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Theoretical Analysis of a Pulsatile Electroosmotic Flow in a Wavy Electrode

Carlos Vargas[1,2], Carlos Escobedo[3], Aristides Docoslis[3], Oscar Bautista[2]
[1]ESIME Zacatenco, Instituto Politécnico Nacional
Calz. Ticomán 600, San José Ticoman, Del. Gustavo A. Madero, Ciudad de México 07340, CDMX
cvargasg1501@alumno.ipn.mx
[2]ESIME Azcapotzalco, Instituto Politécnico Nacional
Av. De las Granjas No. 682, Col. Santa Catarina, Del. Azcapotzalco, Ciudad de México 02250, México
obautista@ipn.mx
[3]Department of Chemical Engineering, Queen's University, Kingston, ON, K7L 3N6 Canada
ce32@queensu.ca

Extended Abstract

Dies et al. [1] experimentally present the formation of a nanostructure through an electric field-guided assembly, which results in an extended and interconnected dendritic nanoparticle structures between the microelectrodes. These structures were used to enhance the detection of proteins, illicit drugs, food contaminants and pesticides. After varying the frequencies, from 1 Hz to 1 KHz, they show that the electrokinetic deposition on the microelectrodes walls decrease. Due to this phenomenon we assume that a pulsatile electroosmotic flow (PEOF) is generated and disrupt the electrokinetic deposition near the microelectrodes.

The analysis of a pulsatile electroosmotic flow (PEOF) of a Newtonian fluid with an electrically neutral solute while considering the curved walls of the microelectrodes in a two-dimensional system is analyzed. To describe the flow and electrical fields, the lubrication approximation theory (LAT) and the Debye-Hückel approximations are used [2]. A resultant electric force is considered between the microelectrodes when they get closer to each other. The angular frequency of the applied electric field in the electrodes plays a major factor in considering the convective terms in the conservation of species, while also being the main cause of the electroosmotic flow appearance and electrokinetic deposition of the solute near the walls and intersections of the microelectrodes. For increasing values of the angular frequency, the order of magnitude of the characteristic time associated to the angular frequency will predominate over the order of magnitude of the characteristic time associated to the mass dispersion, driving the solute away from the microelectrodes, condition where the electrokinetic deposition does not take place.

From the results we appreciate how the flow is driven into the centre of the microchannel, while we observe an interesting phenomenon with the velocity profiles. From the velocity vector we observe two distinguished phenomena, first at $t = 3\pi/4$ the flow is driven into the centre of the upper wall, while at $t = \pi/2$ the flow is driven outside of the microchannel an into the lower wall. When $\omega = 10\ Hz$ the solute will be affected by the oscillatory electroosmotic flow, which will drive the particles into the lower wall and, because this frequency time is longer than the transversal diffusion, the solute will mostly accumulate in only one electrode (lower wall). When $\omega = 100\ Hz$ the convection will greatly affect the distribution of the species, where the particles will also be driven into the lower electrode but the sedimentation will be interrupted by the flow, which will take part of the solute to the other electrode (upper wall), creating the dendritic structure in both electrodes. Finally, assuming an $\omega = 1\ KHz$ the convective part of the conservation of species will avert the sedimentation to take place, which cannot be shown in any equation in this work because the angular Reynolds number can no longer be neglected ($R_\omega \geq 0.1$).

References

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