Solar Equipped Moisture Adsorber using supervised Machine Learning Techniques

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Abstract

In the rapidly changing world, where man is blessed with modern technology that has given power to use and abuse the resources. Gone are the days, when the farmer used to perform extensive farming in order to fulfil the basic needs. With commercialization in agriculture, the extensive farming has shifted rapidly towards intensive farming. Major part of India, the current scenario is facing dryness resulting in serious economic setback due to improper farming condition as a result of water scarcity. Recently we have seen lots of crises in term of life, economy and most importantly health, hence for the better prosperity of our country, it's a major issue to be solve. A device named SEMA Solar Equipped Moisture Absorber consists of MOFs Metal Organic Frameworks. Basically MOFs are linked inorganic and organic units by strong bonds. Device is capable of harvesting 2-3 liters of Water per kg of MOF daily. Thus the collected water can be supplied in farm land for agricultural purpose.

Keyword- *MOF801, Condenser,solar heat adsorber,MOF-801[Zr6O4(OH)4(fumarate)6,*

I INTRODUCTION

Solar Equipped Moisture Adsorber is a device that harvest water from atmosphere, the abundant of water moisture is present in atmosphere, hence trapping of this moisture and releasing it in the form of water becomes an important aspect to solve global water crisis. Solar equipped Moisture Adsorber consists of zirconium base porous MOF that adsorbs moisture from atmosphere and with the help of low grade solar radiation this adsorbed moisture is released in the form of water that can be used to solve various water problem across the globe. Atmospheric water is a resource equivalent to ~10% of all fresh water in lakes on Earth. However, an efficient process for capturing and delivering water from air, especially at low humidity levels (down to 20%), has not been developed. We report the design and demonstration of device based on porous metal-organic framework-801 [Zr6O4(OH)4(fumarate)6] that captures water from the atmosphere at ambient conditions using low-grade heat from natural sunlight below one sun (1 kW per square meter). This device is capable of harvesting 2.8 liters of water per kilogram of MOF daily at relative humidity levels as low as 20%, and requires no additional input of energy

II. PROBLEM DEFINITION

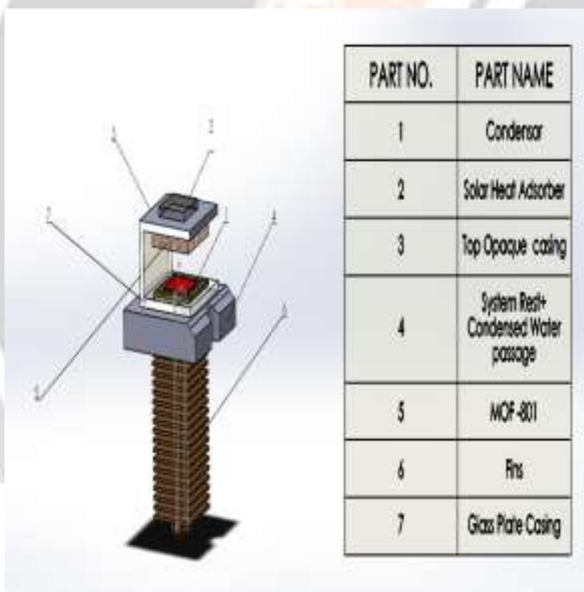
Two third of the world is suffering for water scarcity that results in various crisis namely health hazards and water scarcity for the cultivation of crops. Hence water scarcity is currently a global challenge to be solved.Major part of India current scenario is facing dryness resulting in serious economic setback due improper farming condition as a result of water scarcity. Recently we have seen lots of crises in term of life, economy, and most importantly health hence for the better prosperity of our country it's a major issue to be solved.Though water is present in atmosphere in abundant amount (10 % of fresh lake water still trapping of water from atmosphere and collecting it at a low cost is major challenge. Silica gel and such other stuff are available for trapping of water from atmosphere but the process is complex in extracting the adsorbed water and costly too.Once the water is adsorbed by an adsorbing material, it must be desorbed by mean of low grade energy at very cheap cost which hence is another challenge in the process. Desorption from the available source is complex and hence costly.

III SOLUTION

High porosity of zirconium based MOF (Metal Organic Framework), MOF-801 allows the adsorption of moisture from the atmosphere at very fast rate with cheap cost operation.A critical step after the adsorption process is to release the trapped water by MOF , this can be achieved by the application of low grade heat driven vapor desorption process which is then achieved by the use of solar energy of density 1 sun.We use MOF-801 for the adsorption and desorption processdue to the following reason-Well studied water adsorption behavior on a molecular level,Good performance driven by aggregation of water molecules into clusters of MOF within molecules,Exceptional stability and recycling.Constituents that is widely available and low cost.

