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AES-1

Electrokinetic Velocity Characterization of Microparticles in Glass Microchannels

By José I. Martínez-López1, Blanca H. Lapizco-Encinas2, Héctor Moncada-Hernández2, Marco Rito-Palomares2 and Sergio O. Martínez-Chapa3, (1)Biotechnology and Food Engineering and Electrical Engineering, Tecnologico de Monterrey, Monterrey, Mexico, (2)Biotechnology and Food Engineering, Tecnologico de Monterrey, Monterrey, Mexico, (3)Electrical Engineering, Tecnologico de Monterrey, Monterrey, Mexico

Abstract: Insulator-based dielectrophoresis (iDEP) an efficient technique with great potential for miniaturization. It has been applied successfully for the manipulation and concentration of a wide array of particles, including bioparticles such as macromolecules and microorganisms. When iDEP is applied employing DC electric fields, other electrokinetic transport mechanisms are present: electrophoresis and electroosmotic flow.

In order to achieve dielectrophoretic trapping of bioparticles, dielectrophoresis has to overcome electrokinetics (electroosmosis and electrophoresis). Therefore, in order to improve and optimize iDEP-based separations, it is necessary to characterize these electtrokinetics under the operating conditions employed for dielectrophoretic separations. The main objective of this work is to identify the operating conditions that will benefit dielectrophoretic trapping and concentration of particles when electrokinetics is present.

This study presents the estimation of the electrokinetic mobility of microparticles suspended inside a microchannel. Micro Particle Image Velcimetry (uPIV) was employed to measure the velocity of 1-um-diameter inert polystyrene particles suspended in a 3cm-long, 10-um deep, 1-mm-wide, straight glass microchannel. A parametric study was carried out by varying the properties of the suspending medium (conductivity and pH) as well as the strength of the applied DC electric field. The results obtained using uPIV allowed to identify the conditions under which the electrokinetic force (i.e. particle velocity) is lowest, i.e., optimal conditions for dielectrophoretic trapping. It was shown that high conductivity and low pH values for the suspending medium produce lower electrokinetic mobilities, i.e., low electrokinetic force, thus benefiting dielectrophoretic trapping. These findings were proved by carrying out dielectrophoretic trapping of microparticles employing a glass microchannel that contained cylindrical insulating structures. The results obtained in this study will provide with guidelines for the optimization of iDEP-based separations.

AES-2

Thermoresponsive Microparticle Gels for Electrophoresis: PNIPAm Templated Page

By Jeffery W. Thompson, Holly A Stretz and Pedro E. Arce, Chemical Engineering, Tennessee Technological University, Cookeville, TN

Abstract: Gel electrophoresis is a widely used technique for the separation of biomacromolecules, including DNA, proteins, and antibiotics. Clinical studies, diagnostics, and lab production are some excellent examples where electrophoresis seems to work well for a large family of these molecules. However, for cases where the physical or transport properties, i.e. electrophoretic mobility and/or diffusivity are similar, as well as biomolevualr sizes are of the same order, the separation becomes very challenging. The fibrous gel morphology exposes the biomacromolecules to a "differentiating" material allowing the physical properties mentioned above to yield a motion different for biomacromolecules with different transport properties.

Therefore, controlling the nature and sizes of this architecture or morphology may have a beneficial impact on the separation efficiency. Rill et. al. (1995) proposed a modified architecture by templating gels with DNA (or surfactant) templates that were removed from the gels once the polymerization took place, by electrophoresis action. The resulting material, hypothesized as a "dual" porous structure, displaying both small (of the order of the inter-fiber voids) and larger (of the order of the templating agent) pores or voids, led to an improved separation efficiency.

Templating agents in gels, as mentioned above, are not the only approach to modifying gel morphology Embedded nanoparticles of varying properties are another option because of the multitude of potential alternatives that they offer regarding the physical properties of the gel. For example, the presence of nanoparticles within the gel has the potential to modify the electrokinetic properties of the gel; therefore, these nanoparticles may influence electro-osmotic flows, as it has been shown in preliminary studies for sensor applications (Matos et. al., 2006). Sedrick et. al. (AIChE/ACS, 2008) have synthesized these types of gels by using laponite nanoparticles of a given size and properties. TEM images show an interesting and excellent potential structure that may lead to an improved separation efficiency based on the modified architecture of the nano-composite gels.

Nanocomposite gels whose morphology is sensitive to temperature for drug delivery and bioseparations of proteins or DNA holds great potential. These materials feature, for example, nano or microparticles embedded in the gel structure that creates a thermo-sensitive and composite polymer with different and unique transport properties. The synthesis and characterization of thermally responsive particles as well as including them in gel matrices are described. The particles are synthesized with a precipitation polymerization crosslinking reaction and inserted into gels. In addition, electrophoresis runs are used to test the new gels in proteins motion. Both UV and visual characterization are used to determine and compare the transport (i.e. mobility and dispersion) characteristics of the new gels with standard gels in the electrophoresis runs. The new nanocomposite gels offer excellent potential to improve separation. Details for the current and future work will be offered.

