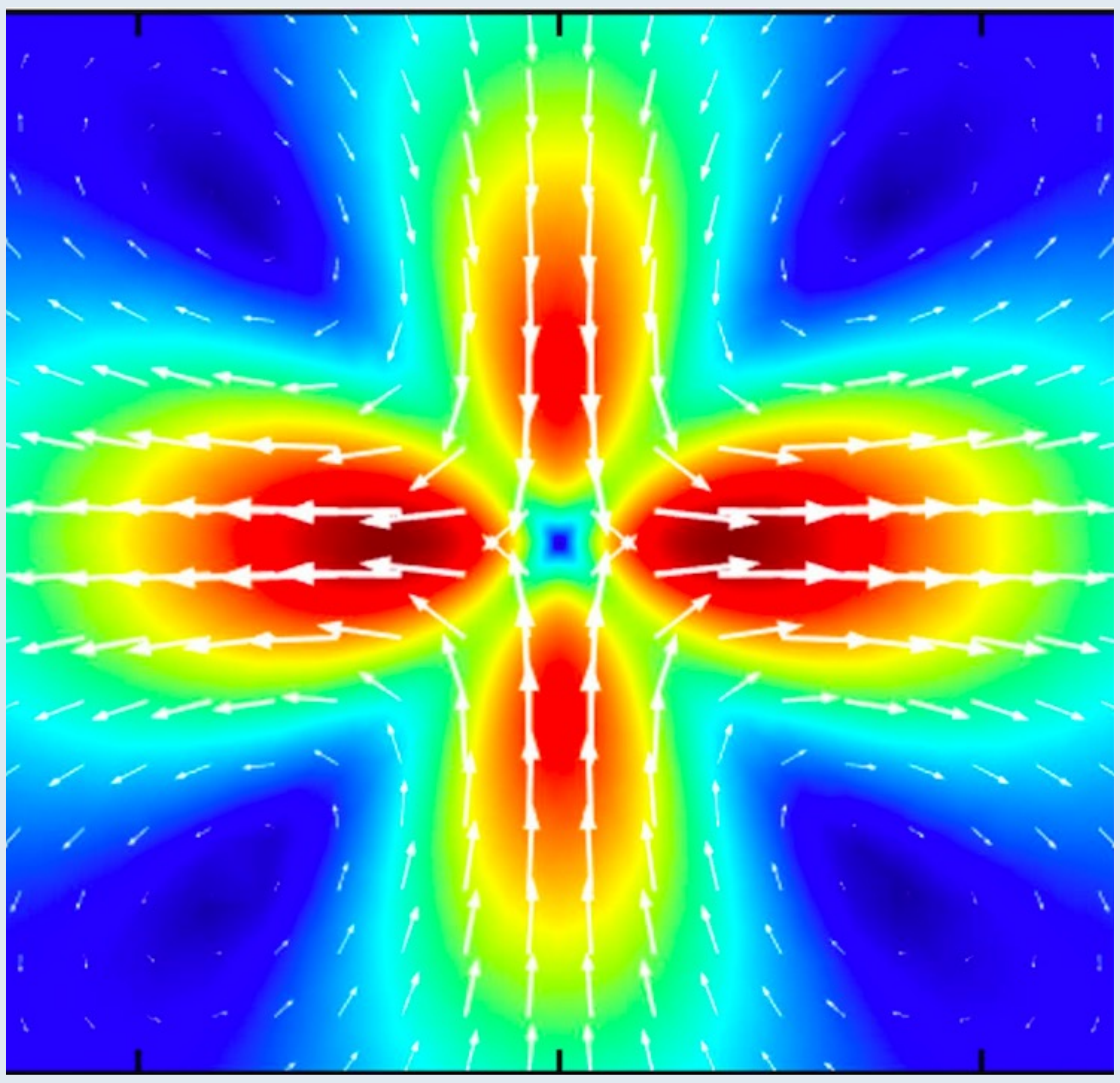

Electrothermoplasmonic Flow in Gold Nanoparticle Suspensions

Lab-on-a-chip technologies involve the transport and mixing of fluids in microchannels. Mixing essentially occurs by diffusion, which is inherently slow. We have performed a detailed analysis of ETP flow with a novel configuration, namely, with AuNPs in bulk instead of deposited on a 2D array.

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Abstract

In recent years, lab-on-a-chip devices are gaining popularity in many fields [1,2]. Nevertheless, fluid flow generation in the microscale is still a hurdle that must be optimized [3].