IV. METHODOLOGY

SYSTEM LAYOUT



PART NO.	PART NAME
1	Condensor
2	Solar Heat Adsorber
3	Top Opaque casing
4	System Rest+ Condensed Water passage
5	MOF-801
6	Fins
7	Glass Plate Casing

Fig. 2.1 System Layout

IV PERFORMANCE EVALUATION

Ideal Porosity = 0.7,1 Sun = 1 kilowatt hour per metre square Crystal Diameter of MOF-801 = 0.6 micrometre,Neutral heat transfer coefficient = 10 watt per metre square per Kelvin Considering MOF of 1mm thickness: Duration of exposure = 24 hrs,Low grade heat adsorption= 1 kilowatt hours per metre square,Result = 2.8 litres per kilogram per day / 0.9 litres per metre square per day,Outer Dimensions of MOF= 7*7*4.5 cm Weight of MOF to beused = 138g

MOF Wt.	THICKNESS	PACKING POROSITY
179 grams	0.41 cm	0.85

Table 5.2.1: MOF Porosity

THICKNESS	EXPOSURE TO SOLAR RADIATION
1 mm	1 hrs.
3 mm	2.3 hrs
5 mm	4.2 hrs

Table 2.2.2: Solar radiation duration

4.1.1STRUCTURE OF MOF-801

It is composed of, 12 connected Zirconium based cluster joined by fumarate linkers into a three dimensional extended pores of face centred cubic structure. It contains three symmetrical independent cavities into which water can be captured and concentrated.

4.1.2 PACKING OF MOF-801

Powder of MOF-801 was synthesized and activated by heating at 150 degree Celsius under vacuum for 24 hrs. The powder was infiltrated into a pores copper foam with thickness 0.41 cm and porosity equivalent to 0.85.

