Jan/Feb 2009 • No. 194


ESA Newsletter
Electrostatics Society of America - The Friendly Society

# President's Message

## DNA Electrostatics

Dear All:

Electrostatics has been playing a major role in cellular mechanisms and may be a contributor to the attraction between DNA molecules (which are high density, negatively charged molecules). Many may wonder how there can be attraction between like-charged molecules, contrary to conventional electrostatics. A number of publications provide possible mechanisms [1-4] such as the possibility that DNA is a fascinating, shape-shifting, molecule whose behavior in solution involves polarity reversal that is contrary to many existing theories and concepts [1].

There are a number of interactions that must occur between DNA and proteins during the development of a life from its inception. Many of these are electrostatic interactions due to the charges of these molecules. Electrostatic forces drive the DNA packaging by alternating between tensed and relaxed states. Under typical experimental conditions (including physiological salt concentrations), the effective range of electrostatic interactions is long enough so that many interactions contribute to the electrostatic potential acting on the surface of DNA.

The fact that the condensed structure of chromatin (inside a cell) is induced by a high monovalent salt, and by the presence of divalent ions like Mg2+ and Ca2+, is indicative of an electrostatic mechanism [4]. The details of the mechanism by which these like-charged particles are able to attract each other is not fully established. [4]. Like-charged molecules would be expected to repel each other on the basis of a simple mean-field Poisson-Boltzmann treatment of the electrostatics. The experimentally observed attraction between negative like-charged biopolyelectrolytes, such as DNA and virus particles, is induced by the presence of multivalent ions, such as Mg2+ and Ca2+, This could be due to the cations shared by different polyanions giving rise to attractive electrostatic force contributions.

When a highly charged colloidal sphere is dipped into a solution of anionic polymer, the charge of the colloid is reversed due to chain connectivity [1]. Successive dippings into polymer solutions of alternating polarity confirm as many as ten reversals of sign, pointing out clearly that charged surfaces could be overneutralized by polyelectrolyte adsorption. Similarly, when a solution contains both DNA strands and positively charged lipids at various mix ratios, the negatively charged DNA molecules associate spontaneously with the lipid molecules. Usually, lipids are either neutral or negatively charged, so the DNA molecules (for gene therapy) are repelled by cell plasma membranes. But due to the reversal of lipid charges, the electrostatic barrier for DNA delivery could be lowered and gene delivery facilitated, as shown in many cases [5].

DNA-lipid complexes are salient biomedical molecules because they have been shown to be effective carriers of DNA inside living cells. All biological cells are surrounded by lipid bilayers comprised of many different (neutral and charged) phospholipid molecules. It can be seen that electrostatic phenomena, in the context of biophysical systems, play a central role in determining how the ions interact. The entropy and local structure of the counterion hidden variables play a significant role in producing surprising effects. While many conceptual questions still remain, we are making progress with X-ray crystallography and other sophisticated experimental methods, analytical and numerical techniques.

I know that I am not an expert in this field; and we have great experts in our group, such as our Vice President John Gagliardi as well as others. I just wanted to wet my feet in this exciting topic and I hope we will have a number of bio-related abstracts for our 2009 ESA annual meeting at Boston in June 2009. I know that Mark Horenstein, our General Conference Chair, is putting forth a lot of effort to have a great meeting. Boston being a hub of biomedical and biotechnology industry with Harvard and other institutions around, we hope to have some interesting invited

*(cont'd. on page 3)*

INTERNATIONAL ELECTROSTATIC ASSEMBLY (IEA)

ELECTROSTATIC PROCESSES COMMITTEE

# CALL FOR PAPERS

## 2009 JOINT CONFERENCE ESA / IEJ / IEA / IEEE-EPC / SFE

June 16-18, 2009

Boston University, MA, USA

The Electrostatic Society of America (ESA), Institute of Electrostatic Japan (IEJ), International Electrostatic Assembly (IEA), Industry Applications Society (IEEE-IAS) Electrostatic Processes Committee, and La Societé Francaise d'Electrostatic (SFE) will hold their 2009 Joint Conference on the campus of Boston University. Please join us for possibly the largest, most diversified, international gathering on electrostatics in North America including technical papers, a student paper competition, poster sessions, informal discussions, and electrostatic demonstrations.

