

# Developing novel food fractionation techniques: The Electrophoresis Case

Kickstarting the design process of an electrophoretic fractionation device: Optimization using particle trajectories.

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## Introduction

In modern day food production, there is an increasing demand for consistent products, with higher levels of protein or fiber, or lower levels of carbohydrates<sup>1</sup>. To satisfy this demand, food ingredient producers embraced novel ingredient production techniques like (precision) fermentation. Although strides have been made in producing high-value ingredients, its downstream processing is a bottleneck<sup>2</sup>. This project aims to develop a new technique, allowing fractionation of ingredients based on their inherent charge.

This project attempts to utilize ideas for unit operations from the medical and pharmaceutical field and expand it towards higher throughput – suitable for food processing. By using the inherent differences in ingredients' electrophoretic mobility, we can fractionate them transversally through a laminar flow field. The unit operation will be called Deterministic Ratchet Electrical Flow Field Fractionation, or DREIF4.

## Methodology

In our DREIF4 device, ingredients undergo several superimposed transversal electric fields generated by mirrored electrodes. This generates electrophoretic velocity (1), which we incorporate in the Stokes drag equation (2):

$$(1) \quad v_{el} = E * \mu_{el}$$

$$(2) \quad F_{drag} = 6\pi r\eta(v_{flow} + v_{el})$$

We utilized “Parameter Optimization” (Optimization Module) to adapt the voltage on the electrodes, to yield optimal separation of three differently-charged particles (Particle Tracing Module).

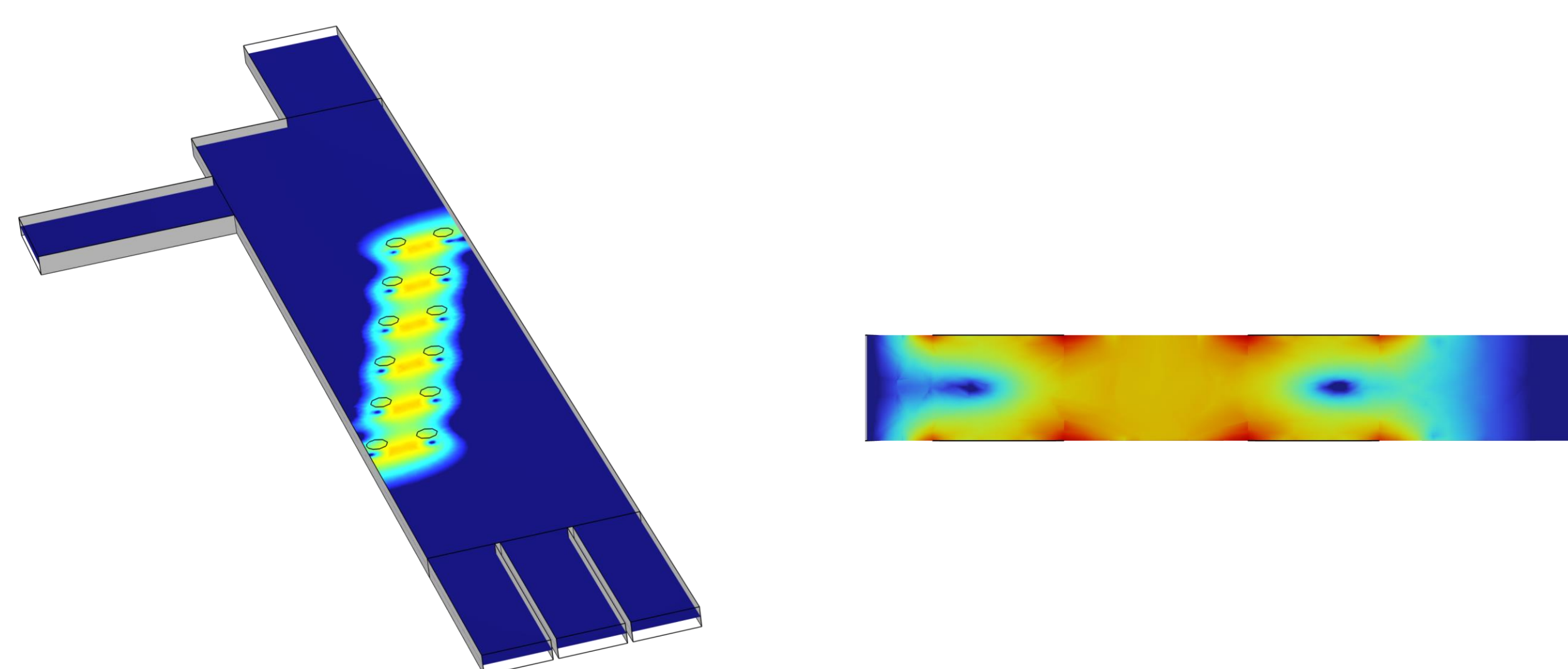


FIGURE 1: Left: A DREIF4 channel with six subsequent ratchets and Right: A cross section of an individual electrically actuated ratchet

## Results

The electrode voltage optimization was conducted with the following objective function:

$$(P_{high} - P_{low}) - \left| \frac{P_{high}}{2} - P_{mid} \right|$$

Where P is the final particle position of high, middle and low electrophoretic mobility particles. The results show that a difference in voltage can result in significant differences in prospective fractionation.

