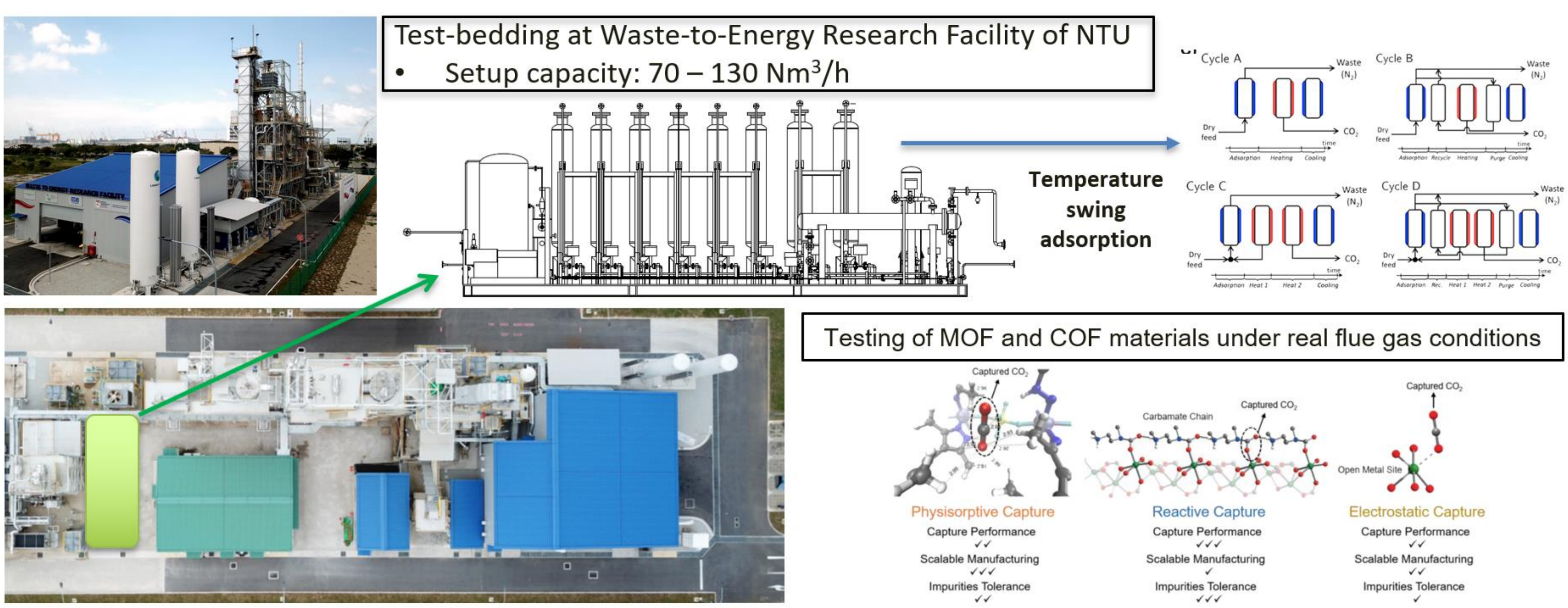
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Nanyang Environment and Water Research Institute

CO_2 CAPTURE: ADSORPTIVE CARBON CAPTURE USING FRAMEWORK MATERIALS

Abstract:

Carbon capture, utilization and sequestration (CCUS) has been identified as a key mitigation strategy towards greenhouse gas induced climate change. Of various CCUS strategies, post-combustion capture addresses greenhouse gas emissions reduction at large point sources with controlled retrofit impact, which is advantageous for mid-term development. Despite possessing solid process fundamentals, adsorption technology needs to overcome a 30-year head-start in process experience to reach competitive levels as the incumbent liquid capture solutions. Key process complications for adsorptive capture arise from contaminants management and the gradual reduction of CO_2 feed concentrations in modern power generation technologies.

However, this aspect of research has been sporadically considered. Recent materials development has centered on porous framework materials, i.e., metal-organic frameworks (MOFs) and covalent organic frameworks (COFs), to yield unparalleled structural and chemical tunability in the solid state. In this project, we seek to expand the capability of adsorptive CO_2 capture leveraging state-of-the-art framework sorbents engineered for remarkable CO_2 selectivities, high intrinsic stability, and facile regenerability from moisture. Two advanced MOF prototypes will be scaled-up for bench-scale research and characterization. We will explore viable temperature swing adsorption (TSA) process configurations using simulation-assisted design backed by bench-scale model validation. The technical and economic feasibility of the technology will be evaluated and compared with benchmark cases. Concurrently, we will look at the next-generation COF materials enabling physisorptive and reactive CO_2 capture for high carbon capture performance at even lower (0.4-4%) CO_2 concentrations. In addition, we will integrate the vacuum swing adsorption (VSA) process and associated pretreatment provisions on an existing pilot-scale waste-to-energy power generation plant. The pilot demonstration will provide key operational data to feed into subsequent scale-up MOF- and COF-based adsorptive capture processes beyond the completion of this project. This is a 3-year project with a requested total direct cost of S$8,327,000.



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