Time adapted linear driving force model for gas-solid adsorption

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Researchers have been paying special attention on adsorption (gas + solid) based heat transformation systems because of its environmental friendliness, energy-saving potentials, and capacity to use low-grade heat. In this technology, a thermal compressor replaces the traditional mechanical compressor, which is powered by low-grade thermal energy rather than electricity. Adsorption based technology has been employed in a wide range of applications, including several fields like refrigeration, thermal energy storage, gas storage and capture and even in desalination. For decades, scientists have been working to improve the efficacy of adsorption based heat transformation systems. Isotherm and kinetics are the two most crucial characteristics that influence performance. Improvements in kinetic performance can lower the adsorption system's operating cycle time, resulting in a more effective cooling/heating effect. Adsorption systems act in a batch-wise manner, which means that adsorption and desorption occur periodically and are time-dependent. As a result, adsorption rate or kinetic equations are commonly employed to characterize adsorption data under non-equilibrium conditions, and they are important to examine the fundamental knowledge of the adsorption process, which varies from transient to cyclic steady state. Therefore, the main objective of this study is to develop and validate a new adsorption kinetics model. To predict the experimental kinetics data of a wide range of adsorption pairs, a time adapted linear driving force (TALDF) kinetics model has been presented. The model is developed using a comprehensive mathematical derivation. For several types of adsorbate – adsorbent pairs with a wide range of particle sizes, a layer thickness of adsorbent, and S-type kinetics data, the proposed model is compared to the LDF, FD, and semi-infinite models. Furthermore, a wide range of temperatures and pressures are also chosen for this comparative study. LDF model underestimates the experimental data during the initial time of the adsorption process and overestimates it from near saturation. The proposed model successfully overcome these limitations. Thus, the proposed kinetics model will play an important role in the precious simulation of adsorption heat exchangers both with short and long cycle times.

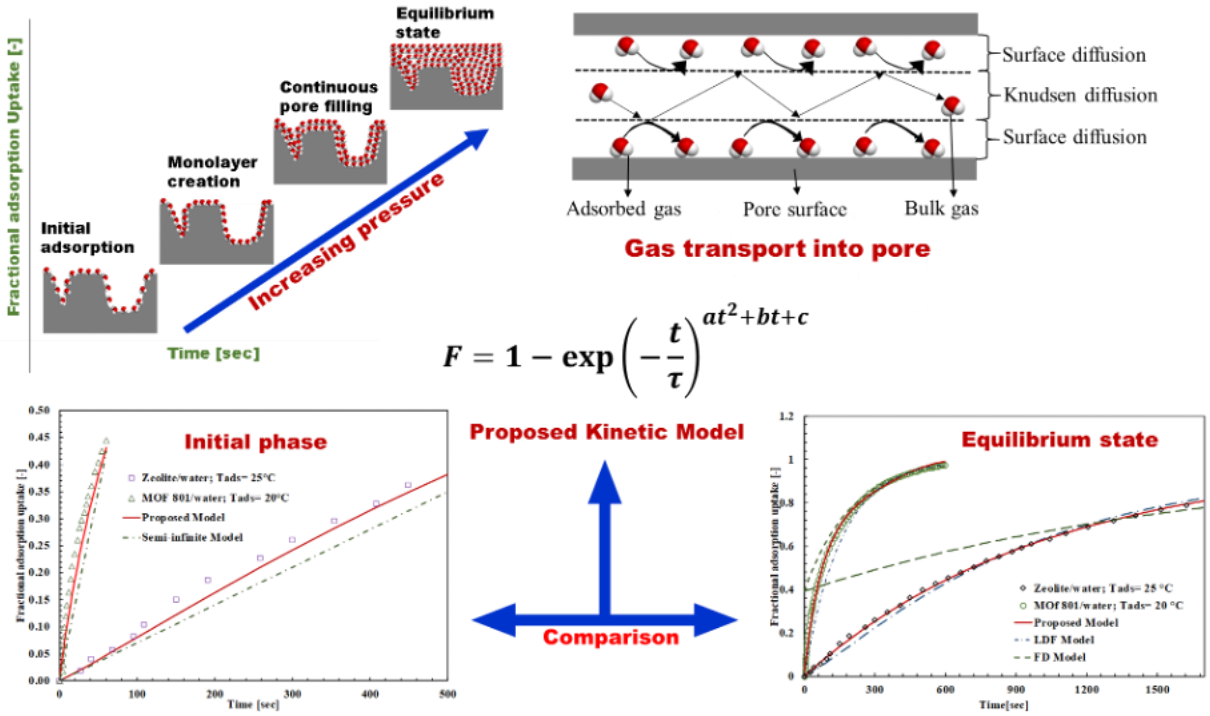

Fig. Schematic of proposed Time Adapted Linear Driving Force Model (TALDF).