Characterization of fluid-mechanic efficiency of porous electrodes using X-ray computed tomography and Lattice-Boltzmann simulations

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ABSTRACT

Flow batteries are a promising solution for storing the energy produced by carbon-free intermittent renewable sources. They are constituted by liquid electrolytes flowing and reacting into carbon felt porous electrodes. In order to enhance their performances it is necessary to maximise electrolyte dispersion and reaction together and to minimize the flow resistance through the porous media [1]. It is well reported in the literature how peculiar and anomalous can be the dispersion behaviour in natural porous media [2] and in fibrous materials [3]; however, it is still badly known how much it affects the performances of real electrodes of flow batteries.

To clarify this issue, real carbon felt electrodes have been reconstructed by means of X-ray computed tomography (CT). In particular, a metrological micro-CT system has been used to obtain accurate three-dimensional reconstructions, which have then been used as input for Lattice-Boltzmann flow simulations coupled with a Lagrangian Particle Tracking algorithm, in order to investigate the dispersion and reaction behaviour of tracers through the medium microstructures, see e.g. Fig.1. For each material, macroscopic dispersion, reaction efficiencies and flow resistance have been evaluated from the underlying microscopic statistics of flow and tracer trajectories.

From these analyses, the overall fluid-mechanic efficiency of each material has been evaluated and compared allowing the identification of the optimal porous microstructure for flow battery applications, which shows the highest dispersion and reaction rate together with the lowest pressure drop.

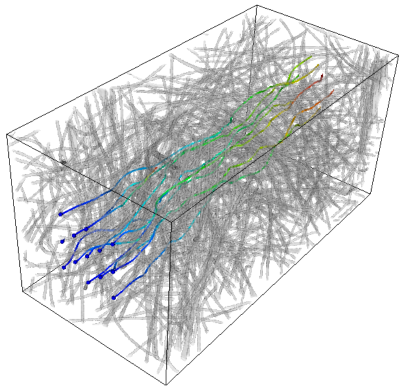

Fig. 1 Computed tracer trajectories in a real geometry of flow battery felt reconstructed by X-ray CT.

REFERENCES

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