AES-3

Investigation of Changes in the Surface Chemistry and Morphology of Platinum Microelectrodes Subjected to a Dielectrophoretic Field

By Aytug Gencoglu1, Emily F. Cotten1, S. Anell Pullen1, Sarah Thompson2, B. Selin Tosun3 and Adrienne R. Minerick1, (1)Dave C. Swalm School of Chemical Engineering, Mississippi State University, Mississippi State, MS, (2)Mississippi School for Math and Science, Mississippi University for Women, Columbus, MS, (3)Metallurgical and Materials Engineering Department, Istanbul Technical University, Istanbul, Turkey

Abstract: Previous studies have suggested that the performance of platinum microelectrodes, a metal widely regarded as inert at microdevice operating voltages, tended to improve in performance in medical microdevices as the microelectrodes aged. Early studies of our microelectrodes were carried out over 4 hours in nonuniform AC fields similar to those utilized in our group's medical microdevices in approximately 0.5 mL of a phosphate saline buffer solution (PBS) at pH 6.7. The nonuniform electric field was generated by application of a 1kHz, 6 VPP signal. Morphological changes that could be pitting or deposition of material were visualized by SEM and gas formation at the electrodes was observed in real time by optical microscopy. Oxidation of platinum on the microelectrode surface was detected by XPS. Oxidation of platinum has been reported before, and recent studies have reported the reduction of platinum by SECM-generated radical anions. However, the previous studies characterized regions whose area was 9 microns squared and 10000 microns squared whereas our work has looked at the macroscopic scale at the order of mm2 on 100 micron diameter platinum microelectrodes 3 cm in length. Here we present the findings of systematic experiments aimed at finding out the source of the chemical and morphological changes on platinum microelectrode surfaces. The morphological and chemical changes were determined as a function of the frequency of the electric field, the exposure duration of the microelectrodes in the electric field, and the chemical species present in the buffer solution. These effects were systematically explored by running fresh microdevices under various conditions and comparing the surface chemical compositions of the platinum microelectrodes by XPS and EDS and their surface morphologies by SEM and XRD.

AES-4

An Electrokinetic-Hydrodynamics-Ekhd Based Approach to Determine Effective Transport Parameters: Illustrative Results and Comparison

By Jennifer Anne Pascal1, Mario Oyanader2 and Pedro E. Arce2, (1)Chemical Engineering, Tennessee Tech University, Cookeville, TN, (2)Chemical Engineering, Tennessee Technological University, Cookeville, TN

Abstract: A number of contributions have been made to the field of electrokinetics, i.e. electrophoresis, EOF, etc. as it relates to the behavior of diffusion and hydrodynamics in various systems. Many of these efforts have been influenced by the work conducted by the group of Giddings (see, for example, Martin and Giddings [1], [2]) who worked in the area of

field flow fractionation (FFF). In this separation technique, an orthogonal applied field (i.e. gravitational, electrical, etc.) drives the motion of the charged molecules towards the channel walls; thus, the solute that is most susceptible to the influence of the field locates closest to the walls, and, depending on the solute properties, different species reach the wall at different locations.

Among illustrative contributions and without being thorough in the literature citations, Giddings ([1]), based on nonequilibrium theory, predicted retention times in various types of FFF devices. Brenner and Edwards ([3]), examined a Couette-based flow apparatus with cross flow in which equations governing the transport of Brownian solute particles (i.e. diffusivity and velocity) were developed. More recently, Horiuchi et. al. ([4]) have examined two dimensional flow in rectangular microchannels with non constant electrostatic potential on the walls. They obtained analytical solutions for the velocity profile and pressure as well as the effective diffusivity. These "effective" parameters control the quality of the separation in the device.

A powerful mathematical framework that is currently available ([5]) for these types of problems is the coupling of EKHD with the spatial averaging approach ([6], [7], [8], [9]). This mathematically efficient approach allows for up-scaling as well as systematization from the micro (molecular or continuum) scale to the macro (bulk) scale. One of the advantages of this combined approach is the prediction of optimal separations for a wide variety of cases with a minimum effort. Moreover, the analytical results are rather simple mathematical functions of the fundamental physical parameters of the system. In this presentation, the authors will present illustrative results for both the Poiseuille as well as the Couette hydrodynamic flows (i.e. optimal separation times). Furthermore, the authors will compare these predictions with results found in the literature related to these cases and draw conclusions about the possible more suitable description and general validity of such predictions.

