

Diffusion measurements using a volumetric differential pressure apparatus

Jinyu Wang, Enzo Mangano*, Stefano Brandani

University of Edinburgh, School of Engineering, Edinburgh, UK

*E.Mangano@ed.ac.uk

In a recent work, we have demonstrated the use of commercial volumetric systems to study the gas transport mechanism in porous adsorbents, providing guidelines and recommendations to ensure the proper use of the methodology to obtain reliable kinetic constants [1].

On the base of these findings, we have designed and built an innovative differential volumetric system for the measurement of adsorption equilibrium and kinetics. The system (figure 1) is equipped with a differential and an absolute pressure transducer as well as thermocouples to measure the temperature of the dosing and the uptake cells, including the direct measurement of the sample temperature. The principle of operation is based on following the differential pressure between two symmetric branches (namely, sample and reference) as the gas expands from the dosing to the uptake volumes.

Double-branch volumetric systems present some key advantages compared to conventional single-branch ones. The use of the differential pressure (as opposed to absolute) significantly improves the quality of the transient pressure signal allowing high accuracy kinetic measurements over the entire range of absolute pressures considered. The apparatus is specifically designed for kinetic measurements therefore particular effort was dedicated to minimise dosing and uptake volumes, hence allowing accurate kinetic and equilibrium measurements with a small amount of sample (<100 mg). An additional advantage of the system is in its modular design, which allows to test different configurations to evaluate and compare different ways in which the experiment can be carried out using the same setup.

In addition to the details on the apparatus, we present kinetic tests carried out on a number of adsorbents using different gases to determine the capabilities (and the limits) of the technique for weak and strongly adsorbed systems. In order to properly interpret the results a detailed model of the system was also developed. The model includes the kinetics of the valve as well as possible imbalances present in the system and offers a direct way to identify different transport mechanisms.

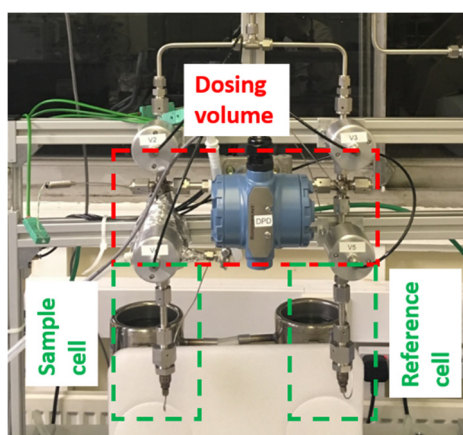


Figure 1: Differential volumetric apparatus for high pressure kinetic measurements.

References

- [1] S. Brandani, F. Brandani, E. Mangano, P. Pullumbi: *Using a volumetric apparatus to identify and measure the mass transfer resistance in commercial adsorbents*. Microporous and Mesoporous Materials, 10.1016/j.micromeso.2019.01.015 (2019).