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CO2 Mitigation

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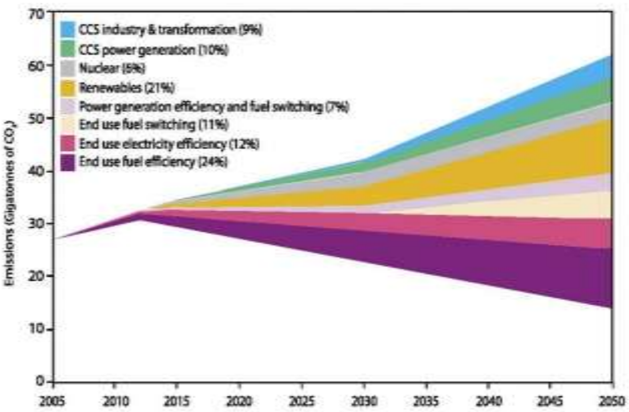
Abstract - *Carbon Dioxide(CO2) with increasing the crisis for ecology and nourishing to extinguish the planet also known as the greenhouse gas. The power plants play the major role to the emission of the flue gas containing CO2. To evade such environmental issue with its mitigation by the methods of pre as well as post combustion in various power plants for the capture of CO2 that uses amine as base. More the CO2 accumulates in the atmosphere more the climate heats up, so to get rid of such crisis towards the environment, there was an increase in the chase of research to capture CO2 from the environment. The post combustion method is the most widely used in various power plants and it's quite similar to the desulphurization. To overcome such technique towards future prospective by developing solid adsorbent with better stability and efficiency in the field of the nano technology, the DFNS-oxyntrides can be used as the solid adsorbents for the CO2 capture was playing a crucial role in the CO2 mitigation with its satisfactory fibrous morphology and at another sight the integrated solar fuel system where sunlight is used to convert CO2 and water vapour into the hydrocarbon by using photocatalytic conversion. Thus urge to remove CO2 from atmosphere and having the recent technology of conversion of direct air to methanol with its highest efficiency by homogeneous catalyst system using pentaethylenehexamine (PEHA).*

Key Words: carbon dioxide, greenhouse gas, amine, DFNS, photocatalytic conversion, methanol, homogeneous catalyst, PEHA.

1. INTRODUCTION

- CO2 the main constituent which is contributing the green house effect upto 26%.
- After industrial revolution the climate change phenomenon has been accelerated with reliance in fossil fuels, coal and oil across the world.
- In carbon capture and sequestration amine plays a good role with its reversible reaction with CO2 where pre and post combustion method belongs too.
- The transformation of technologies or process towards nano-science the DFNS was playing crucial role to capture CO2.
- Overall this reusing and utilizing the CO2 to form the hydrocarbon from where it originated.

As depicted in below graph CCS technology in the various industries & power plant can ultimately lower down the CO2 concentration from atmosphere but as the CCS technology used in this sector which holds to reduce 19% which is just smaller than the use of renewable resources. So what if we combine both CCS technology with renewable to get it to its highest efficiency because as shown in graph we can't end up with the use of the fuels and electricity as the coal which has the highest energy producing fuel and also the fossil fuels on which the whole world is dependent. So just to have such reliance on fossil fuel we need to build up such technique that should be reusable, recyclable and spontaneously reducing the pollution too.



1.1 METHODOLOGY-:

There are various process, synthesis and technology to mitigate CO2 to reuse and recycle it without harming environment. Apart from that we choose some of the techniques from various fields.

PRE-COMBUSTION-: It allows us to capture CO2 and maximize power output an air separation unit produces a stream of almost pure oxygen which flows into the gasifier and reacts with fuel to form syngas which is a mixture of hydrogen, carbon monoxide (co) and water. Shift reactor converting the co to hydrogen and carbon dioxide. The CO2 is captured from gas stream after dehydration and compression, then it is ready for transport and storage. Today hydrogen is used as fuel and also used to make electricity. The excess heat is used to power steam turbine optimizing energy output.

POST-COMBUSTION:- In post combustion method, capture of the flue gas from fossil fuels which are burned as normal but before the free gas travels to chimney that passes through the absorber column which is filled with liquid solvent called as amines which absorbs the CO2 before it enters the atmosphere with superheated steam is then passed through chimney this releases CO2 from the amines and can be stored in the storage tank by evolving the remained flue gas through the chimney.