AES-5

Electrokinetic-Hydrodynamics (EKHD): An Efficient Framework for Systematic Research

By Jennifer Anne Pascal1, Mario Oyanader2 and Pedro E. Arce2, (1)Chemical Engineering, Tennessee Tech University, Cookeville, TN, (2)Chemical Engineering, Tennessee Technological University, Cookeville, TN

Abstract: Currently there are many problems in Chemical Engineering that involve the application of an applied electrical field to a fibrous or porous media in a variety of relevant technological processes. Examples of these types of problems are the separation of biomacromolecules, such as proteins and DNA, bioremediation, drug delivery, and coating flows, among others. These types of problems can be described by the fundamentals of "electrokinetic-hydrodynamics" or EKHD, for short ([1]). What makes the applications within the domain of electrokinetic-hydrodynamics unique is that unlike electrochemical systems, bulk motion of the fluid occurs. Therefore, we can view EKHD as involving two domains: the motion of the fluid (electrohydrodynamics) and the motion of the solute/analyte (electro and convective-diffusive transport). It is apparent that these two domains are representative of two

different scales, the continuum (fluid) and the discrete (solute) . This contribution will discuss how EKHD is an efficient framework for the investigation of systems with low and high values of applied electrical fields.

For the understanding the behavior of the systems in EKHD, one must have a basic background in fluid mechanics, and mass, momentum, and energy conservation. These concepts can then be used to link the principles of electrokinetics to those of hydrodynamics to model the fluid motion, i.e. “electrohydrodynamics”. Once this knowledge is acquired, then the solute/analyte problem can be described. The coupling between these two domains (i.e. fluid and solute) can be effectively handled by using the spatial averaging technique ([2]). This powerful up-scaling approach allows for the computation of analytical expressions which lead to effective, or alternative “macro,” coefficients (i.e. effective velocity and diffusivity) that represent the macroscopic behavior of the system. These coefficients can then be used to determine information relevant to practical applications such as the optimal time of separation of biomacromolecules, time for the cleaning protocol in soil remediation, among others. In this contribution, the authors will discuss the method of EKHD and the different elements associated with it; for the didactic aspects, typical assignments/exercises associated with this field of research including, problems and projects, will be included.

AES-6

Polyacrylamide Gel Modified with Poly-N-Isopropylacrylamide Coated Gold Nanoparticles for Electrophoresis

By Jyothirmai J. Simhadri, Holly A. Stretz and Pedro E. Arce, Chemical Engineering, Tennessee Technological University, Cookeville, TN

Abstract: Traditionally, separation of proteins was accomplished by polyacrylamide gel electrophoresis; usually, gel structure is modified by change in concentrations of polymers in solution. This approach has worked well for many type of macromolecules; however when the electrophoretic mobility and the size of the macromolecules do no cooperate efficiently, the separation of this type of mixture become challenging. Therefore, other approaches must be identified. For example, by modifying the structure of gels by either “macro-voids” (Rills et al, 1995) or by adding nanoparticles (Thompson et al, 2008) have proven successfully in increasing separation efficiency. In this contribution, the synthesis and characterization of core/shell nanoparticles as well as dispersing them into the polyacrylamide gel matrix are described. The particles are synthesized by surfactant free emulsion polymerization and dispersed into the gels. UV-Vis spectrophotometer is used to characterize the particles. Characterization of the material structure and electrophoresis on albumin proteins is performed to confirm the effectiveness of the modified gel matrix on their separation efficiency. Comparison with other type of nanocomposite gel matrix will be also discussed.

AES-7

Characterizing the Abundance and Activity of Soil Microbes by Capillary Electrophoresis Using Single-Strand Conformational Polymorphism

By Alice C. Jernigan1, Greg Thoma1, Duane C. Wolf2 and Christa N. Hestekin1, (1)Chemical Engineering, University of Arkansas, Fayetteville, AR, (2)Crop, Soil and Enviornmental Sciences, University of Arkansas, Fayetteville, AR

Abstract: Bioremediation is the process by which microbes are used to break down soil contaminates. Although bioremediation has the potential to be a useful and potentially less expensive and more natural method of soil reclamation, there is limited information about the actual microbial communities that perform the remediation and how their abundance and activity changes with time. The identification and assessment of activity of microbial soil communities can be accomplished by isolating DNA and RNA from soil samples. These DNA/RNA samples can then be characterized by a technique called single-strand conformational polymorphism (SSCP) analysis of the 16S gene. The 16S gene is highly conserved among microorganisms, but has unique small variable regions that can be used to differentiate between species. These regions can be amplified by polymerase chain reaction (PCR) giving small fragments of the gene sequence. SSCP, a method that is normally used to detect mutations, is the heat denaturing of these fragments resulting in single strand DNA. The refolding of the single strand DNA will form different secondary structures (conformations) depending on the nucleotide sequence. These different conformations can be separated due to their different electrophoretic mobility, even if they are the same size. The traditional method for looking at bioremediation is by viable plate counts or microscopic examination. These methods are both time consuming and can underestimate the numbers due to the inability to culture many soil organisms. The increased speed and automation of capillary electrophoresis (CE)-SSCP will allow for more rapid and reliable results. By isolating both DNA and RNA from the same soil sample, at the same time, a more accurate picture of the microbial community in those samples will be available. This will be important in the study of contaminated soils and the monitoring the progress of bioremediation.

