Pore Tailored and Surface Modified Functional Adsorbents for Selective CO_2 Capture

MD. AMIRUL ISLAM[1], BIDYUT BARAN SAHA[1,2,*]

[1] International Institute for Carbon-Neutral Energy Research (WPI-I²CNER), Kyushu University, 744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan
[2] Department of Mechanical Engineering, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan
* Corresponding Author, e-mail: saha.baran.bidyut.213@m.kyushu-u.ac.jp, phone: +81-92-802-6722

1. Introduction

CO_2 capture and storage (CCS) is one of the greatest challenge. Adsorption-based CCS systems are one of the most potential future technologies to thrive as these systems are environmentally benign, noiseless, and non-corrosive in nature. Additionally, adsorption-based CCS systems require low-grade waste heat, which is available in the power and industrial sectors. The major drawback in the adsorption-based systems is the lack of high-grade adsorbent that can selectively capture CO_2. Therefore, the ultimate goal of this research proposal is to synthesize a high-grade biomass derived activated carbon (BAC) for selective and enhanced CO_2 capture.

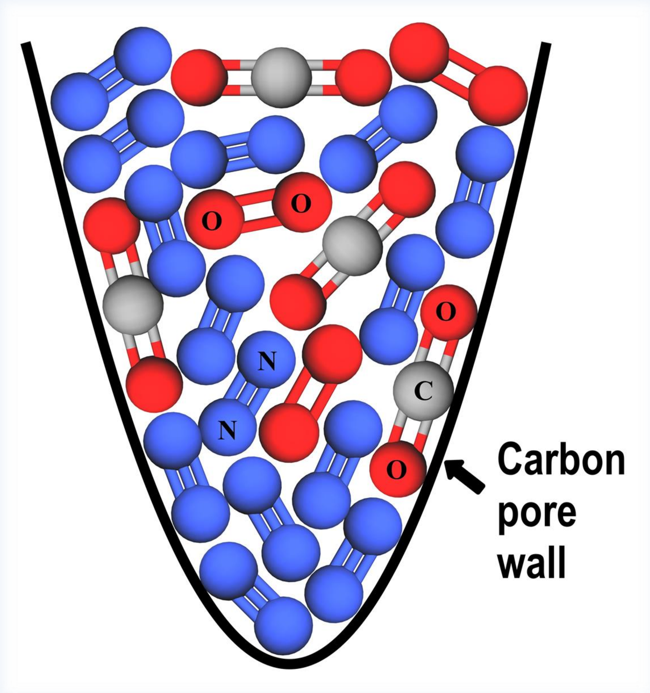
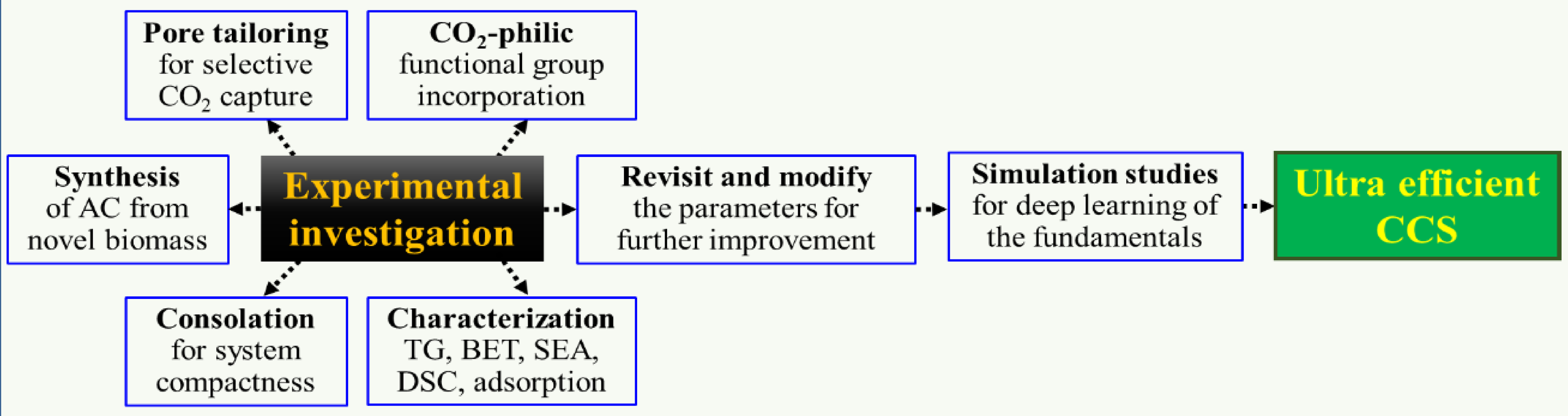


Fig. Air adsorption in regular activated carbon pore (poor selectivity).