DFNS (Dendritic Fibrous Nanosilica):-As it's an urge to evade the climate change phenomenon. Therefore, the rise in demand for CO2 sorbents with high capture capacity and faster kinetics is continuously growing. This can be conceived by development of solid sorbents with improved efficiency. Porous silica functionalization by various amines is one of the best way for CO2 sorbent materials. Ayan Maity and Vivek Polshettiwar envisioned that DFNS as a possible good support to design efficient CO2 sorbents. Due to its open and fibrous structure, it could have high amine loading, with minimum reduction in surface area and improved amine sites accessibility. To study these hypotheses, functionalization of DFNS using various amines was carried out (as depicted in figure). Range of amine molecules such as propyl amine (PA), propylethylene diamine (PEDA), propyldiethylene triamine (PDETA), tetraethylene pentamine (TEPA) and polyethylenimine (PEI) with both low and high molecular weights (LMW and HMW) were loaded on DFNS by physisorption as well as by covalent attachment.

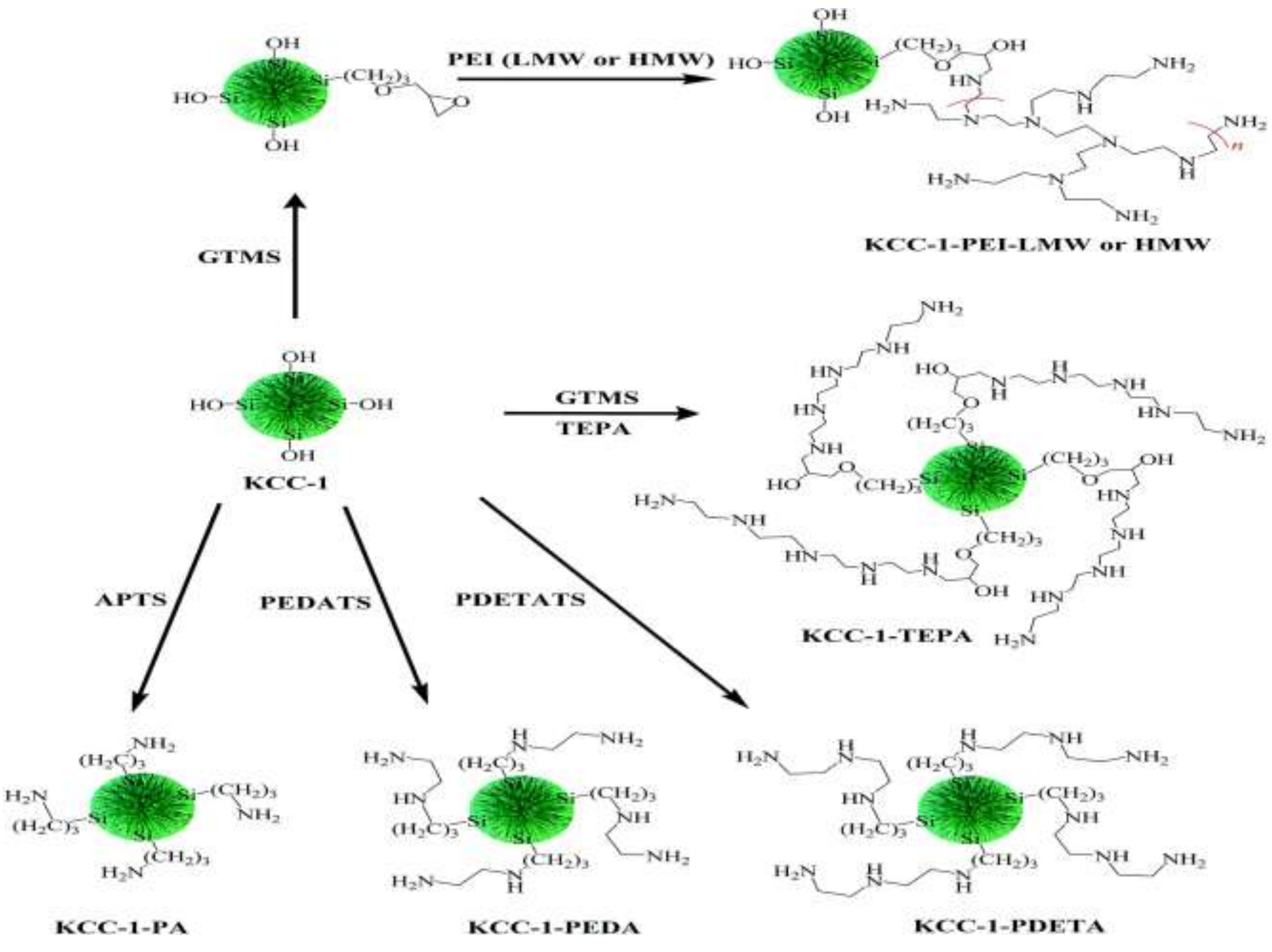


Figure 2: "Functionalization of DFNS with various amines". [4]

Photocatalytic conversion of CO2 into Hydrocarbon.

Direct solar conversion of CO2 and water vapor into hydrocarbon fuels using sunlight is an attractive prospect, serving to reduce atmospheric CO2 concentrations while providing on a renewable basis an energy dense portable fuel compatible with our current energy infrastructure. As depicted in Figure 1, we suggest a strategy of using the fuel on a closed-loop basis; fuel is burned, the CO2 emissions are collected and passed into a photocatalytic bed where solar energy is used to convert the CO2 back into fuel.

