College of Engineering and Computer Science
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Announces the Ph.D. Dissertation Defense of

Amirjavad Ahmadian Hosseini

for the degree of Doctor of Philosophy (Ph.D.)

"DEVELOPING AMINE-MODIFIED SILICA MATERIALS FOR CARBON DIOXIDE CAPTURE FROM DIFFERENT GAS STREAMS"

July 1, 2024, 9:00 a.m.-11:00 a.m.
Engineering West, EG 187 OME Conference Room
777 Glades Road
Boca Raton, FL

DEPARTMENT:
Department of Civil, Environmental, and Geomatics Engineering

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ABSTRACT OF DISSERTATION

DEVELOPING AMINE-MODIFIED SILICA MATERIALS FOR CARBON DIOXIDE CAPTURE FROM DIFFERENT GAS STREAMS

The atmospheric concentration of CO_2 increased from 320 to 425 parts per million by volume (ppmv; 0.0425 vol.%) between 1960 and 2024. Sample CO_2 reduction strategies include shifting to renewable energy sources and implementing CO_2 capture. CO_2 capture from the air (direct air capture; DAC) has recently received increased attention. CO_2 has the potential to act as an asphyxiant at high concentrations, particularly in enclosed environments (e.g., spacecraft, submarines), requiring air revitalization to remove CO_2. Accordingly, the Occupational Safety and Health Administration has established a permissible exposure limit of 5,000 ppmv CO_2 (0.5 vol.%) throughout an 8-hour work shift. Considering the trace levels of CO_2 and the presence of humidity in DAC and air revitalization applications, similar materials can be developed for implementation in both cases. CO_2 capture involving amine-functionalized silica materials ("aminosilicas") can achieve high CO_2 uptakes at low concentrations due to high selectivity. Additionally, the presence of moisture in CO_2-containing gas streams enhances the CO_2 uptake and stability of aminosilicas. Therefore, this research investigated the potential of aminosilicas for removing CO_2 from dilute streams, including DAC and air revitalization. Aminosilicas were synthesized using mesoporous silica supports with different particle sizes that were impregnated with tetraethylenepentamine (TEPA) or branched polyethylenimine (PEI) with different molecular weights (600, 1200, and 1800), or grafted with 3-aminopropyltrimethoxysilane (APTMS). The performance of aminosilicas was assessed in terms of equilibrium CO_2 uptake, adsorption kinetics, and cyclic stability. Overall, smaller amines (e.g., TEPA) achieved higher CO_2 uptakes than bulky amines (e.g., PEIs), although the former amine suffered from lower thermal stability; a higher amine loading increased CO_2 uptake; however, materials with very high amine loading faced slower adsorption kinetics due to pore blockage; bulky impregnated amines (e.g., PEIs) and grafted APTMS maintained their performance over 50-100 successive adsorption-desorption cycles; increasing the particle size of silica supports slowed down adsorption kinetics; grafted APTMS achieved similar cyclic performance regardless of desorption purge gas (air versus N_2); column-breakthrough experiments depicted a boost in CO_2 uptake in the presence of humidity. The findings of this study provided compelling evidence of aminosilica's potential for DAC and air revitalization.

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BIOGRAPHICAL SKETCH
Born in Mashhad, Iran
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CONCERNING PERIOD OF PREPARATION
& QUALIFYING EXAMINATION

Time in Preparation: 2021 - 2024

Qualifying Examination Passed: Summer 2022

Published Papers:

1. **Amirjavad Ahmadian Hosseini and Masoud Jahandar Lashaki. "A comprehensive evaluation of amine-impregnated silica materials for direct air capture of carbon dioxide."** ***Separation and Purification Technology*** **325 (2023): 124580.**

Plus, seven conference posters and presentations.