**TECHNICAL PROGRAM:** We invite papers in all scientific and technical areas involving electrostatics. Contributions can range from fundamental investigations of electrostatic phenomena to studies of the implications, mitigation, or utilization of electrostatic phenomena in diverse settings. Technical topics include:

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| • Atmospheric and space applications | • Flows, forces, and fields | • Measurement and instrumentation |
| • Biological and medical applications | • Materials behavior and processing | • Particle control and charging |
| • Breakdown and discharge | • Plasma Chemical Reactors | • Safety and hazards |

**ABSTRACT SUBMISSION:** Abstracts should be submitted online, at http://www.electrostatics.org

**STUDENT PAPER COMPETITION:** Undergraduate and graduate student authors and co-authors presenting their work are eligible. The Conference Registration Fee is waived for student authors and co-authors participating in the competition.

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| **IMPORTANT DATES** | February, 2009 | Detailed conference information available at http://www.electrostatics.org |
| | March 2, 2009 | Abstract submission deadline |
| | March 18, 2009 | Notification of paper acceptance |
| | April 17, 2009 | Final manuscripts due |

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## President's Message (cont'd.)

and other presentations on related topics of electrostatics and biology. This year we are also having our joint meeting with other professional organizations, including the Institute of Electrostatics Japan (IEJ), the International Electrostatics Assembly (IEA), the IEEE-IAS Electrostatic Processes Committee (EPC), and the La Société Française d'Electrostatique (SFE).

We look forward to seeing you all at the conference.

Yours for the Friendly Society,
*Raji Sundararajan,*
*ESA President*

References:


[1] W. Gelbart, R. Bruinsma, P. Pincus, and V. Adrian Parsegian, DNA-inspired electrostatics, Physics Today, Sep 2000, pp. 38-44.

[2] Sun, et al., The structure of the Phage T4 DNA packaging motor suggests a Mechanism dependent on electrostatic forces, Cell, 135, Dec 26 2008, pp. 1251-1262.

[3] Electrostatics in DNA-peptide complexes, 1/27/2009, *http://www.cryst.bbk.ac.uk/PPS2/projects/soler/Project.html*

[4] N. Korolev, A. Lyubartsev, and L. Nodenskiold, Computer modeling demonstrates that electrostatic attraction of nucleosomal DNA is mediated by histone tails, Biophysica Jl, Vol. 90, June 2006, pp. 4305-4316.

[5] R. Zhou, J E Norton, and D A Dean, Electroporation-mediated gene delivery to the lungs, David Dean, Methods Mol Biol. 2008; 423:233-47.


## Calendar

- ISEHD2009. March 25-28, 2009, Universiti Malaysia Sarawak, Sarawak, Malaysia, Contact: ISEHD2009 Secretariat, Tel: 006-082-58-3326, *isehd2009@feng.unimas.my* or *aigit@feng.unimas.my* , website: *http://www.feng.unimas.my/ISEHD2009/* (abstracts due Oct. 31, 2008)
- 11th Int'l. Conf. of Electrostatics. May 27-29, 2009, Valencia, Spain, Contact: Dr. Pedro Segovia, Tel: (+34) 96 136 66 70, *pedro.llovera@ite.es*, website: http://electrostatics.ite.es (abstracts due Feb. 29, 2008)
- ESA-2009, June 16-18, 2009, Boston, MA Contact: Mark Horenstein, Tel: 617-353-5437, *mnh@bu.edu,* website: http://www.electrostatics.org
- ESA-2010, June, 2010, Charlotte, NC Contact: Maciej Noras, Tel: 704-687-3735, *mnoras@uncc.edu,* website: http://www.electrostatics.org

## ESA08 Conference Follow-up

### ESA08 Presentations - Where are they?

Once again I must apologize for not having the ESA08 presentations ready for viewing. On the first day of the conference we did not realize that we were feeding our mixer/preamplifier sound into another house amplifier that was set very high. This required us to keep the input volume (and hence the recorded volume) very low in order not to have feedback and squeal. In essence, the sound sent to the computer was buried in noise. At the moment my attempts to amplify the audio (but not the noise) result in the presenters all sounding like Mickey Mouse. On the second day of the conference we found the audio problem, but we also added a second computer and did not have a proper setting on that computer's volume so we have low volume presentations that become distorted when amplified. We also had a black screen on either computer whenever a movie was being shown on the multimedia projector. So we had to bring in the original presenter's voice and dub it into a new recording of the movie. Problems at the moment are in the cut and paste of the movie into the talk and in synchronizing the compressed audio and video. The original recorded presentations were somewhat compressed at the time of recording, but they were well over 100 megabytes (for simple slides with black letters on a white background) to well over a gigabyte when movies were also a part of the presentation. Most presentations were in the 300 megabytes to 700 megabytes range. Unfortunately, for streaming video the files should not be over a few tens of megabytes, so all files had to be dramatically compressed. For example, YouTube has a 100 megabyte limit. We now have the largest ESA08 files compressed down below 30 megabytes. In other words, at the moment we have met some of the criteria but not all of the criteria to go online.