In 1979, Inoue and co-workers examined the use of semiconductor powders for CO2 reduction, including TiO2, ZnO, CdS, WO3, etc suspended in CO2 saturated water illuminated by a Xenon lamp. Small amounts of formic acid, formaldehyde, methanol, and methane were produced. According to Inoue suggested that co2 to methane conversion can be take placed in several multistep as follows-

$H2O + 2h^+ \longrightarrow 1/2O2 + 2H^+$
$CO2\ (aq.) + 2H^+ + 2e^- \longrightarrow HCOOH$
$HCOOH + 2H^+ + 2e^- \longrightarrow HCHO + H2O$
$HCHO + 2H^+ + 2e^- \longrightarrow CH3OH$
$CH3OH + 2H^+ + 2e^- \longrightarrow CH4 + H2$

Light Source	**Catalyst**	**Reaction Medium**	**Product**
UV Hg Lamp	TiO2 loaded zeolite	CO2 and H2O vapor	Methanol
UV Lamp	TiO2 powder	CO2 and H2O vapor	Methane, Hydrogen, CO
Natural sunlight of AM1.5 illumination	Cu, Pt co catalyzed N-doped TiO2 nanotube arrays	CO2 and H2O vapor	Methane, other alkanes, olefins, Br-paraffins, H2, CO.

Table -1: "Photocatalytic Reduction of CO2". [10]

Direct Air to Methanol using polyamine and homogeneous catalyst

There is one-pot CO2 capture and conversion to CH3OH at relatively mild temperatures (125–165 °C) involving pentaethylenehexamine (PEHA) and a Ru-PNP complex.

It consists of directly capturing and converting a carbon dioxide from atmosphere and converting it into methanol. Thus a homogeneous catalyst is being used for hydrogenation purpose in the reaction. Several results were obtained by manipulating the data as temperature, additive and time period. Firstly CO2 is captured from air with the help of polyamine in which the flow rate was adjusted at 200 ml/min for 64 hr. Thus the proposed reaction for this is as given-

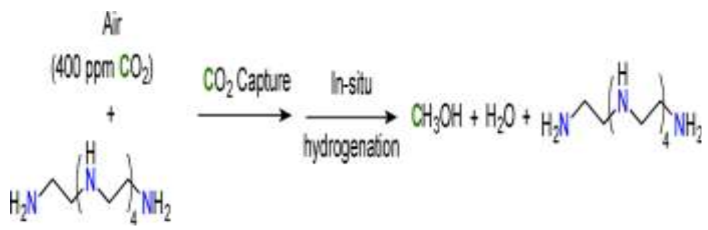
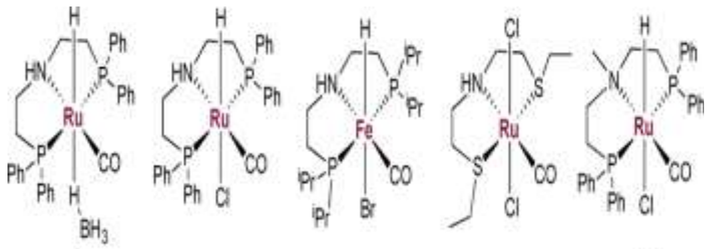


