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ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Electrospinning – Revolutionizing the fiber production and applications

Nanofibers are an exciting new class of materials finding applications in many different industries. These nano-scale fibres have several remarkable characteristics such as flexibility in surface functionality, superior mechanical properties, stiffness and tensile strength, the capacity to be formed into a variety of shapes and the fact that they can be produced from a wide range of organic and inorganic polymers and ceramics. These days, electrospinning is used extensively in producing a variety of nanofibers. What makes electrospinning unique from other spinning methods is the electrostatic force stretching the polymer as it comes out of the spinneret and the transit time from spinneret to counter-electrode enabling the solvent to fully evaporate. With the ever increasing demand for novel materials, electrospun nanofibers are marking a new era in materials science. Some of the possible major fields of applications are tissue engineering, environmental engineering, biotechnology, medical sciences, energy, electronics, defense and security.

The history of electrospinning dates back to the nineteenth century. It was first observed by Rayleigh in 1897 and studied in detail by Zeleny with respect to electrospray techniques. Formhals patented electrospinning as a viable fibre-spinning technique in the 1930s. Thereafter, Taylor, Saville, Denn, and others made significant contributions to electrostatically driven jets and laid the groundwork for the electrospinning research that took place in the late 1960s and early 1970s. The statistics of publications demonstrates that electrospinning has attracted a significant attention in recent years (based on the Web of Knowledge Scholar search system). It is interesting enough that the IOP (Institute of Physics, UK) has been organizing conferences titled Electrospinning: Principles, Practices and Possibilities covering all aspects of electrospinning, and a fourth IOP conference is to be held in December 2015. In my opinion, it is not reinventing, rather, with the rapid development of nanotechnology, the use of electrospinning is revitalizing fiber production for research and commercial applications. The two most successful nanofiber producing companies in the US, eSpin Inc. and NanoStatics Corporation, are founded by two long term ESA members, Dr. Jayesh Doshi and Dr. John Robertson, respectively.

Electrospinning is a straightforward and inexpensive process that produces continuous nanofibers from submicron down to nanometer diameters. The process involves an electrically charged jet of polymer solution or polymer melt consisting of polymer molecules with a chain of sufficient length such that they do not break up due to Rayleigh instability. The surface of the fluid droplet held at the spinneret by its own surface tension becomes electrostatically charged with the application of high voltage. The interactions of the electrical charges in the polymer fluid with the external electric field result in the formation of the well-known Taylor cone. When the cone is subjected to a very strong electric field with an appropriate field gradient at the tip of the cone, the droplet becomes unstable, and a fluid jet is drawn out from the head of the Taylor cone. The travelling jet is subjected to a variety of forces including electrostatic (Coulombic), viscoelastic, gravitational, air drag and surface tension. The onset of a bending instability can be observed; creating a complex path for the jet and aiding in the evaporation of the solvent and shaping of the fibers.

(cont'd. p. 2)

President's Message (cont'd.)

Although studies have used single-needle schemes for electrospinning, high throughput requirements for industrial use are driving the need for new schemes. Electrospinning apparatuses include multi-needle systems, free-surface electrospinning systems, rotary electrospinning systems and melt electrospinning apparatuses for mass production of nanofibers. In principle, it is possible to obtain self-organized, multiple electrostatically driven jets from planar and cylindrical surfaces by applying very high electric fields.

During the recent ESA annual meetings we have had the opportunity to listen to speakers from around the world on electrospinning and its applications. Many deficiencies or limitations with current technologies and the potential uses of electrospinning were discussed. Examples include problems with membranes for air/water filtration, poorly soluble or insoluble drugs in water, batch processing from powdered ingredients in pharmaceutical industries, limitations with solid phase extraction, etc., and the potential solutions using electrospun materials.

If you missed ESA meetings, you are certainly missing a lot. I would like to encourage you to participate in our annual meetings to present and discuss during the forums, and submit articles for the ESA Newsletter. Our "Friendly Society" allows everyone, members and non-members, to enjoy the free access to ESA publications online. Please let other colleagues/friends know about this.

