# A 1-D Model of the 4 Bed Molecular Sieve of the Carbon Dioxide Removal Assembly

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## Abstract

Introduction: Developments intended to improve system efficiency and reliability for water and carbon dioxide separation systems to be used on crewed vehicles combine sub-scale systems testing and multi-physics simulations. This paper describes the development of simulations in COMSOL Multiphysics® software in support of the Life Support Systems (LSS) project within NASA's Advanced Exploration Systems (AES) program. Specifically, we model the 4 Bed Molecular Sieve (4BMS) of the Carbon Dioxide Removal Assembly (CDRA) operating on the International Space Station (ISS).

Use of COMSOL Multiphysics: The transport of concentrated species, water and carbon dioxide, in a carrier gas (air) was modeled as flow through the 4 beds of sorbent pellets. The adsorption rates and pellet loading were determined from solving a distributed ODE based on Toth isotherms. The resulting heat transfer in the porous media and the solid housing was modeled as well. The mass fractions exiting an upstream bed were used as inlet boundary conditions for the next bed. A heater-assisted vacuum desorption model was developed as well for the desorption of the carbon dioxide bed. Due to the complexity of the overall model, the use of COMSOL simulations in 2-D has proven unsuccessful, so we have developed a pseudo-1-D model which represents the same physics.

Results: As reported elsewhere, using COMSOL software has resulted in a favorable match to temperature and concentration data for a range of inlet vapor pressures, initial conditions, and flow rates for individual sorbent/sorbate pairs in subsystem tests. Using these results for calibration of the full 4BMS CDRA system, we have applied the model to data sets from the CDRA version 4 ground unit test bed (CDRA4-EU). The model uses the measured inlet vapor pressures and temperature for time-dependent inlet boundary conditions.

Conclusions: The need for optimized atmosphere revitalization systems is necessitated by the aggressive new missions planned by NASA. Innovative approaches to new system development are required. This paper presents such an approach for the LSS ARREM project, where testing is supplemented with modeling and simulation to reduce costs and optimize hardware designs. The application of the COMSOL model in 1-D shows promise in predictively modeling the behavior of the ISS CDRA 4BMS. These modeling and simulation efforts are expected to provide design guidance, system optimization, and troubleshooting capabilities for atmosphere revitalization systems being considered for use in future exploration vehicles.