Here, we present a novel technique that combines an AC electric field with a small temperature gradient, which leads to a strong electrothermal flow.

This effect is known as electrothermoplasmonic flow [4,5].

COMSOL Multiphysics® simulations provide a description of the phenomenon that is compatible with experiments and constitute a way to understand and estimate the absorption and scattering cross-sections of both dispersed particles and/or aggregates.

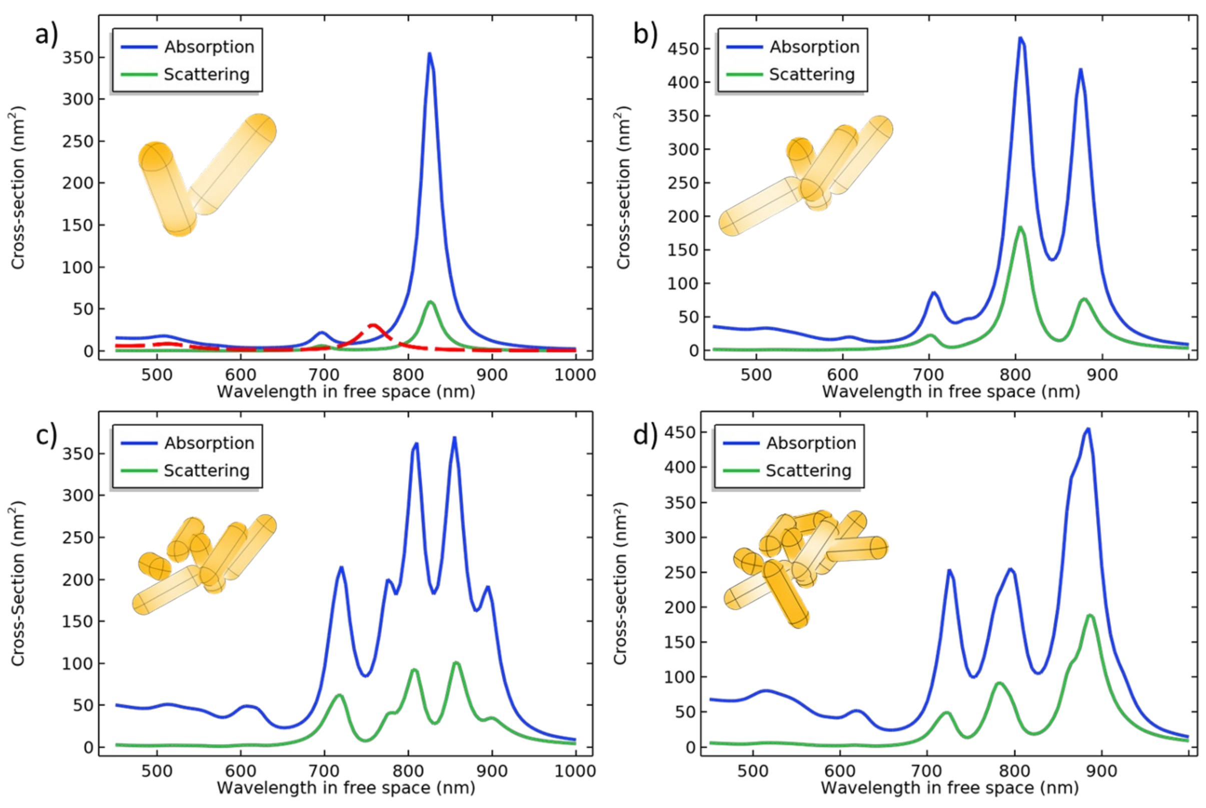

FIGURE 1. Cross-section spectra for different disordered aggregates of gold nanorods.

Methodology

We performed simulations in COMSOL Multiphysics to model the flow field produced by the combination of the AC electric field and the small temperature gradient. To so, we used the Fluid Flow and Heat Transfer in Solids and Fluids physics interfaces. Coupling was introduced by the Electro-thermal body force:

$$\mathbf{F}_{\mathrm{ET}}(\mathbf{r}) = \frac{1}{2}\mathrm{Re}\left[\frac{\varepsilon(\alpha-\beta)}{1+i\omega\tau}(\nabla T(\mathbf{r})\cdot\mathbf{E})\mathbf{E}^{*} - \frac{1}{2}\varepsilon\alpha|\mathbf{E}|^{2}\nabla T(\mathbf{r})\right]$$

In a different model, we also performed electromagnetic simulations using Electromagnetic Waves, Frequency Domain physics interface to estimate the absorption cross-section of the gold nanoparticles and to detect the possible presence of aggregates in the sample used.