For the Friendly Society
Shesha Jayaram, *shesha.jayaram@uwaterloo.ca*
President, Electrostatics Society of America

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Calendar

- Electrospinning: Principles, Practices and Possibilities 2015 Conf., Hallam Conf. Centre,, London, UK, *http://electro15.iopconfs.org/* Contact: Dawn Stewart, *dawn.stewart@iop.org (abstracts due by Sept. 30, 2015)*
- 2016 Electrostatics Joint Conference, June 13-16, 2016, Purdue University, West Lafayette, IN, USA, *http://www.electrostatics.org/conferences.html* Contact: Raji Sundararajan, *rsundara@purdue.edu*
- IEEE 34th Electrical Insulation Conf (EIC), June 19-22, 2016, Montreal, Quebec, *http://sites.ieee.org/eic/* Contact: Bernard Noirhomme, *noirhomme.bernard@ireq.ca*
- 1st Int'l Conf. on Dielectrics (ICD), July 3-7, 2016, Montpellier, France, *http://www.ies.univ-montp2.fr/icd2016/* Contact: Jérôme Castellon, *chairman@icd-2016.org*
- XIV Int'l. Conf. on Electrostatic Precipitation (ICESP 2016), Sept. 19-23, 2016, Wroclaw, Poland, *http://www.icesp2016.pwr.edu.pl* Contact: Arkadiusz Świerczok, *icesp2016@pwr.edu.pl*

Electrostatic Attraction?

Longtime ESA member Professor Stuart Hoenig, Emeritus, from Arizona State Univ., is interested in learning whether anyone is interested in working with him on either of the following ideas:

1) New electrostatic methods for getting low cost fresh water out of the ocean. About 20 years ago a group showed that salt water contains many + ions of water. These ions are very sensitive to electric fields in the air above the surface. Applying a negative field brings them out of the water. A negative discharge gets rid of the + charge and the water drops can be condensed into drinking water. We built a system and showed that they were right. Water is real problem here in the West.

2) Improvement of drilling techniques. It seems that rocks have a large number of $+H_20$ ions. If you charge the drill to -25 volts the drops come up to the interface with the drill and speed up the drilling process about 25%. It even works for deep drilling of 25 feet.

If anyone would like to learn more, please contact Stuart at *hoenig@ece.arizona.edu* .

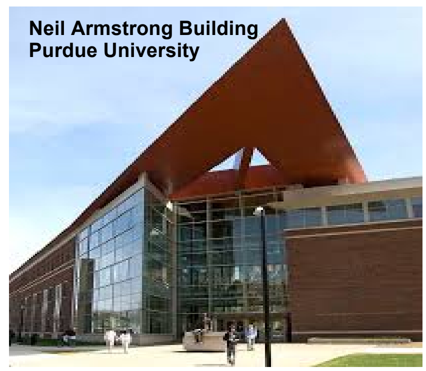
2016 Electrostatics Joint Conference

Purdue University
West Lafayette, Indiana, USA
June 14 - 16, 2016

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'Electrostatique (SFE) invite papers in all scientific and technical areas involving electrostatics. The scope of the conference ranges from the fundamental physics underlying electrostatics to applications in industry, atmospheric and space sciences, medicine, energy, and other fields. The meeting will bring together experts across the diverse field to present the latest developments in electrostatics.

Anticipated Technical Session Topics

- Atmospheric and space applications
- Biological and medical applications
- Breakdown phenomena, safety and hazards
- Contact charging and triboelectric effects
- Electrically-induced flows and electrokinetics
- Flows, forces and fields
- Gas discharges and microplasmas
- Electrospinning and material processing
- Measurements and instrumentation
- Particle control and charging



Conference information, including abstract submission, registration, student travel grants and lodging, will be updated and available at http://www.electrostatics.org

Student paper competition: Presentations by students (undergraduate and graduate) are eligible; please indicate participation when submitting abstract.

Important dates:
March 1, 2016 Abstract submission deadline (submit on-line at http://www.electrostatics.org)
March 17, 2016 Notification of paper acceptance
May 16, 2016 Final manuscripts due
June 13, 2016 Reception (6-9PM)
June 14, 2016 Conference begins (8AM)
June 16, 2016 Conference ends after evening banquet (7 PM – 10 PM)

Contact information:

For questions regarding the technical program and abstract submission, contact

Technical Chair: Dr. Keith Forward, California State Polytechnic University, Pomona, kmforward@cpp.edu, (909) 869-3621

For all other questions, contact

General Chair: Dr. Raji Sundararajan, Purdue University, raji@purdue.edu , (765) 494-6912

About Purdue University: The University is located at West Lafayette, 69 miles from Indianapolis and 144 miles from Chicago. With a student population of over 39,000, and alumni like Neil Armstrong, it is one of the best universities for Engineering and Sciences in the USA.