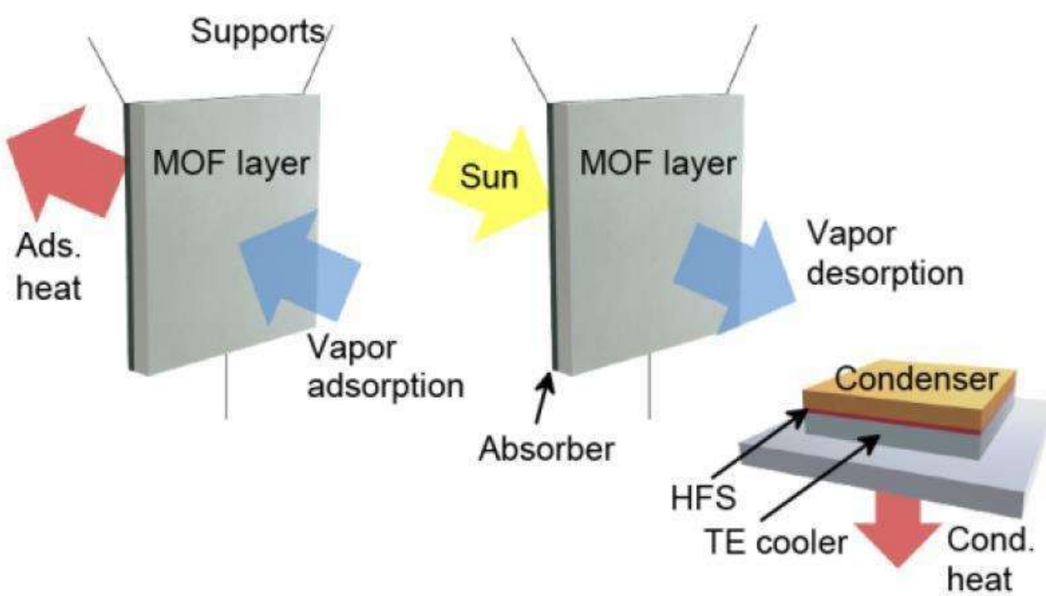


Fig. 4.1.1Vapour Adsorption and Desorption

V 3-D LAYOUT

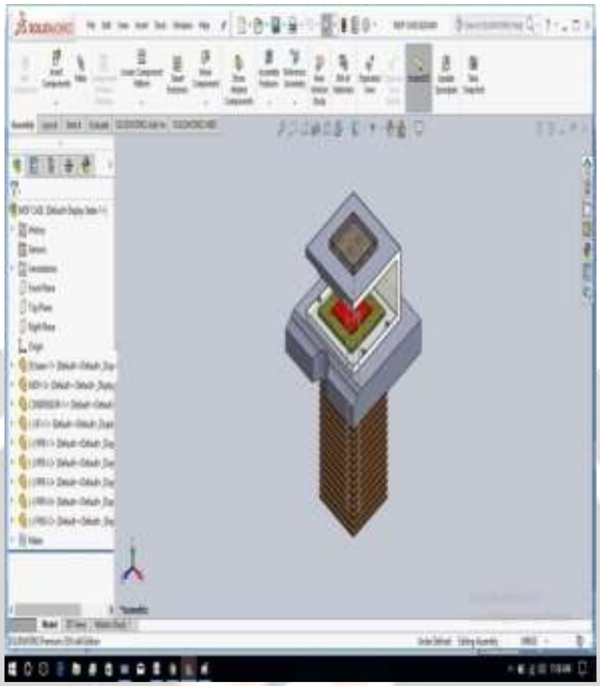


Fig. 5.1.1 3-D Layout

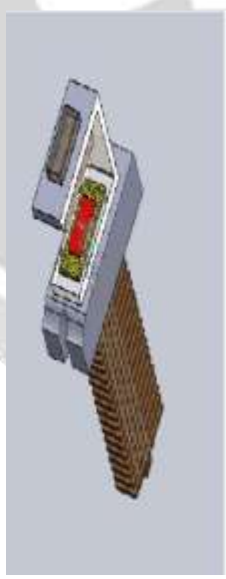



Fig 5.1.1 Fig 5.1.2

VI WORKING PRINCIPLE

Water-adsorption isotherms of Zr-based MOFs (MOF-801, MOF-841, UiO-66, and PIZOF-2) at 25°C, showing a rapid increase in adsorption capacities (in kilograms of water per kilogram of MOF) with a relatively small change in the relative humidity (RH) (P_{sat}–1, vapor pressure oversaturation pressure) . The background color map shows the minimum difference between the temperatures of the ambient air (T_{amb}) and the condenser (T_{dew}) required for dew collection with active cooling & Water adsorption. Isotherms of MOF-801, measured at 25° and65°C, illustrating that the temperature swing can harvest greater than 0.25 kg kg–1 at >0.6 KPa vapor pressure 20% RH at 25°C. A MOF water-harvesting system, composed of a MOF layer and a condenser, undergoing solar-assisted water-harvesting and adsorption processes. During water harvesting, the desorbed vapor is condensed at the ambient temperature and delivered through passive heat sink, requiring no additional energy input. During water capture, the vapor is adsorbed on the MOF layer, transferring the heat to the ambient surroundings (right). Ads. And cond., adsorption and condensation, respectively .Zr6O4(OH)4(-COO)12 secondary building units are linked together with fumarate to form MOF-801,The large yellow, orange, and green spheres are three different pores. Black, C; red, O; blue polyhedral, Zr.