*Al Seaver*
*Past ESA President*

## ESA OFFICERS

# Current Events

**Dynamic holograms change shape in seconds**

*R&D Mag*

*(excerpted from ...*

*http://www.rdmag.com/ShowPR.aspx?PUBCODE=014&ACCT=1400000100&ISSUE=0812&RELTYPE=PHOT&PRODCODE=00000000&PRODLETT=E&CommonCount=0 )*

Researchers at Purdue University have developed a technique that uses a laser and holograms to precisely position numerous tiny particles within seconds, representing a potential new tool to analyze biological samples or create devices using nanoassembly.

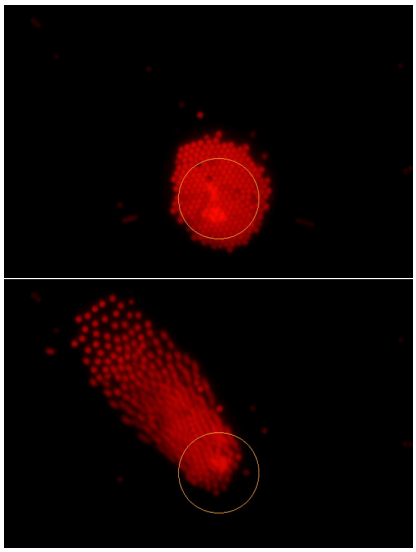
The technique, called rapid electrokinetic patterning, is a potential alternative to existing technologies because the patterns can be more quickly and easily changed, said mechanical engineering doctoral student Stuart J. Williams. The research is based at the Birck Nanotechnology Center in Purdue's Discovery Park.

The experimental device consists of two parallel electrodes made of indium tin oxide, a transparent and electrically conductive material. The parallel plates were spaced 50 micrometers, or millionths of a meter, apart, equivalent to two-thousandths of an inch or about the diameter of a human hair. A liquid sample containing fluorescent beads was injected between the two electrodes, a laser in the near infrared range of the spectrum was shined through one of the transparent electrodes and a small electrical voltage was applied between the two electrodes. The particles in the liquid sample automatically move to the location of the light and assume the shape of the hologram, meaning the method could be used to not only move particles and molecules to specific locations but also to create tiny electronic or mechanical features.

The light heats up the liquid sample slightly, changing its density and electrical properties. The electric field applied to the plates acts on these altered properties, causing the heated sample to circulate, much like heated air causes convection currents in the atmosphere, producing a donut-shaped "microfluidic vortex" of circulating liquid between the two plates. This vortex enables the researchers to position the particles in the circulating liquid by moving the laser light.

"You could take one particle, a hundred particles or a thousand particles and move them anywhere you want in any shape that you want," Williams said. "If you have particles of two different types, you can sort one group out and keep the other behind. It's a versatile tool."

Separating particles is important for analyzing medical and environmental samples. The system could allow researchers to design sensor technologies that move particles to specific regions on an electronic chip for detection or analysis.



*These images were taken from a video illustrating a new technique that uses a laser and holograms to precisely position clusters of numerous tiny particles within seconds, representing a potential new tool to analyze biological samples or create devices using "nanoassembly." The red dots are individual particles.*

The technique overcomes limitations inherent in two existing methods for manipulating particles measured on the scale of nanometers, or billionths of a meter. One of those techniques, called optical trapping, uses a highly focused beam of light to capture and precisely position particles. That technique, however, is able to move only a small number of particles at a time. The other technique, known as dielectrophoresis, uses electric fields generated from metallic circuits to move many particles at a time. Those circuit patterns, however, cannot be changed once they are created.

The new method is able to simultaneously position numerous particles and be changed at a moment's notice simply by changing the shape of the hologram or the position of the light. "If you want to pattern individual particles on a massive scale using electrokinetic methods as precisely as we are doing it, it could take hours to days, where we are doing it in seconds," Williams said.

The method offers promise for future "lab-on-a-chip" technology, or using electronic chips to analyze biological samples for medical and environmental applications.

