Automated Eco-Friendly and Cost-Efficient CO_2 Capture System: a Novel Zeolite-MOF Hybrid Material

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Problem

In the last few years, increasing CO_2 levels in the atmosphere have become one of the biggest problems earth is facing. Not only is it causing global warming, which critically affects the environment, but it is also affecting human health significantly as it directly impacts the cardiovascular, respiratory and nervous system causing 6.7 million deaths annually [1][2]. In addition, the ocean and marine life is also paying the price by ocean acidification. This is also caused by CO_2 emissions which factories and other transportation vehicles mainly emit [3]. (FIG.1.)

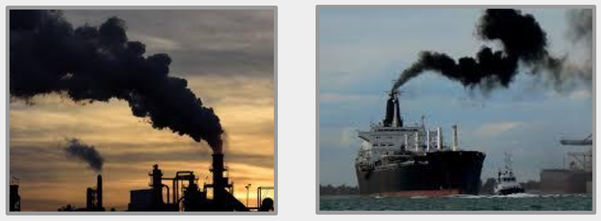


FIG.1. Examples of main polluters

Our Goals

First — Our goal is to reduce suffering and save lives and Supporting SDG 13 for climate action and SDG 14 to mitigate climate change impacts on oceans and the planet.

Second — Empowering factories and cargo ships to increase production and revenue by eliminating taxes and limits on CO_2 emissions.

Third — Helping governments and world associations monitor the emissions to maintain the progress and change.

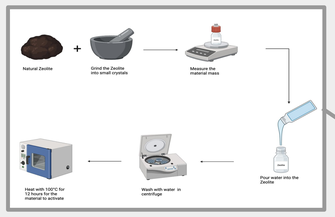
Background

A primary example used for CO_2 capturing currently are Amine Solutions. Although it has good capture rate, it lacks the sustainability as it can't be reused or regenerated. This can also cost more for it to be used. In addition, it is very corrosive to the environment which can negatively impact it in the long run.

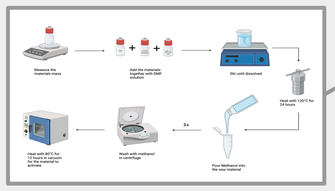
Hypothesis

It is expected that the hybrid material will show improved CO_2 capture rate and efficiency alongside the device which will increase its sustainability while maintaining its stability over multiple reuses. The material will also achieve lower costs of synthesis and usage compared to the materials currently available.