AES-8

Chip-based concentration and identification of bacteria from the human microbiome

by Robert J. Meagher, Yooli K. Light, and Anup K. Singh, Sandia National Laboratories, Biosystems Research Department, P.O. Box 969, Livermore, CA 94551

Abstract: The emerging field of metagenomics seeks to assess the genetic diversity of complex mixed populations of bacteria, such as those found at different sites within the human body. A single person's mouth typically harbors up to 100 bacterial species, while surveys of many people have found more than 700 different species, of which ~50% have never been cultivated. In typical metagenomics studies, the cells themselves are destroyed in the process of gathering sequence information, and thus the connection between genotype and phenotype is lost. We

seek nondestructive means of assessing microbial diversity in mixed populations. As a first step, we have developed a microfluidic device for concentrating and specifically labeling bacteria from a mixed population. Bacteria are electrophoretically concentrated against a photopolymerized membrane element, and then incubated with a specific fluorescent label, which can include antibodies as well as specific or non-specific nucleic acid stains. Unbound stain is washed away, and the labeled bacteria are released from the membrane. The stained cells can then be observed via epifluorescence microscopy, or counted via flow cytometry. We have tested our device with three representative bacteria from the human microbiome: E. coli (gut, Gram-negative), Lactobacillus acidophilus (mouth, Gram-positive), and Streptococcus mutans (mouth, Grampositive), with results comparable to off-chip labeling techniques.

AES-9

DIELECTROPHORETIC CONCENTRATION OF YEAST CELLS

By Héctor Moncada-Hernández1, Blanca H. Lapizco-Encinas1, Blake A. Simmons2.
1Tecnológico de Monterrey, México, 2Sandia National Laboratories

Abstract: This work presents manipulation and trapping of yeast cells employing insulatorbased dielectrophoresis (iDEP) and direct current (DC) electric fields. Numerous reports exist in the literature describing the manipulation of yeast cells with the use of microelectrodes and alternate current (AC) electric fields.1,2,3 An array of insulating structures and DC electric fields were employed in this work, instead of an array of microelectrodes and AC electric fields.

Dielectrophoresis (DEP) is described as the motion of particles resulting from Polarization effects induced by non-uniform electric fields.4 This technique has been successfully employed for the manipulation of a wide range of bioparticles.5 The use of microelectrodes in the generation of non-uniform electric fields has some disadvantages compared with the use of insulating posts: higher cost of fabrication, less durability.5,6 The present study focuses on the potential of iDEP for yeast cells manipulation. A microdevice made from the polymer Zeonor was employed, this device contained eight microchannels that were 10.2-mm long, 1-mm wide and 75-µm deep. Each microchannel contained an array of cylindrical insulating structures, 150-µm in diameter and 200-µm center-to-center (Figure 1). Different electric field intensities across the post array were achieved by applying DC field between the inlet and outlet reservoirs of the microchannel. A buffer solution of controlled pH 6 and conductivity of 115-µS/cm was used as a suspending medium. After a sample of the yeast cells was injected in the inlet reservoir, the electric field was applied, and the presence of the cylindrical posts formed zones of higher and lower field intensity. Results were recorded in video and photo files.

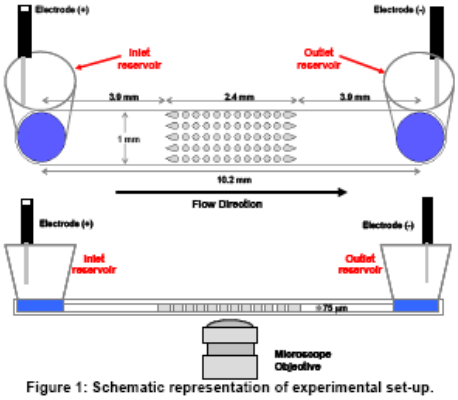

Figure 1: Schematic representation of experimental set-up.

In Figure 2a it can be seen that under effect of an electric field of 200 V/cm, there is no dielectrophoretic trapping, yeast cells are moving mainly under the influence of the electrokinetic force. Figure 2b shows some cells moving while some others are being trapped when an electric field of 400 V/cm is applied. This is a regime called streaming dielectrophoresis, where dielectrophoresis dominates diffusion but is overcome by electrokinetic flow. Particles travel electrokinetically down the array in flowing streams. Figure 2c shows the effect of dielectrophoresis overcoming the electrokinetic force by trapping the yeast cells when an electric field of 600 V/cm is applied, this regime is called "trapping dielectrophoresis". The results presented here demonstrate the potential of iDEP for the manipulation of microorganisms, with potential applications in microbiology and food analysis. It is expected that the results from this study will provide valuable information and guidelines to be used for the design and operation of iDEP microdevices.