Figure 4: "CO2 Capture from Air and Conversion to CH3OH". [12]

Hydrogenation with the help of homogenous catalyst and carbon capture with PEHA which then further converted into methanol and the polyamine is again recovered for recycling. Following catalyst is being used for various results as shown in table no-1.



1 2 3 4 5

Figure 3: "Catalysts". [12]

The results depicted in below table no-1 shows the production of methanol in terms of TON (turnovernumber).

Entry	Amine	catalyst	T(°c)	Additive	CH_3OH (mmol)	(TON) CH_3OH
1	PEHA	1	95–155	K_3PO_4	9	450
2	PEHA	2	95–155	K_3PO_4	9.1	455
3	PEHA	3	95–155	K_3PO_4	–	–
4	PEHA	4	95–155	K_3PO_4	–	–
5	PEHA	5	95–155	K_3PO_4	–	–
6	TMG	1	95-155	K_3PO_4	–	–
7	DBU	1	95-155	K_3PO_4	1.6	80
8	PEHA	1	95	K_3PO_4	–	–
9	PEHA	1	95-155	–	7.6	380
10	PEHA	1	155	K_3PO_4	13.8	690
11	PEHA	1	155	–	10.4	520
12	PEHA	1	155	–	21.2	1060

Table -2: "Catalyst Screening for Hydrogenation of CO2". **[**14]

Reaction condition: PEHA=3.4 mmol, TMG = 8.5 mmol, DBU = 8.5 mmol, K3PO4 = 1 mmol, CO2/H2 (1:3) = 75 bar, catalyst = 20 μmol, and THF = 10 mL. Entries 1−7 and 9, 95 °C for 18 h and 155 °C for 18 h. Entry 8, 95 °C for 18 h. Entries 10−12, 155 °C for 40 h. Determined by 1H NMR.

This shows the production of methanol were there was problem of recovering from water with the help of distillation process because of solvent being used (THF)66oc having boiling point near to methanol(64.7oc) which having lower efficiency of separation which then being changed to triglyme, 1,4-dioxane which having boiling point 216 and 101oc respectively which changed its yield from 29 to 79% as shown in table no-3

Entry	Amine	CO2 captured (mmol)	Solvent	CH3OH (mmol)	NMR yield(%)
1	PEHA	5.4	1,4-dioxane	2.1	39
2	PEHA	5.4	Triglyme	3.3	61
3	PEHA	5.4	Triglyme	4.3	79

Table-3: "CO2 Capture from Air and Conversion to CH3OH" [12]

Reaction conditions: PEHA = 3.4 mmol, catalyst 1 = 20μmol, H2 = 50 bar, t = 40 h, T = 155 °C, and organic solvent (10 mL)−H2O (8 mL). bt = 55 h.

By implementing this method in a flow system, continuous production of CH3OH can be achieved.

3. CONCLUSION

This literature includes an overall CO2 capture methods and as the atmospheric CO2 level is increasing. As Pre and post combustion are the traditional methods being used and are much costly and is limited up to thermal power plants. Where a new technology of reducing CO2 with the help of renewable source and water which requires a purified carbon dioxide for synthesis thus getting inspire from these technology we are having latest CO2 from air to methanol technique. An integration to build an environment friendly techniques for mitigation of carbon dioxide from atmosphere and converting back into useful chemicals as well as fuels from where it is being originated.