ESA 2015 Annual Meeting

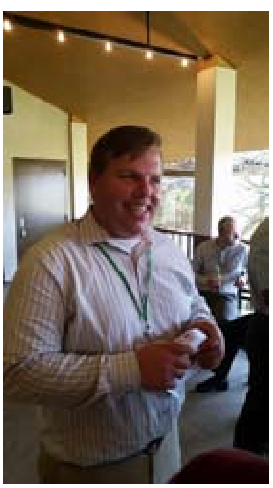
The 2015 Annual Meeting of the Electrostatics Society of America was held on the campus of California State Polytechnic University at Pomona (Cal Poly Pomona) at the Kellogg West Conference Center and Hotel. The conference center is set atop of a hill, overlooking the campus' Arabian horse pastures and wine vineyards. This was the first time the meeting was held on the West Coast since the 2006 meeting at University of California, Berkeley. Over 60 electrostatic experts and enthusiasts from eight different countries (Australia, Canada, Finland, Great Britain, Japan, New Zealand, Poland and the United States of American) attended the meeting. General Chair Prof. Keith Forward and Technical Chair Dr. Peter Ireland organized the meeting.

The technical program consisted of 48 oral presentations which were organized into 12 sessions. The meeting featured several keynote and invited talks. Keynote speaker Professor Zhong-Lin Wang of Georgia Institute of Technology presented a fascinating talk on the future of energy generation by means of triboelectrification. Professor Matti Murtomaa delivered a Keynote address on his latest development in producing a coaxial induction probe for measuring electrostatic charging in granular materials. In the Electrically-induced Flows and Electrokinetics session, Professor Leslie Yeo discussed his journey of developing microscale centrifugation and lab-on-a devices. In the growing field of electrospinning, Professor Woodrow explained how electrospun fibers are viable platforms for sustaining drug release of antivirals. As the "friendly society," the ESA continues to encourage student presenters to participate at the meeting. This year, nearly 44% of the technical talks were delivered by students. The conference provided them with a welcoming opportunity to present their latest research. First, second, and third place awards were given out to 24 students by a panel of judges.

One of the traditions of the ESA is the entertaining and educational post banquet talk. Professor Horenstein gave a wonderful presentation entitled "Series and Parallel." Special honors and recognitions were given at the banquet to John Robertson (ESA Honorary Life Member), Bruce T. William (ESA Lifetime Achievement) and Daniel J. Lacks (ESA President's Plaque). The organizers would like to thank the staff of the Kellogg West Conference Center and Hotel for their efforts to ensure that the meeting ran smoothly, and the students of the Forward Research Group at Cal Poly Pomona who helped with the organizing of the meeting. We would like to express deep appreciation to the sponsors of the meeting: Trek Inc. and Mystic Tan Inc.

The 2016 ESA annual meeting will be held at Purdue University from June 14-16th. Professor Raji Sundararajan will serve as General Chair and Professor Keith Forward will serve as technical chair.

Keith Forward, Conference General Chair



Kellogg Conference Center, Cal Poly Pomona

ESA 2015 Annual Meeting - Photo Collage

Banquet Speaker - Mark Horenstein

Banquet Talk Participation/Exploration

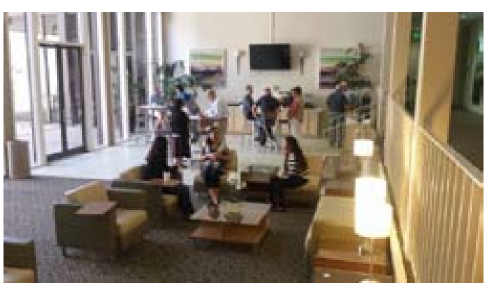
Banquet Speaker Demo Table

Banquet Award Presentation to John Robertson

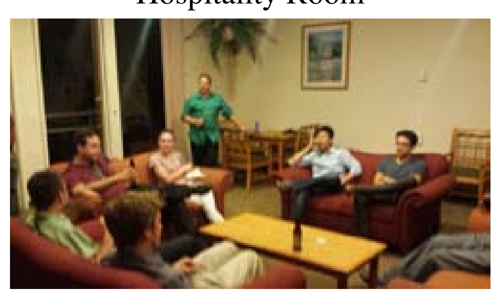
Off-site Brainstorming Location

Student Paper Competition Winners

Break Time!!