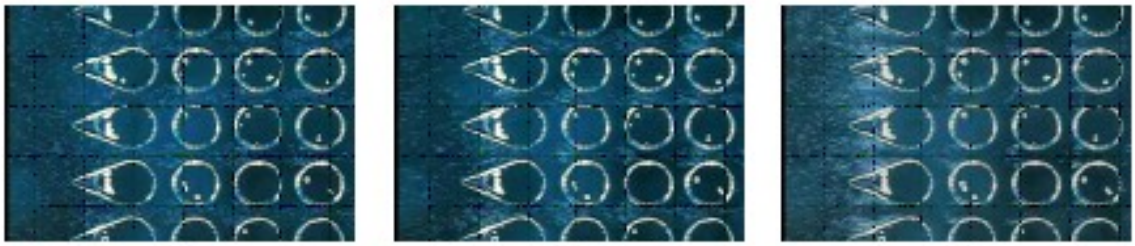

Figure 2: Dielectrophoretic response of yeast cells. Particles flow from left to right, post diameter is 150-µm, suspending medium has a conductivity of 115-µS/cm and a pH of 6. (a) E = 200 V/cm. (b) E = 400 V/cm. (c) E = 600 V/cm.

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AES-10

PREDICTION OF TRAPPING ZONES IN AN INSULATOR-BASED DIELECTROPHORETIC DEVICE

*By Javier L. Baylon-Cardiel, Blanca H. Lapizco-Encinas, Sergio O. Martínez-Chapa**
Tecnológico de Monterrey, México

Abstract: Insulator-based dielectrophoresis (iDEP) is an efficient technique with great potential for miniaturization. It has been successfully applied for the manipulation and concentration of a wide array of particles.[1-4] When iDEP is applied employing DC electric fields, other electrokinetic transport

mechanisms are present: electrophoresis and electroosmotic flow. In order to concentrate and immobilize particles iDEP has to overcome electrokinetics. This study presents the mathematical modeling of the performance of an iDEP microdevice, in order to identify the optimal conditions for particle concentration employing DC-iDEP.

The geometry of an iDEP microdevice was captured with COMSOL Multiphysics software, the microchannel considered was 10.16-mm long, and 2-mm wide containing an array of 32 insulating posts, distributed in 4 rows of 8 posts each. The posts had a diameter of 440 μm, arranged 520 μm center-to-center. For this model, particles having a diameter of 1 μm and a conductivity of 40 μS/cm were considered.

For the mathematical model, the Laplace equation, with the following boundary conditions, is solved in the region between the insulating posts:

$$\nabla^2 V = 0 \qquad (1)$$

$n \cdot J = 0$ in the microchannel boundaries and in the posts (2)

$V = V_{in}$ at channel inlet (3)

$V = 0$ at channel outlet (4)

where n in the normal vector to the surface, J is the electrical current and V_{in} is the electrical potential applied between the posts. From the solution for the electric potential, numerical values for the electric field are obtained.

As mentioned, the objective of the present work is to predict the conditions under which dielectrophoretic trapping of particles occurs. In order to obtain dielectrophoretic trapping, its contribution to the particle flow must overcome diffusion and electrokinetic (EK) flow. The dielectrophoretic velocity can be expressed as:

$$u_{dep} = -\mu_{dep} \nabla E^2 \qquad (5)$$

where u_{dep} is the dielectrophoretic velocity, μ_{dep} is the dielectrophoretic mobility, and E is the electric field intensity. The EK velocity is related to electric field as: [5,6]

$$u_{ek} = \mu_{ek} E \qquad (6)$$

$$\mu_{ek} = \mu_{ep} - \mu_{eo} \qquad (7)$$

μ_{ek} is defined to be the electrokinetic mobility, and it takes account for the electroosmotic (μ_{eo}) and electrophoretic (μ_{ep}) mobilities. Since the particles considered in this model are relative large and have low surface charge, it is possible to assume that the electrokinetic and electroosmotic mobilities are almost equal. For this model, it is assumed that the main contributions to the particle flux j along the microchannel come from DEP and EK flow. This can be expressed as:

$j \cdot n = 0$ in the microchannel boundaries (8)

$j = C(u_{ek} + u_{dep})$ between the cylindrical posts (9)

where C is the concentration of particles. From Eqn. (9), a simplification for trapping regions where the flux along electric field lines is equal to zero ($j \cdot E = 0$) can be obtained:

$C(\mu_{ek} E - \mu_{dep} \nabla E^2) \cdot E = 0$ in the channel (10)

Thus, in a given region, a condition for dielectrophoretic trapping is:

$$\frac{\mu_{dep} \nabla E^2}{\mu_{ek} E^2} \cdot E > 1 \qquad (11)$$

Following the model described, the simulation of an electric field applied across the microchannel was performed, and the results are shown in Figure 1, when a potential of 500 V is applied with a suspending medium having a conductivity of 100 μS/cm and a pH of 8. Regions of higher and lower electric field intensity were generated, making it possible to predict where the regions for dielectrophoretic trapping are located. Experimental work has shown that insulator-based dielectrophoretic trapping is improved when high conductivities and low pH are employed for the suspending medium.7 Figure 2 shows how trapping regions obtained in the simulation correlate to the regions observed in experiment. By employing the criteria en Eqn. (11), it was possible predict the regions across the post array where dielectro- phoretic trapping should occur under these conditions, these regions are shown in Figure 2a. For comparison, Figure 2b shows the experimental results obtained under the same conditions. It can be seen that there is an agreement between the mathematical model and the experimental results. Dielectrophoretic trapping of microparticles occurs at the zones predicted by the model.

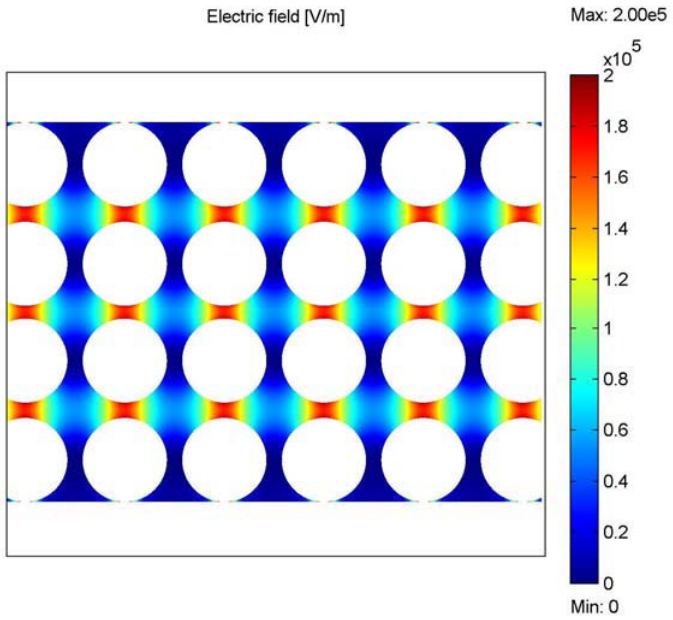

Figure. 1 Electric field distribution across the post array when a 500 V electric potential was applied in a medium with a conductivity of 100 μS/cm and a pH of 8.

According to experimental work, dielectrophoretic trapping should decrease when the conductivity of the suspending medium decreases or when the pH increases. Figure 3a shows a prediction of the zones for dielectrophoretic trapping, under the same conditions but decreasing the conductivity of the suspending medium to 25 μS/cm. Figure 3b shows the a prediction of the zones for dielectrophoretic trapping when the pH is increased to 9. As it can be seen, Figures 3a and 3b show smaller zones for dielectrophoretic trapping when compared with Figure 2a, this is in agreement with experimental results.7 Weaker dielectrophoretic trapping is expected for the conditions in Figures 3a and 3b.

It was demonstrated that the results obtained with the mathematical model are in agreement with experiments. This mathematical model will allow predicting the performance of dielectrophoretic devices, providing with guidelines for the optimization of iDEP separations, since mathematical modeling can be carried out to predict the system performance and aid on the selection of operating conditions.

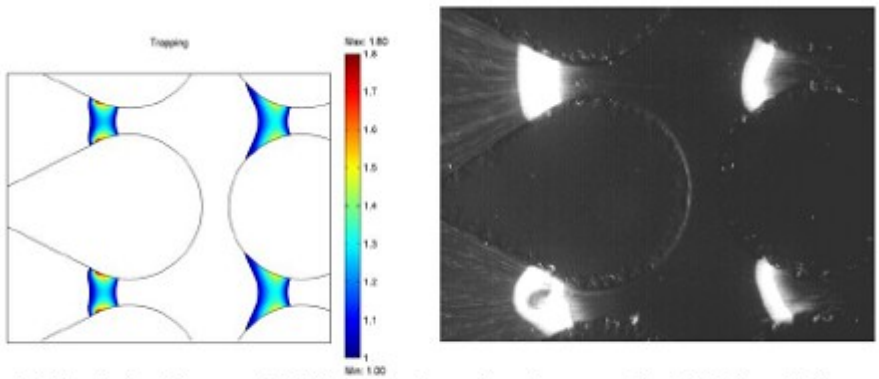

Figure 2. (a) Prediction of the zones for dielectrophoretic trapping when a potential of 500 V is applied with a suspending medium with conductivity of 100 μS/cm and pH of 8, employing particles having a diameter of 1 μm, (b) Experimental results obtained under the same conditions.

