Hawai‘i Natural Energy Institute Research Highlights

Advanced Materials

Development of Novel Air Filtration Materials

OBJECTIVE AND SIGNIFICANCE: The objective of the project is the design, synthesis, and characterization of novel, reversible high-performance acidic gas (SO_x, NO_x and H_2S) contaminant absorbent materials. The materials under development would enable fuel cell vehicles to be efficiently operated under harsh atmospheric air environments. If successful, sorbents under development will assist the fuel cell filter industry and reduce environmental contamination from hazardous absorbent waste.

BACKGROUND: Current state-of-the-art gas purification technologies for acidic gas capture based on metal oxides and hydroxides do not meet all of the performance requirements of today's gas purification in terms of sorption: kinetics, capacities, selectivity and reversibility. This leads to large volumes of polluted absorbent waste. This situation can be expected to worsen in the future with the increased use of fuel cell vehicles that require abundant efficiently purified air as oxygen source.

The sorbent classes under development include ionic liquids, metallo ionic liquids, and metal organic framework-activated carbons. The sorbent material properties are optimized through a combination of careful selection of reactants and modification of the sorbent cation and anion groups. For instance, metallo ionic liquids with a high content of the small, highly charged acetate and croconate groups, and transition metal ions with expandable coordinative environments are being designed, synthesized, and characterized.

PROJECT STATUS/RESULTS: Nano confinement of the absorbents in highly porous materials is being performed in order to increase acidic gas-sorbent interactions and hence gas sorption performance. Nano confinement is especially critical for ionic liquids absorbents since they have high viscosity, which limit gas diffusion distances into the bulk of the material. We have physically deposited thin films of 1-ethyl-3-methyl imidazolium acetate ionic liquid onto activated carbon that remain intact during exposure to SO_2 and/or NO_2 contaminated air streams. The sorbents being developed also have relevance in other applications requiring acidic gas (SO_x, NO_x and H_2S) contaminant mitigation, including flue gas cleaning and natural gas purification.

We synthesized and characterized metal containing ionic liquids (metallo ionic liquids) containing Zn, Mg, Fe or Mn cations with general empirical formula $M_x(OAc)_y[EMIM]_z$. About 5 wt% or 10 wt% of the synthesized metallo-ionic liquids (MIL) were supported onto nano-porous coconut based activated carbon. The activated carbon-metallo ionic liquids absorbents were screened for their potential to filter elevated levels of sulfur dioxide (10 ppm in simulated air) using a custom designed and fabricated filtration materials test stand. The lab scale tests were performed at 1-2 LPM and relative humidity of 40-50%. The initial results indicate higher sulfur dioxide break through times with the Mg and Zn MIL-activated carbon absorbents (Figure 1).

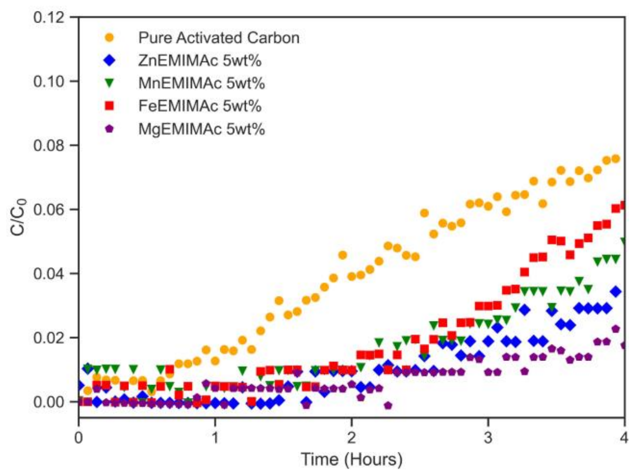

Figure 1. Comparative studies of sulfur dioxide (SO_2) breakthrough curves for 5 wt% metallo ionic liquids supported onto nano-porous activated carbon under a challenge gas of 10 ppm SO_2 with balance purified air.

Further work will involve optimizing the performance testing and integration of the developed absorbents with commercial media to form improved hybrid multiple gas contaminant filter media with higher breakthrough filtration performance under harsh environments with elevated levels of gas contaminants.

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