Results

We were able to simulate the electrothermoplasmonic flow in the chamber. This configuration can lead to strong convection, which could be useful for mixing in microfluidic devices.

The shape of the simulated flow field is in good agreement with the experimental flow field. More work is needed to model the second order relationship between the gold nanoparticles concentration and the maximum velocity achieved.

Also, thanks to the electromagnetic simulations, we detected the presence of particle aggregation in our solution. Further work is required to understand better the type of aggregation present in the sample used.

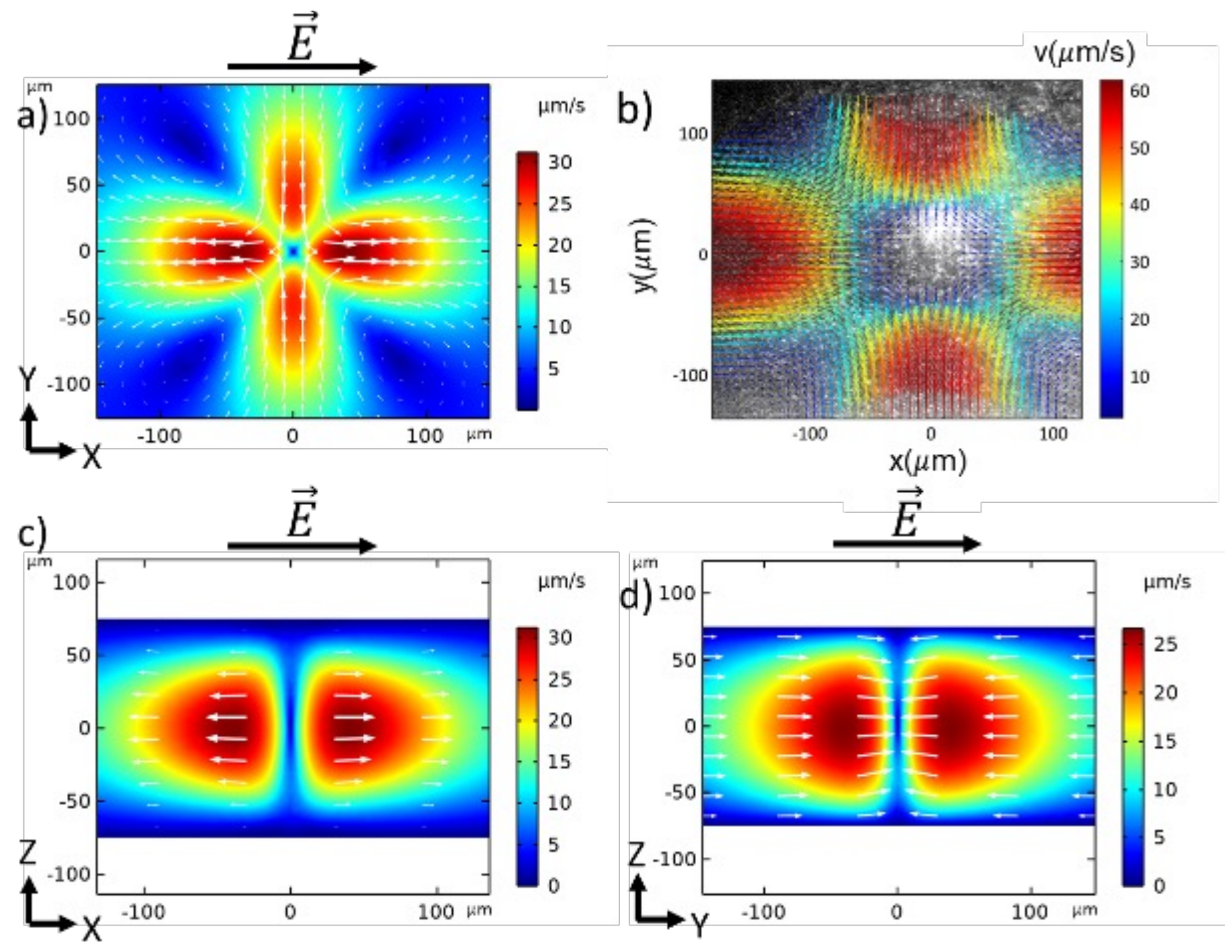

FIGURE 2. Comparison between simulated and experimental flow fields.

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