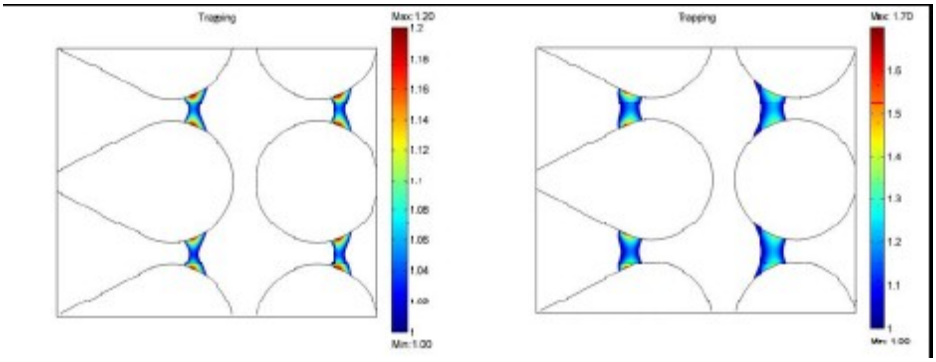

Figure 3. (a) Prediction of the zones for dielectrophoretic trapping when a potential of 600 V is applied with a suspending medium with conductivity of 25 μS/cm and pH of 8, employing particles having a diameter of 1 μm, (b) prediction of the zones for dielectrophoretic trapping when a potential of 500 V is applied with a suspending medium with conductivity of 100 μS/cm and pH of 9, employing particles having a diameter of 1 μm

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AES-11

MICROALGAE DIELECTROPHORETIC CONCENTRATION

By José I. Martínez-López, Roberto C. Gallo-Villanueva, Ileana Hernández-Mireles, Sergio O. Martínez- Chapa, Mario M. Álvarez, Blanca H. Lapizco-Encinas Tecnológico de Monterrey, Monterrey, México*

Abstract: Microalgae are a diverse group of photosynthetic, heterotropic organisms. They constitute the base of the food pyramid in the oceans, and play a fundamental role in the CO_2 equilibrium in our planet. Recently, their massive culture has been suggested as an alternative to attenuate or control global warming through CO_2 capture (Hirata *et al*., 1996), to produce fuels (Nagle *et al*., 1990; Chisti *et al*., 2007) and as a food source (Brown *et al*., 1997) among other applications. Microalgae can be grown in open-culture systems such as ponds or lakes or in highly controlled closed-culture systems, similar to those used in commercial fermentation processes.

One limiting factor of collecting microalgae from fresh and sea water is the isolation and concentration of each strain. Traditional isolation techniques may require 3 or 4 weeks of laboratory work. Cell growth processes may take a significant amount of time if the culture starts from only a few cells. Therefore, having samples of concentrated microalgae can significantly accelerate growth. In this study an alternative way to concentrate microalgae in a rapid manner is presented. Our research objective was to develop a microalgae concentrator employing insulator-based dielectrophoresis (iDEP), a technique that can concentrate and fractionate a sample of microalgae in minutes. Dielectrophoresis (DEP) is an electrokinetic transport mechanism in which a force is exerted on a particle when it is subjected to a non-uniform electric field. In iDEP the nonuniform electric field is obtained by employing arrays of insulating structures and only two electrodes. The electric field is applied along an array of micro-insulating structures creating zones of higher and lower electric field intensity throughout the array, creating dielectrophoretic traps. This technique has been successfully employed for the concentration of several biological particles like DNA (Chou *et al*., 2002), protein (Lapizco-Encinas *et al*., 2008), yeast cells (Zhou *et al*., 2002; Suehiro *et al*., 2003) and bacteria (Lapizco-Encinas *et al*., 2004). A set of iDEP experiments was carried out utilizing a microchannel containing an array of cylindrical insulating posts. The microchannel used in this work was 10.12-mm-long, 1-mmwide, 10-µm deep, and had an array of 8 columns x 4 rows of cylindrical insulating posts 200-µm in diameter and arranged 250-µm center-to-center (Figure 1).