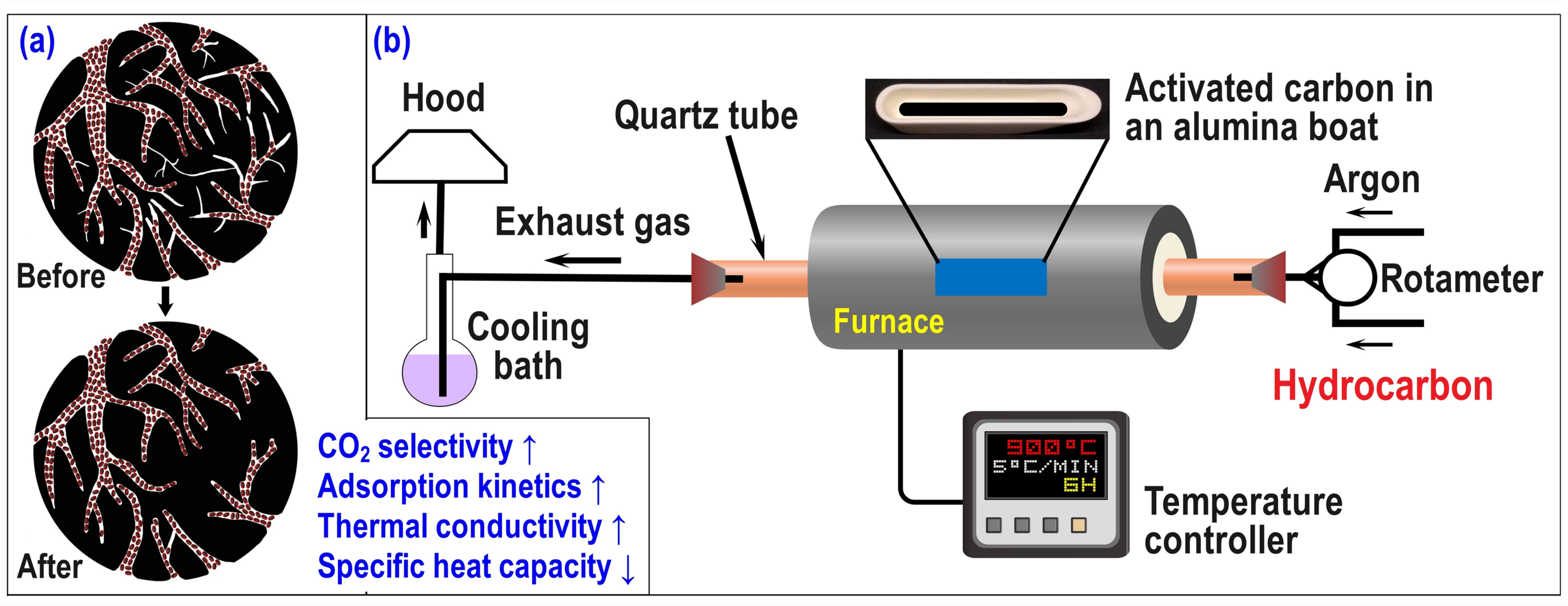
2. Implementation Strategy



There are seven milestones to achieve the ultimate goal, which are as follows:

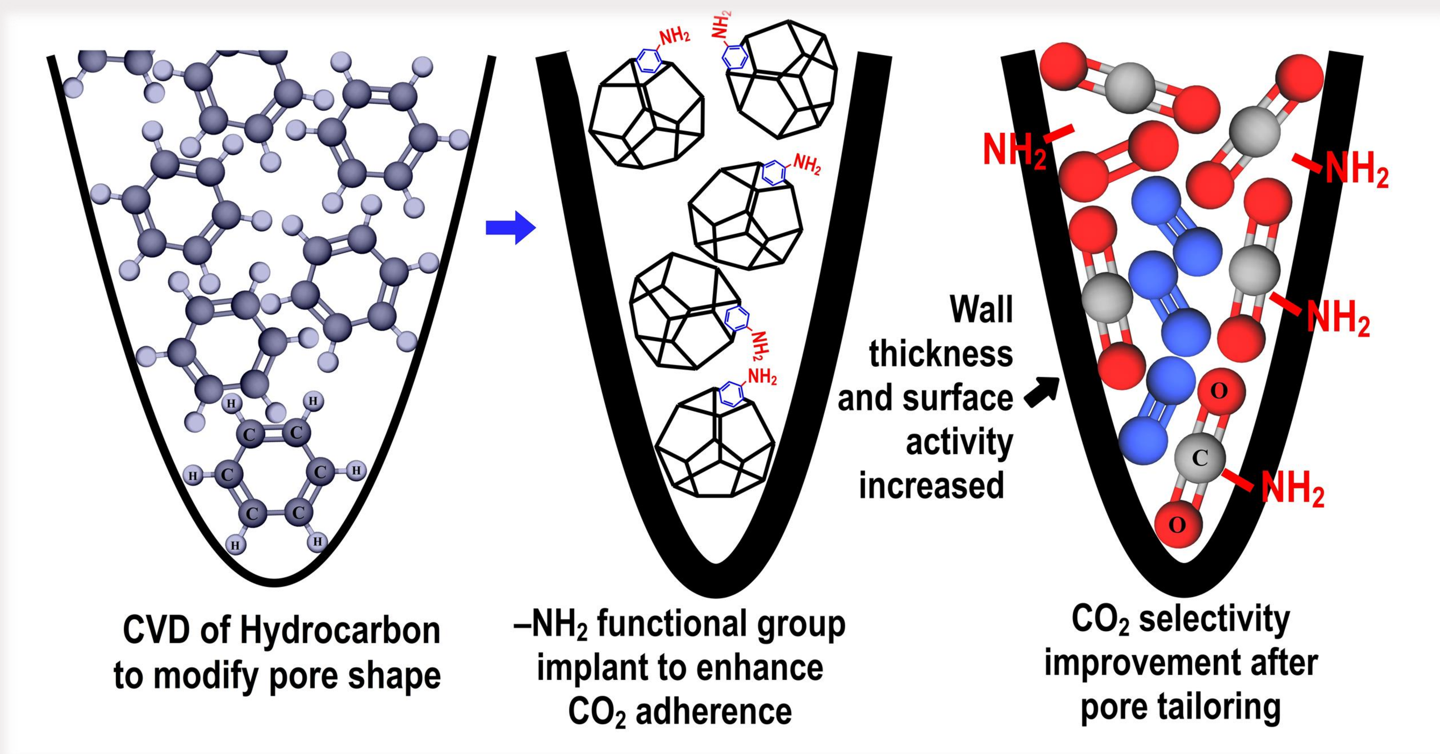
(i) Identify and prepare high-grade biomass-derived ACs
(ii) Pore shaping for efficient CO_2 capture
(iii) Surface treatment to enhance capture quantity
(iv) Composite adsorbent
(v) Characterization:
(vi) GCMC, molecular dynamic (MD), and cycle simulations
(vii) Ultrasonication based adsorption bed

