NON-ORTHOGONAL FREE FLOW ELECTROPHORESIS

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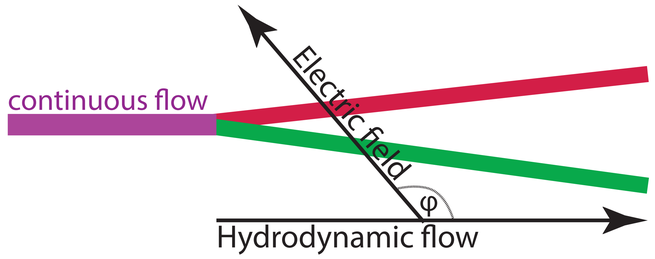
Introduction

Free-flow electrophoresis (FFE) is a promising technique for continuous separation of species produced by in-flow synthesis [1]. In FFE, an electric field is always applied at 90° to the continuous flow of species, which are then separated according to their different electrophoretic mobilities. A big challenge in FFE is achieving baseline separation of species with similar charge-to-size ratios. In this work, we counterintuitively apply non-orthogonal fields in order to markedly improve the resolution in FFE.

Non-orthogonal FFE?!



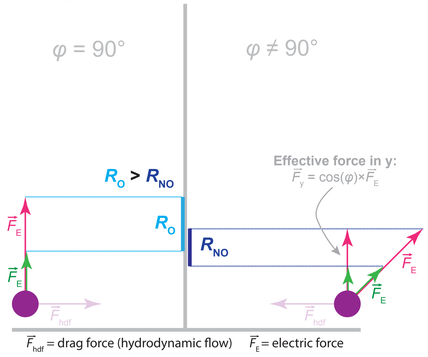
Intuitively, applying a field perpendicularly to the flow vector is the best way to resolve species and it's how the field is always applied in FFE.

However, it was theoretically predicted by our group that the resolution can be substantially improved by applying non-orthogonal electrical fields [2, 3]. Although counterintuitive at first glance, it can be explained graphically.

Scenario: Separation of two species (+ =) in a continuous flow by applying an electric field at an angle of φ.

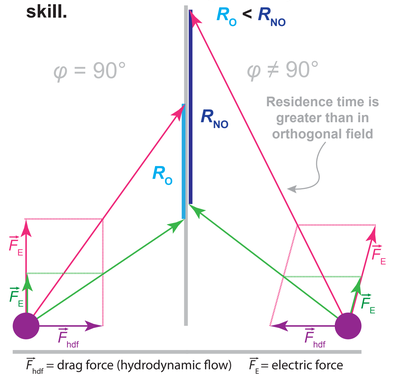
Intuition tells you:

Forget about the hydrodynamic flow. Orthogonal field is the best.



Reality tells you:

Please use your 9th grade physics skill.



Preliminary results

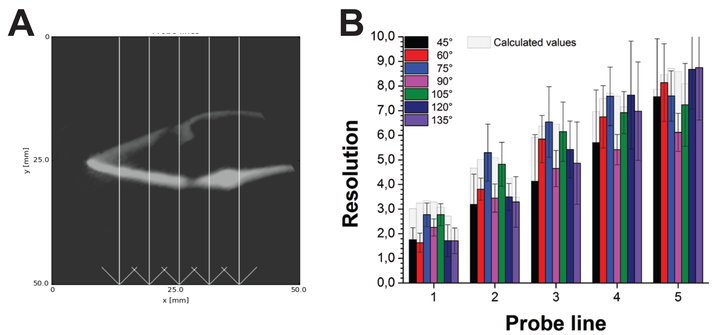


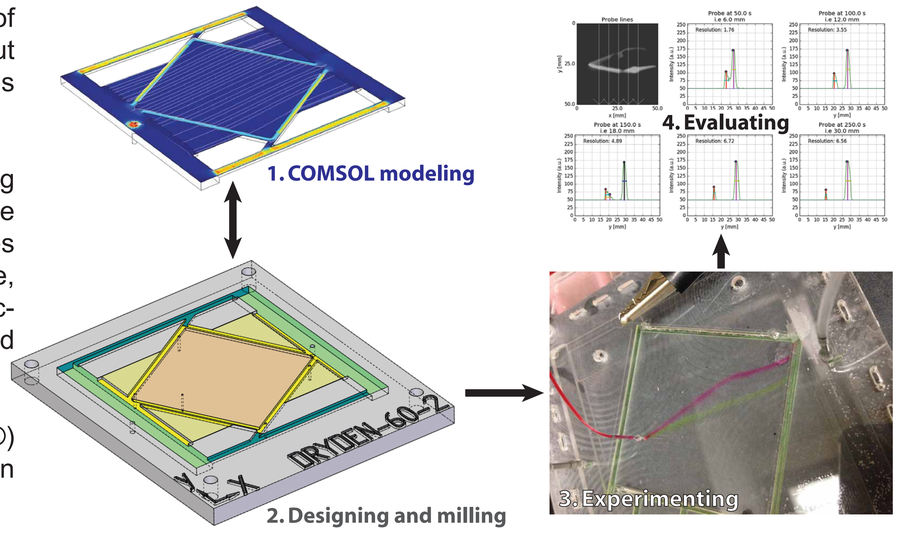
Figure 1. A: Example image of a measurement with depicted probe lines. 50-100 of such pictures are evaluated per measurement and per angle. **B:** Shows the resolution at various probe lines and for different angles, at which the electric field was applied. The light grey boxes show the values derived from the theoretical models (see refs. 3 and 4).

Implementation

The big challenge of this project is the implementation of non-orthogonality not only in one physical FFE device but in many *comparable* devices. In theoretical considerations electric fields can be put anywhere without limitations.

In practice, however, electric fields are created by applying a potential to electrodes - physical objects with a finite sizes. In non-orthogonal FFE devices, these electrodes greatly interfere with the hydrodynamic flow. Furthermore, gas bubbles are created on the electrodes by water electrolysis. These bubbles interfere with the electric field and the flow.

We use computational models (COMSOL Multiphysics®) together with our theoretical and practical experience in FFE to address this challenge.



Conclusions

These preliminary results indicate that

a) the theoretical model developed earlier is in good agreement with the practical performance of *non*-orthogonal FFE and
b) applying *non*-orthogonal electric fields can result in higher resolution compared to an orthogonal field.

However, the results also clearly show that the practical performance of the devices has to be further improved specifically with respect to stability of separation.

References:
[1] Jezierski, S., Tehsmer, V., Nagl, S., Belder, D., *Chem. Comm.* **49** (2013) 11644-11646.
[2] Evenhuis, C. J., Okhonin, V., Krylov, S. N., *Anal. Chim. Acta* **674** (2010) 102-109.
[3] Okhonin, V., Evenhuis, C. J., Krylov, S. N., *Anal. Chem.* **82** (2010) 1183-1185.

Group page:

Digital poster: