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DESIGN OF A PRE-CONCENTRATOR PAPER-BASED MICROFLUIDIC DEVICE WITH VARIABLE CROSS-SECTIONS

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Abstract. Microfluidic paper-based analytical devices are now a well-established technology. However, aspects related to the pre-concentration of target analytes need to be improved to reach higher analytical precision and efficiency and improve the detection limits. This work focuses on the numerical simulation of a pre-concentrating device for environmental target analytes. The numerical model includes advective, electromigrative, diffusive, dispersive, and electrodispersive mechanisms, the effects of porosity, tortuosity, and permeability of paper substrates and the solvent velocity profile due to the electroosmotic flow are taken into account. The porous medium created by the cellulose fibres is considered as a network of tortuous capillaries and macroscopic parameters represent it following an effective medium approach. The device design consists of 2 cascade stages: the first uses the moving boundary electrophoresis (MBE) technique which serves as a dynamic preconcentration and injection stage. The concentration profile obtained after the MBE process serves as the initial condition for the final isotachophoresis (ITP) stage, in which the most important pre-concentration effect develops. The main challenges are the numerical resolution of the high gradients of conductivity generated in ITP and the meshing process in non-uniform section geometries. Numerical prototypes were implemented in OpenFOAM®software, using the `porousMicroTransport` and `electroMicroTransport` toolboxes. Consequently, the aforementioned numerical tools, considered valuable in any microfluidic pad design, were objectively validated. The results can be used in the near future to build a Lab-on-a-chip (LOC) device to quantify substances of medical and environmental interest through direct optical methods.