REFERENCES

[1] Environmental Assessment of the Integration of Amine-based CO2 Capture Unit to Coal-fired Power Plants for Greenhouse Gas Mitigation. Bhurisa Thitakamol, Amornvadee Veawab and Adisorn Aroonwilas Faculty of Engineering, University of Regina, Regina, Saskatchewan, Canada S4S 0A2 Tel: (306) 585-5665, Fax: (306) 585-4855, Email: veawab@uregina.ca

[2] Bello, A. and R. O. Idem. Pathways for the Formation of Products of the Oxidative Degradation of CO2-loaded Concentrated Aqueous Monoethanolamine Solutions during CO2 Absorption from Flue Gases. Industrial & Engineering Chemistry Research 44(4): 945-969, 2005.

[3] CO2 Capture and for Improving Heavy Oil Recovery. Lei Tao, Zhaomin Li China University of Petroleum (East China) Dongying, China taolei2365@yahoo.com.cn Na Zhang Shengli Oilfield, Sinopec Dongying, China Henan Sun Heriot-Watt University Edinburgh, UK.

[4] Dendritic Fibrous Nanosilica (DFNS) for Catalysis, Energy Harvesting, CO2 Mitigation, Drug Delivery and Sensing. Ayan Maity, Vivek Polshettiwar* Nanocatalysis Laboratories (NanoCat), Department of Chemical Sciences, Tata Institute of Fundamental Research (TIFR), Mumbai, India. Email: vivekpol@tifr.res.in, ChemSusChem 10.1002/cssc.201701076.[Fig-2]

[5] Samanta, A.; Zhao, A.; Shimizu, G. K. H.; Sarkar, P.; Gupta, R. Post-Combustion CO2 Capture Using Solid Sorbents: A Review. Ind. Eng. Chem. Res. 2011, 51, 1438-1463.

[6] Didas, S. A.; Choi, S.; Chaikittisilp, W.; Jones, C. W. Amine- Oxide Hybrid Materials for CO2 Capture from Ambient Air. Acc. Chem. Res. 2015, 48, 2680-2687.

[7] Singh, B.; Polshettiwar, V. Design of CO2 Sorbents using Functionalized Fibrous Nanosilica (KCC-1): Insights into the Effect of the Silica Morphology (KCC-1 vs MCM-41). J. Mat. Chem. A. 2016, 4, 7005-7019.

[8] Patil, U.; Fihri, A.; Emwas, A.; Polshettiwar, V. Silicon Oxynitrides of KCC-1, SBA-15 and MCM-41: Unprecedented Materials for CO2 Capture with Excellent Stability and Regenerability. Chem. Sci. 2012, 3, 2224-2229.

[9] Radu, D. R.; Pizzi, N. A.; Lai, C. -Y. Functionalized Stellate Macroporous Silica Nanospheres for CO2 Mitigation. J. Mater. Sci. 2016, 51, 10632-10640.

[10] Toward Solar Fuels: Photocatalytic Conversion of Carbon Dioxide to Hydrocarbons. Somnath C. Roy,† Oomman K. Varghese,† Maggie Paulose, and Craig A. Grimes*, Department of Electrical Engineering, and Materials Research Institute, The Pennsylvania State University, University Park, Pennsylvania16802. February 8, 2010. 10.1021/nn9015423.

[11] Inoue, T.; Fujishima, A.; Konishi, S.; Honda, K. Photoelectrocatalytic Reduction of Carbon-Dioxide in Aqueous Suspensions of Semiconductor Powders. Nature 1979, 277, 637–638.

[12] Conversion of CO2 from Air into Methanol Using a Polyamine and a Homogeneous Ruthenium Catalyst, Jotheeswari Kothandaraman, Alain Goeppert, Miklos Czaun, George A. Olah,* and G. K. Surya Prakash*, Loker Hydrocarbon Research Institute and Department of Chemistry, University of Southern California, University Park, Los Angeles, California 90089-1661, United States. DOI: 10.1021/jacs.5b12354.[Fig-3, Fig-4]

[13] Alberico, E.; Nielsen, M. Chem. Commun. 2015, 51, 6714−6725.

[14] (a)Li,Y.-N.;He,L.-N.;Liu,A.-H.;Lang,X.-D.;Yang,Z.-Z.;Yu,B.; Luan, C.-R. Green Chem. 2013, 15, 2825. (b) Li, Y.-N.; He, L.-N.; Lang, X.-D.; Liu,X.-F.;Zhang,S.RSCAdv.2014,4,49995−50002.