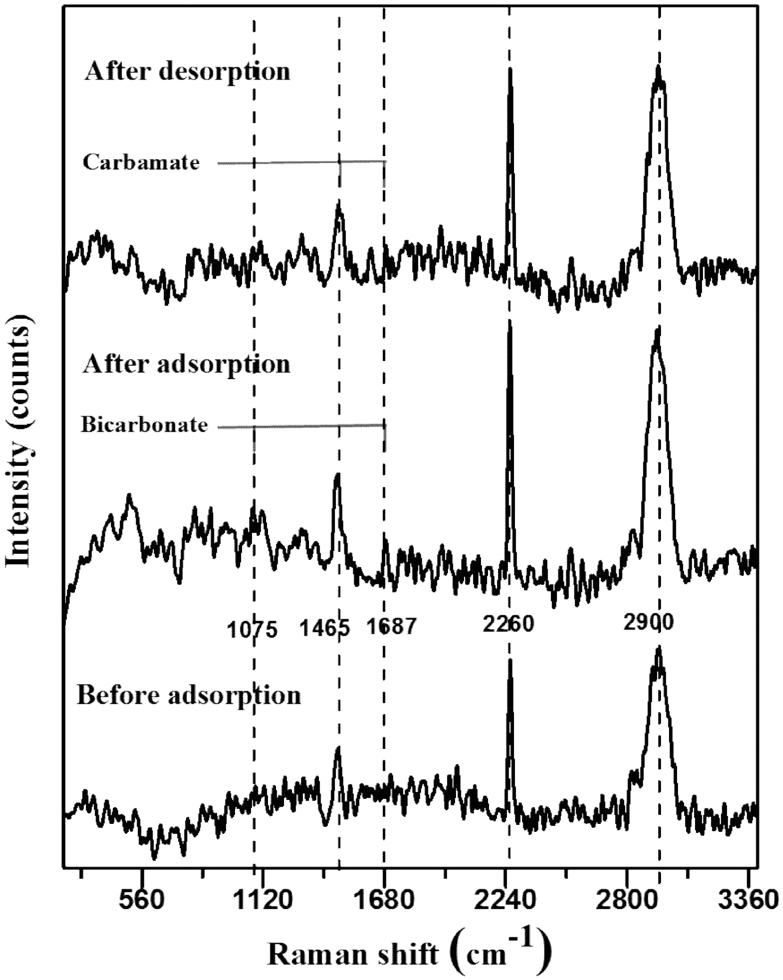

FIGURE 9

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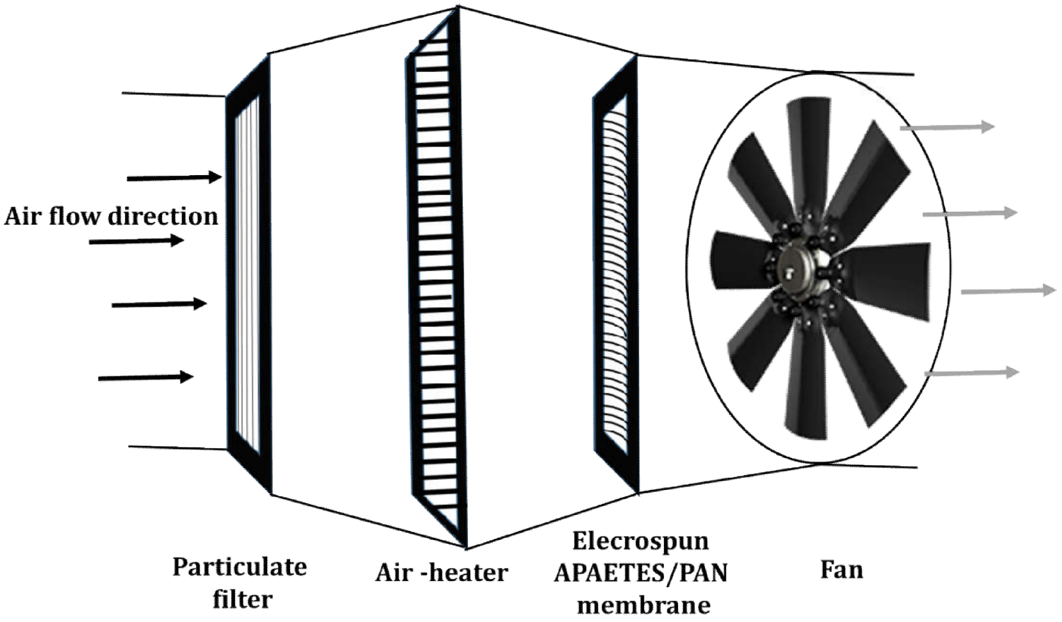

FIGURE 10

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