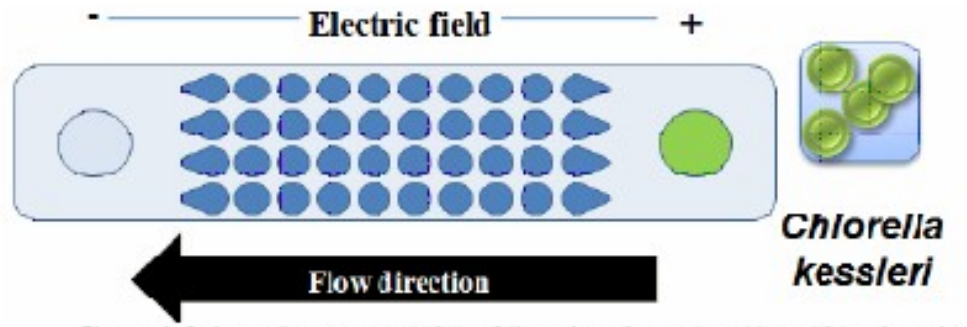

Figure 1. Schematic representation of the microchannel employed for microalgae dielectrophoretic trapping.

Green algae (*Chlorella kessleri*) having an average diameter of 5 μm were fluorescently labeled employing a DNA intercalating dye (Syto 11). Samples of the labeled algae were introduced at the microchannel inlet, the electrodes were placed at the inlet and outlet reservoirs and a DC electric field was applied. Results showed that it was possible to dielectrophoretically immobilize and concentrate microalgae. Cells were concentrated in bands across the cylindrical post array as a function of the applied electric field. Figure 2a shows a picture of microalgae cells concentrated when a field of 800 V/cm was applied. By increasing the applied field to 1000 V/cm (Figure 2b), it is possible to increase the amount of retained cells. The results demonstrated the potential of this novel technique to be used as a strategy for rapid microalgae concentration, and that operating conditions can be manipulated to improve dielectrophoretic separation processes.

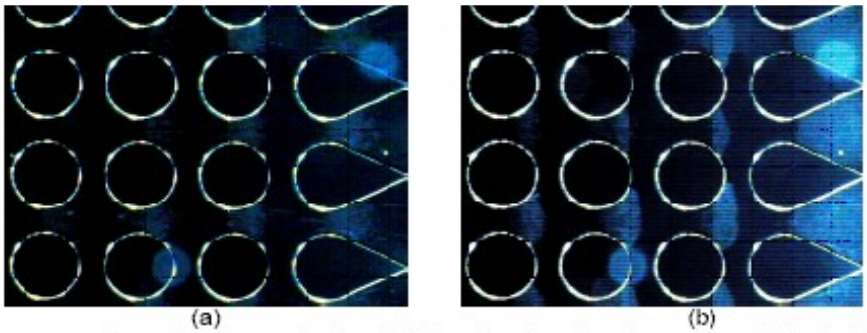

Figure 2. Pictures showing dielectrophoretic microalgae concentration inside a microchannel with cylindrical insulating structures, post diameter is 200 μm, flow direction is from right to left. a) E=800 V/cm; b) E=1000 V/cm.

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AES-12

Evidence of Entropic Trapping in Microchip DNA Gel Electrophoresis

By Nan Shi, Roger C. Lo, Jian Wang, and Victor M. Ugaz Department of Chemical Engineering, Texas A&M University, College Station, TX 77843, USA

Abstract: Miniaturized DNA electrophoresis devices pose unique design challenges that arise from theneed to exert increasingly precise and reproducible control over all aspects of the process so that separation performance can be maintained over ultra-short distances. The properties of the sieving gel matrix are particularly important because its nanoscale pore morphology plays a keyrole in directing DNA migration. Here we describe experiments aimed at exploring this interplay in photopolymerized crosslinked polyacrylamide gels by employing a unique combination ofmethods that enable both the mean pore size and pore size distribution of the gel to be quantified, and a versatile microfluidic platform that allows continuous monitoring of DNA separation progress so that the size dependence of mobility and diffusion coefficients can be established.Analysis of double-stranded DNA separations in the size range below 1 kb reveals that varyingthe rate of photopolymerization induces a corresponding change in the physical mechanism of DNA migration between reptation and entropic trapping. We then develop an interpretation of these observations based on the distribution of pore sizes and their arrangement within the gel matrix.

AES-13

Optimal Separation Times with Varying Electrical Fields: Comparison

By Hope Sedrick, Dr. Mario Oyanader, and Dr. Pedro Arce Tennessee Technological University, Department of Chemical Engineering, Cookeville, TN 38505

Abstract: When using electrical fields to separate molecular species for example pharmaceutical applications, a researcher must know an approximate optimal separation time for the two molecules. In order to calculate this optimal separation time, one must look at the contributions of the varying applied electrical fields. In this study, we analyze the effect, on optimal time of separations, of different types of applied electrical fields, i.e. orthogonal, parallel and in both directions for a typical case of a capillary with Poiseuille flow and no EOF. The case for the no applied electrical field will be also included for comparison purposes. Future work could include the comparison of these four cases for different convective regimes such as Couette or/and electroosmotic flow.

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