The voltage where the three particles are optimally separated is at a voltage of 2.95 V. Changes of 0.5 V alter separation negatively by more than 40 percent. Minute changes of less than 0.05 V have non-significant effects.

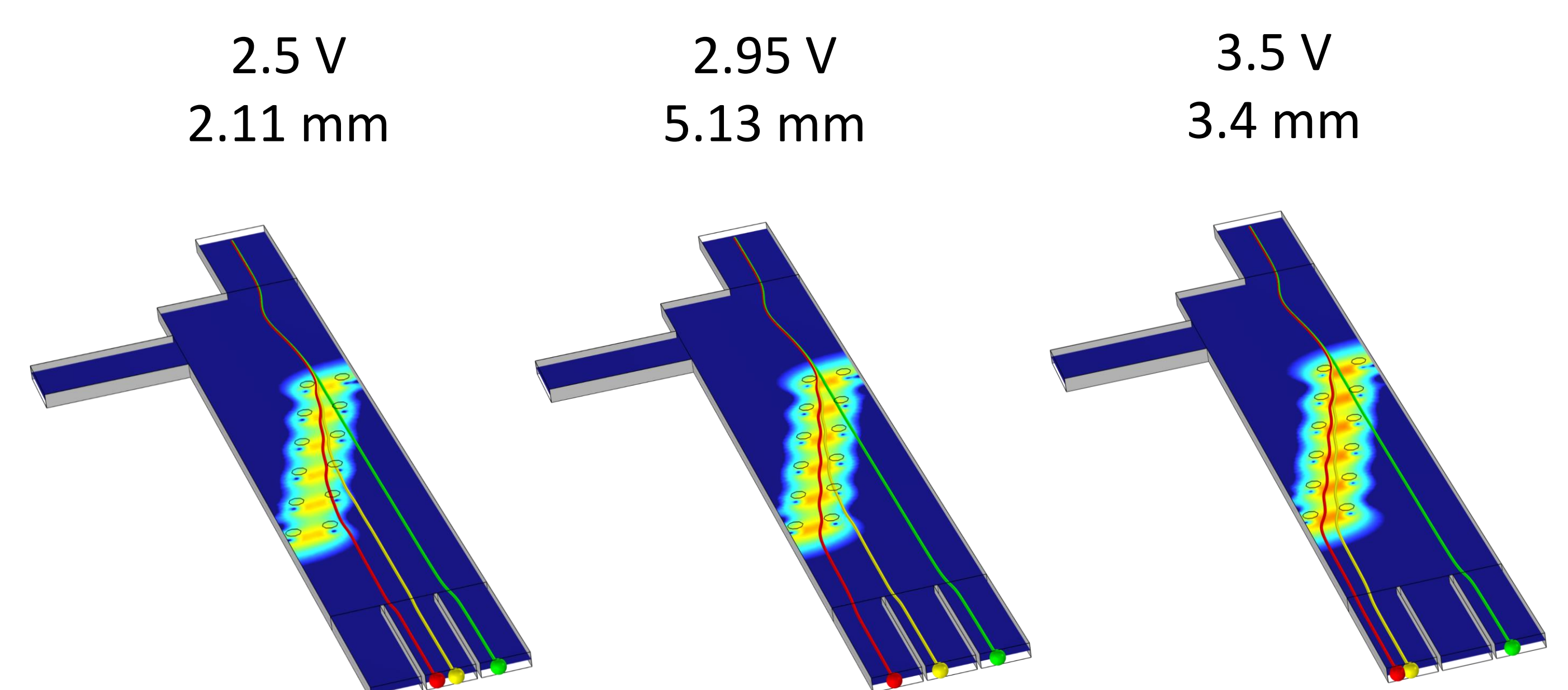


FIGURE 2: Three results from the Parameter Optimization. Particle mobility in: Left – 2.5 V, Middle – 2.95 V (optimal) and Right – 3.5 V.

## REFERENCES

- Kim, D. E., Kalaitzandonakes, M., & Ellison, B. (2026). Added protein, added value? Consumer demand for protein labels across product types, flavors, and consumer segments. *Food Quality and Preference*, 139, 105842.
- Verma, K., Duhan, P., Pal, D., Verma, P., & Bansal, P. (2025). Precision fermentation for the next generation of food ingredients: Opportunities and challenges. *Future Foods*, 12, 100750.

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