Tuning porosity to improve efficiency of adsorption columns

Authors:

- Maria Aguareles, Universitat de Girona (maria.aguareles@udg.edu)
- Maria Bruna, University of Oxford (bruna@maths.ox.ac.uk)

Abstract: Assessing and improving the performance of adsorption columns is crucial for various applications. To this end, several mathematical models have been developed over recent years to describe the adsorption process using a set of partial differential equations. These equations capture the evolution of contaminant concentration in the fluid traveling along the filter and the amount of contaminant captured by the adsorbent (see, for instance, [1], [2]).

Traditionally, adsorbents are manufactured using pellets of similar sizes, resulting in a media with roughly constant porosity. However, both experimental and analytical evidence suggest that using porosity-graded adsorbent media can enhance performance. In this talk, we will explore the impact of porosity gradients on breakthrough curves, which describe the time evolution of contaminant concentration at the outlet and serve as the industry-standard measure of adsorption performance.

We will begin by deriving the governing equations under the assumption of axial porosity gradients, corresponding to columns where grains of different sizes are arranged in layers. We will then demonstrate how various porosity functions influence the profiles of the breakthrough curves.

References:

[1] M. Aguareles, E. Barrabés, T.G. Myers, A. Valverde. Mathematical Analysis of a Sips-Based Model for Column Adsorption. Physica D, 448 (2023) 1337690.

[2] L.C. Auton, M. Aguareles, A. Valverde, T. Myers, M. Calvo-Schwarzwalder. An analytical investigation into solute transport and sorption via intra-particle diffusion in the dual-porosity limit. Applied Mathematical Modelling, 130 (2024), pp. 827-851.