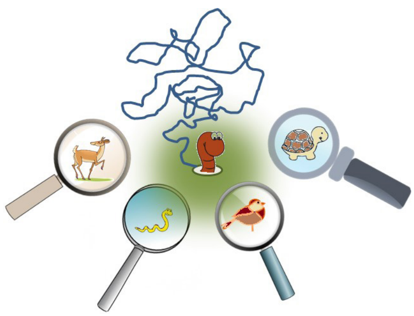
Can Random Motion Look the Same from Different Perspectives?

Diffusion is an ubiquitous phenomenon in nature. Its random patterns may be found in an extreme variety of very different processes—in the haphazard trajectories of animals seeking a better environment or food, the distribution pathways of ideas in societies, or the chaotic journeys of chemical species searching for active reaction pairs in porous catalysts. Therefore, it is not surprising that it was a botanist and a medical doctor who most ingeniously recognized the hidden traces of randomness in macroscopic observations of the epidemic spread of diseases or elegant dances of pollen in water observed in a microscope and exerted the initial thrust to understand the physics and mathematics of diffusion. Since that first development, substantial advances in theoretical descriptions of diffusion-related phenomena and their experimental measurements have been made. Despite the long history of diffusion studies, some areas still remain hot topics of current research, in particular the diffusion processes occurring in nanoporous materials.



An important constituent of chemical technology, porous solids have continuously attracted interest. Mass transfer within their bodies is recognized to be one of the key elements among their different properties. As the most illustrative example, during their exploitation in mass separation and catalytic conversion, the gain in value-added products can never be faster than allowed by the rate of mass transfer. Hence, experimental assessment of transport properties in these materials is of vital importance for process engineering. From the early days of diffusion studies in porous and, especially, in microporous solids, experimental scientists have faced various challenging problems. Most exceptionally, scientists have been puzzled by the observation of dramatic differences in the diffusion rates in microporous solids probed by different experimental techniques, approaching, in some cases, several orders of magnitude. This situation is exemplified in the accompanying cartoon showing that, from the perspective of different observers using different experimental tools, the rate of a chaotic underwater excursion by the Loch Ness Monster may appear to approach the rates of an antelope run, snake creep, bird fly, or turtle crawl.

In recent decades, the advent of "microscopic" techniques of diffusion measurement, together with a concurrent refinement of "macrosocopic" techniques, has revolutionized our knowledge. It has been rationalized that, rather than being controlled by the diffusional resistance of the genuine micropore network as was generally assumed, diffusive mass transfer in nanoporous materials is now in many cases known to be subject to a hierarchy of resistances. Though nowadays techniques and methodologies are available to experimentally determine all these resistances, our knowledge of mass transfer in the nanoporous materials in technological use is generally rather limited, if not totally wrong. This situation is mainly caused by the fact that transport resistances occur over essentially all length scales. The sensitivity of the measuring techniques must, correspondingly, be adjusted to these length scales. Inappropriate use of these techniques will therefore lead to wrong conclusions, which the unexperienced user is scarcely able to avoid.

This problem, which has increasingly been recognized by the scientific community, will be the focus of a recently established task group, **"Diffusion in nanoporous solids"**, under the IUPAC auspices. It brings together worldwide leading specialists in the different fields of diffusion measurement, representing both academia and industry. This initiative follows previous local activities aimed at a clarification of the discrepancy often encountered in diffusion measurement. Providing the broadest coverage of the experimental techniques, including experts from theory and quickly-growing computer modeling, the group now intends to develop the practical procedures for diffusion measurements in nanoporous solids, with emphasis on the conditions that must be fulfilled and any experimental checks that should be undertaken to ensure reliable results. A special effort shall be made to formulate the criteria under which the results obtained within different approaches and for different classes of porous materials may be compared to each other.

Recalling the figure, the Loch Ness Monster may indeed move with quite different speeds—an antelope or a turtle—depending on the surrounding environment. By collecting the information from different hunters acquired on different time- and length-scales, the mystery of Loch Ness may finally be solved.

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