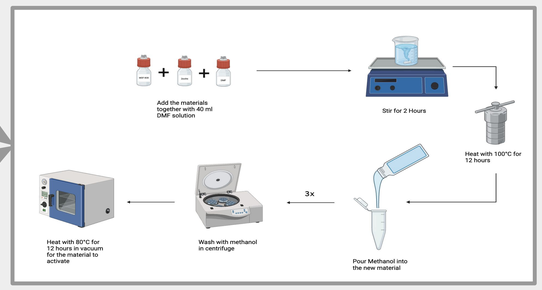
Procedure



Synthesis of Zeolite

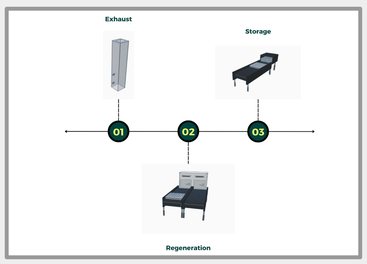


Synthesis of MOF-808

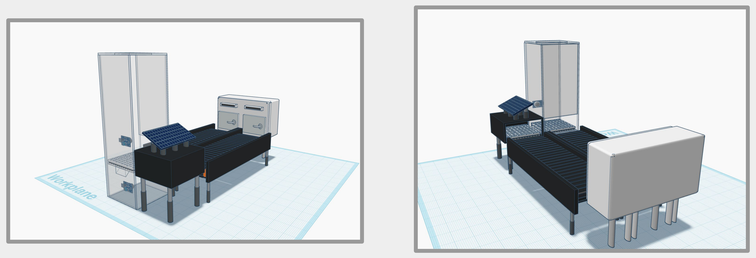


Synthesis of new hybrid material

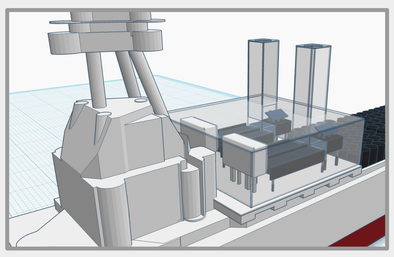
System

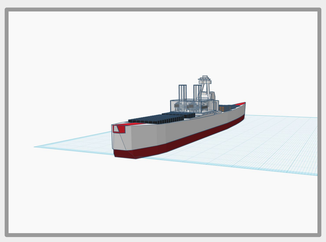


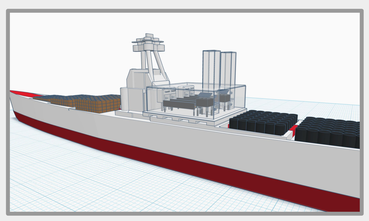
Process of Regeneration



Angled View of the System

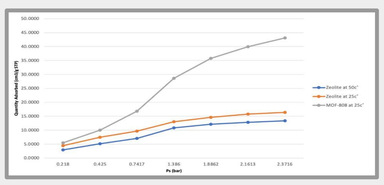




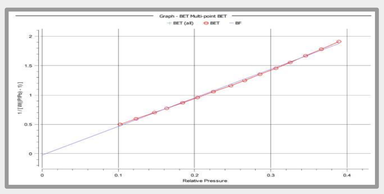


System Embedded Into a Cargo Ship

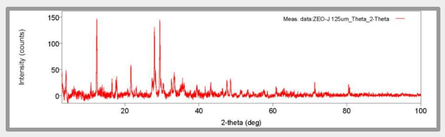
Graphs



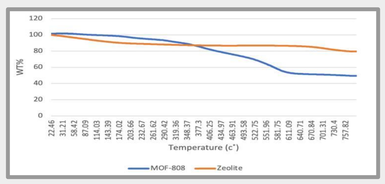
Zeolite and MOF-808 Adsorption Performance by HPVA



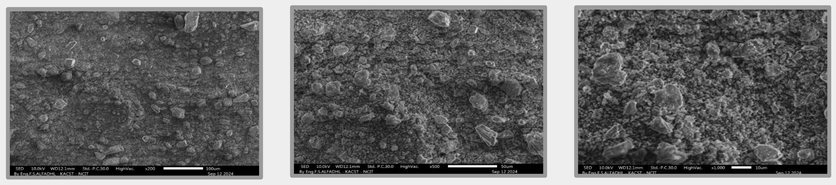
Graph of analysis for surface area of Zeolite by BET



Zeolite Crystalline Structure by XRD



Zeolite and MOF-808 Thermal Stability by TGA



Pictures of Zeolite under SEM

Results

When the materials were tested, Zeolite CO_2 capture rate was lower than MOF-808's as expected through the HPVA II analysis. This was mainly due to its limited surface area and porosity. That was also proven when examined by SEM. However, Zeolite had a better thermal stability when tested by the TGA instrument showing vividly its strength.

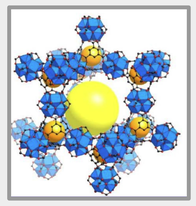


FIG.2. Representation of MOF-808 structure

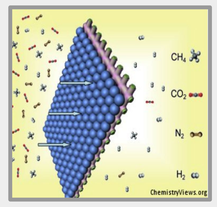


FIG.3. Representation of MOF-808 capturing CO_2

System description

The solar-powered system captures CO_2 from ship exhaust using a filter containing the hybrid material, monitored by sensors for saturation, with automated conveyor belts transporting the material to the regeneration area where it is heated before being returned to the exhaust for over 80 cycles of efficient use.

Application

The system efficiently captures CO_2 from ship exhaust monitored by advanced sensors for effectiveness, and utilizes solar energy for regeneration. (System)

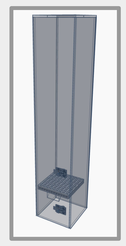


FIG.4. Exhaust with the filter containing the porous material and two sensors

Future Work

The research will focus on exploring the new synthesized hybrid material and varying synthesis ratios to develop an optimal CO_2 capturing solution that focuses on performance and delivers with efficiency.

Referencing