3. Pore Modification



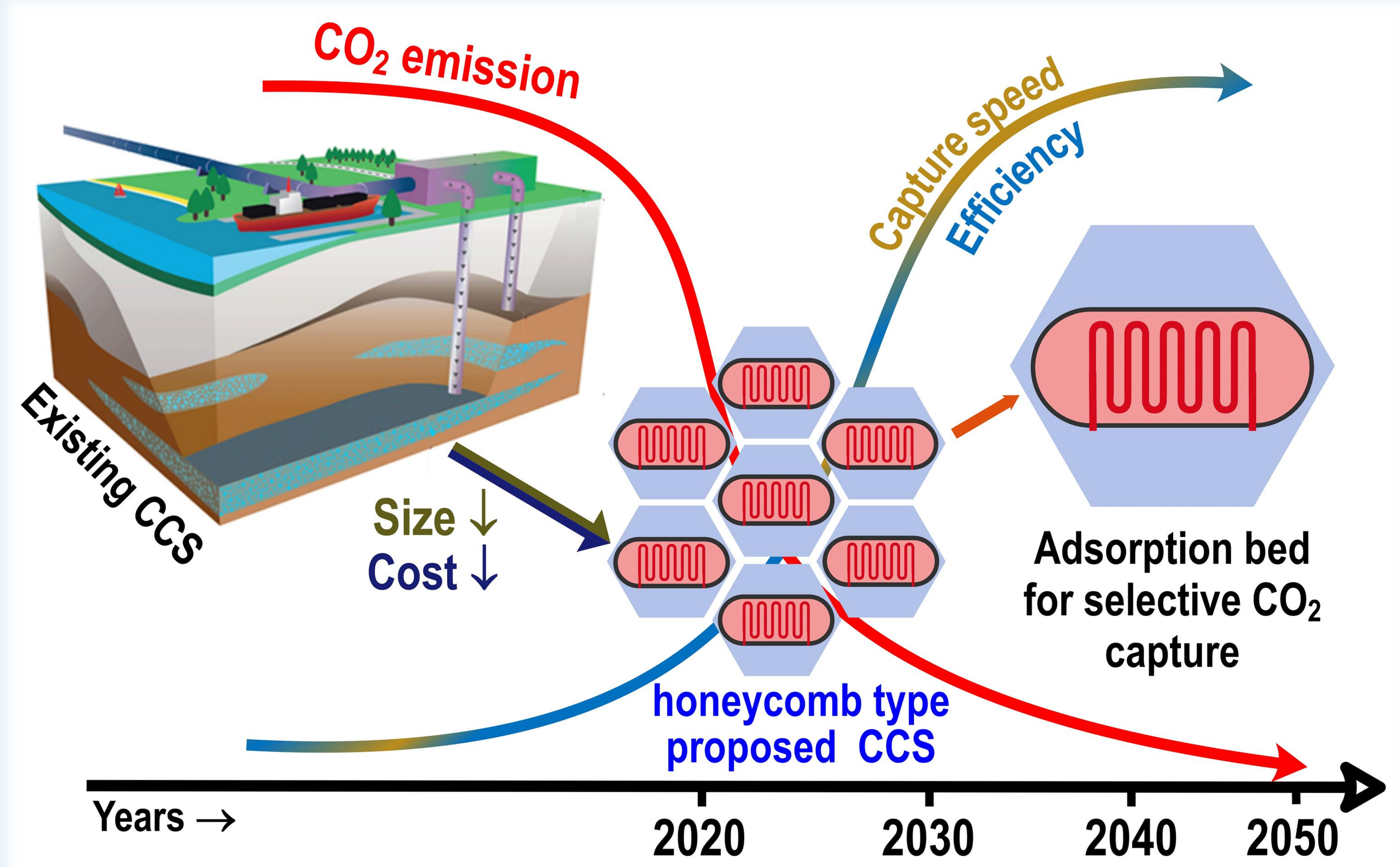
Since the pores have poor CO_2 selectivity, the pore shape will be engineered (narrowed and made comparable to CO_2's kinetic molecular size) by CVD of hydrocarbon. The schematic of executing the process is shown in the figure. The tailoring will also enhance some physical properties such as thermal conductivity, specific heat capacity and adsorption kinetics.

4. Pore Engineering and Functionalization



Further enhancement of CO_2 capture will be performed by incorporating CO_2–philic functional groups (e.g. $–NH_2$) on the pore surface. This active surface will hold the CO_2 molecules more strongly.

5. Expected Result



After the tailoring and incorporation of functional groups, the modified adsorbent will be consolidated using selective ionic liquid. The consolidation will be helpful to achieve a compact system. Once the desired properties are achieved, the synthesized AC will be coated on a finned tube heat exchanger. A closed chamber, namely an adsorption bed, will be built, including a low-power consuming ultrasonication system for faster desorption of CO_2. Several adsorption beds will be accumulated to form a honeycomb type ultraefficient CCS.

6. Conclusions

Former prime Minister of Japan, Mr. Suga, announced in parliament "Japan will be carbon neutral by 2050". Hence, industries are investing billions of dollars in removing CO_2 during production. For example, $20 billion dollar was invested to build the Tomakomai CCS Demonstration Project in Hokkaido which removed about 300,110 tonnes of CO_2 from 2016–2019. Toyota announced that they will reduce 90% CO_2 emissions from their plants and cars. They are investing millions of yens to achieve their target. Sumitomo Chemical invested 490 million yen in designing a membrane-based CO_2 separation system.