Hospitality Room



More pictures may be found at *http://electrostatics.us/esa/2015/page_01.htm*
Many thanks to Al Seaver for downloading and archiving these photos.

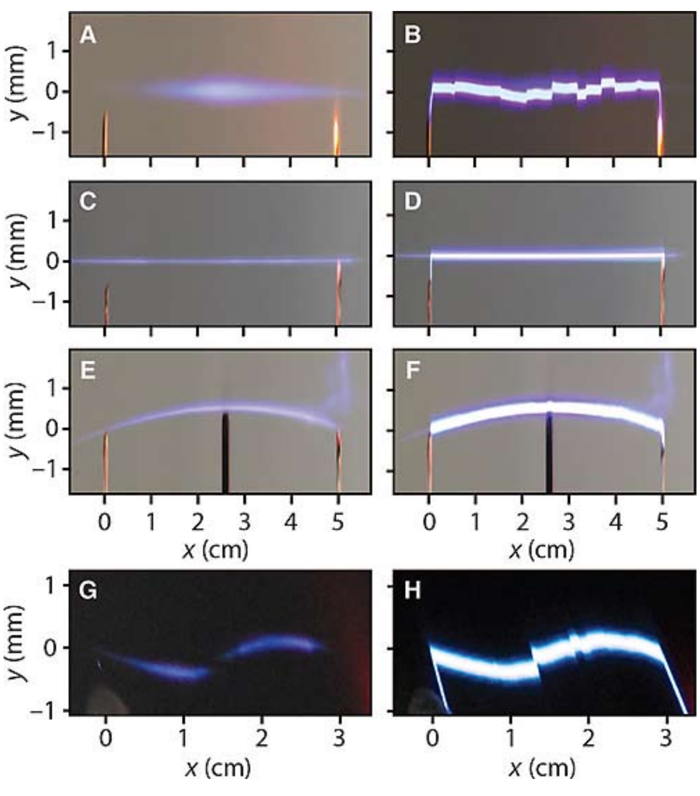
Could we one day control the path of lightning?

Stéphanie Thibault

Using the Advanced Laser Light Source (ALLS) facility, researchers from the INRS Énergie Matériaux Télécommunications research centre tackled this challenge, which had previously been the subject of intensive research, particularly in the 1970s.

Electric arcs have long been used in such technologies as combustion engines, pollution control applications, lighting, machining and micromachining. Potential applications could multiply with the ability to precisely control the path they take. A first step in this direction has been made and research into the new possibilities and parameters for guiding electric arcs promises to spark researchers' creativity.

Recent scientific and technical advances, as well as the ingenuity of Professor Morandotti's team (particularly researcher Matteo Clerici, a postdoctoral fellow with the research group at the time of the experiments), set the stage for this spectacular demonstration, where we see an electric charge follow a smooth path along a straight or parabolic trajectory.

