**Influence of cross-flows on the performance of open-channel liquid chromatography**

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**1.Introduction**

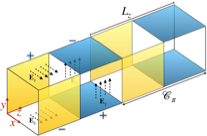
Taylor-Aris dispersion represents an undesired phenomenon in pressure-driven liquid chromatography, often responsible for the unchecked increase of the Height Equivalent of the Theoretical Plate (HETP) when high throughput operating conditions are sought.

The augmented dispersion in empty microchannels can be contained by inducing cross-sectional velocity components yielding an overall helical structure of the flow streamlines, that speed up mixing in the direction orthogonal to the channel walls.

The cross-sectional components can be induced e.g. by AC or DC electroosmosis. A beneficial effect of the cross-flow in reducing axial dispersion is found in both cases, for adsorbing and non-adsorbing walls as well.

Removing the assumption that the flow is independent on the axial coordinate and steady (e.g. by enforcing a spatially periodic structure along the axis or an explicit time dependency, or a combination of the two) a remarkably complex geometry of the flow streamlines can be obtained, which is typically associated with the phenomenon of chaotic advection. Such strategy has been applied extensively (and successfully) for enhancing mixing rate in micromixers and microreators. Remarkably, to the best of our knowledge, no thorough study of the impact of chaotic advection has been pursued in dispersion theory and it is quite reasonable that it represents a valuable approach for taming axial dispersion in pressure-driven liquid chromatography.

We consider a class of physically realizable incompressible flows, where alternate patterns of embedded electrodes along the channel axis create a DC-induced cross-sectional flow possessing different degrees of chaotic behavior.



**Figure 1**. Electrode placement for the electroosmotically-induced spatially-periodic flow. The axial flow is created by a superimposed pressure gradient along the z coordinate.

Brenner’s macrotransport approach is used to predict the axial dispersion coefficient in flows possessing regular, partially chaotic and globally chaotic kinematic features. Both cases of absorbing and non-adsorbing walls are investigated.

The validity and reliability of the numerical solution of the moment hierarchy as obtained by FEM 3-d simulations via Comsol Multiphysics is supported by independent Lagrangian stochastic simulations of particle ensambles.

**4. Conclusions**

Superimposing cross-sectional velocity components to the main pressure-driven driven axial velocity profile in an empty microchannel can drastically reduce the axial dispersion of an analyte carried by the flow and allows to increase the velocity of the eluent at moderate expenses as regards the increase of axial dispersion. The practical impact of our results is demonstrated by considering the chromatography of a mixture of three-species undergoing adsorption equilibrium with a stationary adsorbing phase coating the channel walls.

**References**

1. Zhao, H., Bau, H. H., Analytical Chemistry 79 (2007) 7792–7798.
2. Lester, D. R., Dentz, M., Le Borgne, T., Journal of Fluid Mechanics 803 (2016) 144–174.
3. Giona, M., Adrover, A., Cerbelli, S., Vitacolonna, V., Physical Review Letters 92 (2004) 114101.
4. Cerbelli, S., Adrover, A., Garofalo, F., Giona, M., Microfluidics and Nanofluidics 6 (2009) 747– 761.