IEAGHG 8th Post Combustion Capture Conference

16th to 18th September 2025 Marseille, France

Pilot-scale Demonstration of a Laminate-Based CALF-20 Rapid-Cycle Vacuum Swing Adsorption Process for Point-Source Carbon Capture

Nicholas Stiles Wilkins*, David Murray McKinnon, Chinmay Baliga, Tai Tran Thanh Nguyen, Berenice Moroy, Xilan Lin, Onder Tulpar, Nigel Wheeler, Victor Tran, Desmond Cronin, Sabereh Rezaei, Andrew Liu*

Svante Technologies Inc., 8800 Glenlyon Pkwy, Burnaby, BC, V5J 5K3, Canada

Abstract

A pilot-scale rapid-cycle vacuum swing adsorption (VSA) process study was conducted using the metal-organic framework (MOF) CALF-20 in a structured laminate adsorbent bed for point-source carbon capture. In particular, this study aims to evaluate the benefits of structured laminate adsorbent beds, and their use in rapid cycle VSA processes more generally. To achieve these aims, we present a comparison against the traditional packed bed design, provide experimental & simulated VSA process results, and numerical process optimizations for both a dry and wet operation. An experimental rapid cycle VSA apparatus was constructed to test a large number of process conditions in the basic 4-step cycle for dry CO_2/N_2 separation. These were done at feed compositions of 8, 12, and 16 mol% CO_2 (balance N_2). Their cycle time varied between 64 and 103 seconds. Dynamic column breakthrough measurements for CO_2 (in N_2) were performed to provide a validation set for our process simulations. Process optimizations were performed for the basic 4-step cycle at the three dry feed compositions tested (8, 12, and 16 mol% CO_2 in N_2). The most optimal recovery at 94-95% purity for these process experiments were achieved at: 94.9 mol% and 77.7% for the 16 mol% CO_2 feed, 94.6 mol% and 69.5% for the 12 mol% CO_2 feed, and finally, 94.1 mol% and 67.9% for the 8 mol% CO_2 feed. Other process performance indicators, such as process productivities, were also calculated. Good agreement was found between the rapid-cycle VSA process experiments and simulations. Simulated process studies were extended to test more optimized adsorption process cycles to improve recovery and productivity while reducing energy consumption. Preliminary process experiments and simulations were performed to assess humid point-source CO_2 capture using a rapid cycle VSA process in structured laminate adsorbent beds. These developments open new markets for structured laminates and CALF-20.

Keywords: carbon capture; adsorption; vacuum swing adsorption; pilot demonstration; process simulation; process optimization; CALF-20; MOF

* Corresponding authors.
E-mail addresses: nwilkins@svanteinc.com, aliu@svanteinc.com