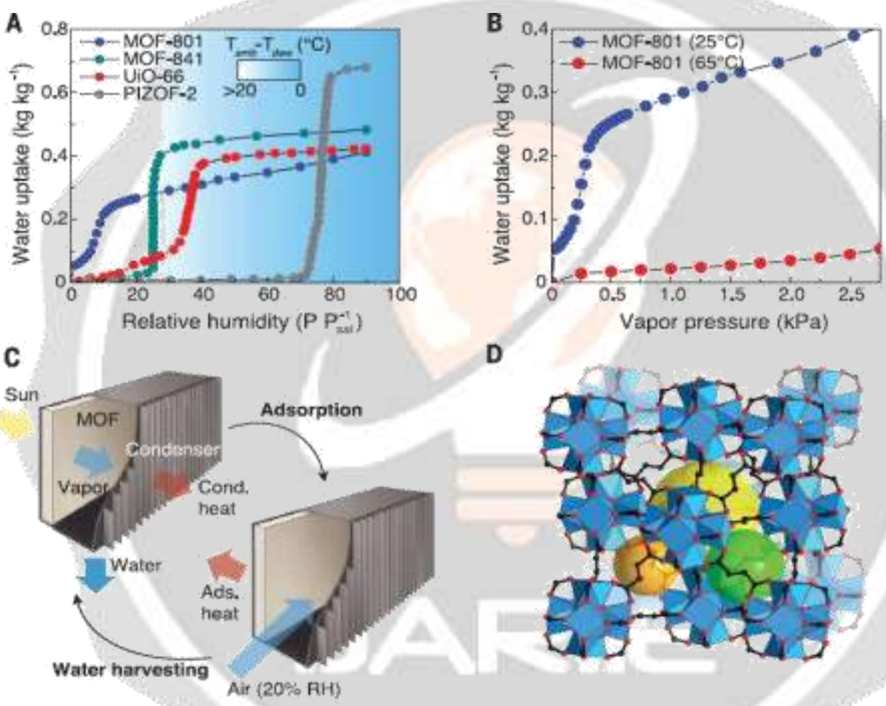


Fig 6.1.1 working principal of water harvesting

HARVEST ANALYSIS

Table 6.1.2: Harvest

THICK NESS	AREA	TIME OF EXPOSUR E	HARVEST
1 mm	1 m^2	1 hour	0.08 liters
3mm	1m^2	2.3 hours	0.24 liters
5mm	1m^2	4.2 hours	0.40 liters
4mm	1m^2	1 hour	0.32 litters

Harvesting Calculation

Time of desorption = 7 hrs,
Therefore for 7 hrs.
Exposure to solar heat harvest=0.32*7 = 2.24 litres (For 4mm thickness of MOF)
Rate of desorption of condenser = 0.32 litres per hours,
Therefore, for 4mm thick of MOF of 1m^2 area with desorption period of 7 hrs, harvest equals 2.24 litres.Harvest water = 84% of adsorbed moisture,
Therefore, moisture adsorbed= (2.24*100)/84= 2.67 litres Since, maximum adsorption porosity of MOF is 84%.

RESULT AND DISCUSSION

USING MOF-801, water can be harvested from atmosphere with a efficiency of 2.8 litres per kg of MOF per day. Harvesting of water is achieved by adsorption desorption process where adsorption time depends on environmental condition such as relative humidity and desorption vapour timing is around 7 hours at a density of 1 flux of sun, where 1 sun = 1 k-watt hr/ metre sq. The desorption process is made possible due to the high porosity of zirconium based MOF .MOF-801 allows the adsorption of moisture at very fast rate with cheap operation cost. Desorption process is achieved, to release the adsorbed moisture, by applying low grade heat driven vapour desorption process i.e. solar energy.REASON FOR CHOOSING MOF-801,Well study water adsorption behaviour on a molecular level,Good performance driven by aggregation of water molecules into clusters within the pores of MOF.Exceptional stability and recycling.constituents that are widely available and at low cost.

FUTURE SCOPE

If the current scenario follows, the major issue in the upcoming future will be water crises globally, even today two third of the world population don’t have access to safe drinking water and water for the purpose of irrigation. Solar Equipped Moisture Adsorber will not only utilise the unused moisture of atmosphere for drinking purpose but also it is going to solve the global agricultural issue based on water scarcity. Water is a source of life, from giving life to constructing buildings, we all need water. This device based on MOF for harvesting water with almost no maintenance cost can solve the issue of water crises globally. In the upcoming future we may have MOF based on aluminium which will decrease the cost of manufacturing the device by almost 90%, which will further make the device much affordable for daily use. Dry countries like India, UAE, and other such countries will be at the maximum benefit.

COST ESTIMATION

Table Cost Estimation

SL.NO	NAME	QUANTITY	COST
1	MOF-801	138 grams	Rs.2200
2	CONDENSER (heat sink)	1 piece	Rs.500
3	GLASS HEAT ADSORBER	1 piece	Rs.300
4	CABIN	1 piece	Rs.800
TOTAL			Rs.3800

CONCLUSION

Water is available in abundant amount in atmosphere, which is enough to tackle water crisis globally .thus we need a system to collect water from atmosphere since there are measures to extract water from atmosphere using certain substances like silica gel but extracting water from them is not just complex but costly too. Using adsorption desorption process with the help of MOF-801 for adsorption and solar radiation for desorption, we have come with a device called solar equipped moisture absorber that can extract water from atmosphere at negligible working cost . In designing solar equipped moisture absorber, we have used MOF-801 which is very expensive around ₹12000 per kg. hence we need a Mof with much cheaper cost that can be achieved by use of aluminium based MOF instead of zirconium based MOF.

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