Researchers are trying to develop such chips that have a "high throughput," or the ability to quickly detect numerous particles or molecules, such as proteins, using the smallest sample possible.

"For example, a single drop of blood contains millions of red blood cells and countless molecules," Williams said.

"You always want to have the smallest sample possible so you don't generate waste and you don't have to use as many chemicals for processing the sample. You want to have a very efficient high throughput type of device." So-called "optical tweezers" use light to position objects such as cells or molecules.

"You can't use mechanical tweezers to move things like molecules because they are too delicate and will be damaged by conventional tweezers," Kumar said. "That is why techniques like optical tweezing and dielectrophoresis are very popular."

The students also have designed an experiment containing one indium tin oxide plate and one gold plate, an important development because gold is often used in biomedical applications.

"It's a technique that you would likely use in sensors, but we also see definite potential ways in which you could use it to manufacture devices with nanoassembly," Wereley said. "But it's really too soon to talk about scaling this up in a manufacturing setting. We're just beginning to develop this technique."

The researchers recorded videos of the circulating particles to document the effect. A video showing the effect was selected as an outstanding entry during a meeting of the American Physical Society in November. The video can be accessed at *http://ecommons.cornell.edu/handle/1813/11399*

"This technique has not been done before," Williams said. "We can pattern light, we can pattern particles, we can pattern the vortex. No other tool can do all of these."

The researchers demonstrated how the method could be used to cause particles to stick permanently to a surface in a single crystalline layer, a structure that could be used in manufacturing. They used their technique to move fluorescent-dyed beads of polystyrene, latex and glass in sizes ranging from 50 nanometers to 3 micrometers.

Future work may involve using a less expensive light source, such as a common laser pointer, which could not be used to create intricate patterns but might be practical for manufacturing.

**'Intelligent' materials to revolutionise surgical implants: Nanotechnology will provide superior implants for orthopaedic patients**

*Scientific and Technology Facilities Council*

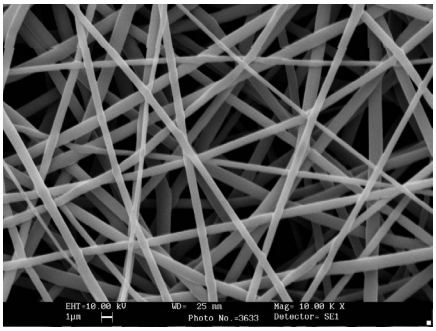
*(excerpted from ... http://www.scitech.ac.uk/PMC/PRel/STFC/Nanotech.aspx )*

A brand new process that could revolutionise the reliability and durability of surgical implants, such as hip and knee replacements, has today , 2 December 08, received recognition for its medical and commercial potential by achieving one of the world's most sought after accolades. A team of researchers, led by the Science and Technology Facilities Council (STFC), has received a Medical Futures Innovation Award for its high technology process designed to coat surgical implants with fibres that, for the first time, will encourage the implant to 'bond' with living bone and to last the lifetime of the patient.

This unique surface engineering process is being developed at the Micro-Nano Technology Centre (MNTC) at STFC. In collaboration with the Electrospinning Company Ltd (TECL) and Anglia Ruskin University, the concept will be taken forward under the guidance of a Medical Futures team, and eventually exclusively licensed to TECL, a spin out company of STFC.

This advanced nanotechnology technique builds on an existing technique known as electrospinning, and will utilise a vastly superior electrospinning source to create bespoke fibrous materials. Electrospinning is a process that uses an electrical charge to turn polymers into extremely thin fibres that are 'spun' to form a mat of fine fibres. It is seen as a platform technology for the medical sector with a wide range of applications including tissue regeneration and drug delivery. The MNTC has developed systems to increase the production rate of nanofibres which has been previously prevented this technology from being adopted by industry.

In this case, nanosized hair- like structures, a thousand times thinner than the width of a human hair, are electrospun at MNTC and added to the surface of an orthopaedic implant to create a 'living interface' between the artificial implants and living bone. Not only does this improve the performance of the implants it also significantly increases their durability to last the lifetime of the patient. Any stress on the implant is relieved, making it more reliable and durable. Additionally, it is also possible to add a unique biological coating that can facilitate growth and improve the bonding of healthy tissue to the implant, primarily benefitting patients with osteoarthritis in the aging population and sports injuries in the younger population.



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# ESA-2009 Annual Meeting: June 16-18, 2009
# Boston University, Boston, MA

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# University of North Carolina, Charlotte, NC