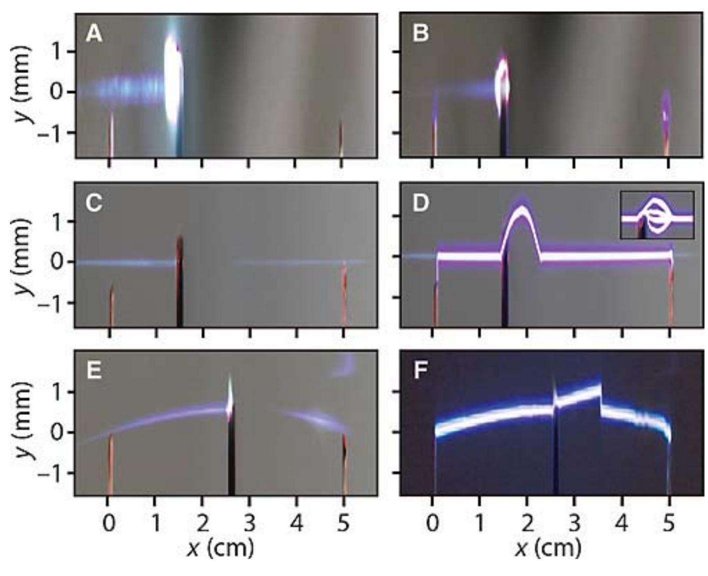


Different shapes of discharge achieved based on the type of beam used. A and B: Gaussian beam (control). C and D: Bessel beam. E and F: Airy beam. G and H: S-shaped beam obtained by combining two conventional Airy beams. Left: Photographs taken when no voltage is applied (only the laser beam is visible). Right: Discharge in the presence of high voltage between the two electrodes.

Experimental figures show how different shaped lasers give discharges distinct properties and trajectories. By combining beams, it is even possible to achieve an S-shaped trajectory, with all other kinds of trajectory achievable in principle.

In his bold quest for knowledge, Professor Morandotti wanted to determine whether the self-healing properties of certain shapes of laser beams (such as Airy and Bessel beams) could be put to use in these new experiments. This attribute means that a laser beam whose intensity peak is blocked by an obstacle can reconstruct itself once past the object. Professor Morandotti's team placed an object between the two electrodes and observed that the discharge leapt over the obstacle, without damaging it, and returned to its laser guide on the other side.

"Our fascination with lightning and electric arcs aside, this scientific discovery holds out significant



A and B: Gaussian beam (control). C and D: Bessel beam. E and F: Airy beam. Left: Laser beam with no voltage applied in the presence of an obstacle. Right: For both the Bessel and Airy beams, the discharge follows the laser and circumvents the obstacle before reconstructing itself. The inset in D is a multi-shot photo of the various trajectories the discharge take around the obstacle before converging on a single rectilinear trajectory.

potential and opens up new fields of research," said Yves Bégin, vice dean of research and academic affairs at INRS. "This spectacular proof of concept, which was conducted over a distance of a few centimetres, required the high-power lasers, state-of-the-art facilities, and extraordinary research environment that our professors helped to create at INRS. Being able to work in such cutting-edge labs enables our students and postdoctoral fellows to embark on the path of scientific discovery even while still in school."

(from *http://www.inrs.ca/english/actualites/could-we-control-path-lightning?*)

Electric fields signal 'no flies zone'

A new piece of research led by the University of Southampton has found that the behaviour of fruit flies, which are commonly used in laboratory experiments, is altered by electric fields. The research indicates that the wings of the insects are disturbed by static electric fields, leading to changes in avoidance behaviour and the neurochemical balance of their brains.

The paper, published in the Proceeding of the Royal Society B, suggests that the plastic housing laboratory fruit flies are commonly kept in (which hold their own static electric charge) could agitate the flies, changing their behaviour and neurochemical profile which has the potential to impact or confound other studies for which they are being used.

"Fruit flies are often used as model organisms to understand fundamental problems in biology," say Professor Philip Newland, Professor of Neuroscience at the University of Southampton and lead author of the study. "75 per cent of the genes that cause disease in humans are shared by fruit flies, so by studying them we can learn a lot about basic mechanisms.

"Plastic can retain a charge for a long period and, given the use of plastic in the rearing of these insects and other small insects such as mosquitoes, long term exposure to these fields is inevitable."

The researchers put fruit flies in a Y-shaped maze, with one arm of the maze exposed to an electric charge and the other receiving none. They found that the flies avoided the charged chamber and gathered in the non-charged arm. Interestingly flies with no wings didn't display this behaviour, and flies with smaller wings only avoided higher charges - suggesting it is the wings of the fly that are involved in detection and are affected by the fields.

This was borne out when subjecting stationary flies to electric fields. The researchers observed that the wings of the flies could be manipulated by a field of a similar strength to that which produced the avoidance behaviour. Professor Newland explains: "When a fly was placed underneath a negatively charged electrode, the static field forces caused elevation of the wings toward the electrode, as opposite charges were attracted. Static electric fields are all around us but for a small insect like a fruit fly it appears these fields' electrical charges are significant enough to have an effect on their wing movement and this means they will avoid them if possible."

The effect on the wings being moved seems to agitate the flies, as revealed by changes in their brain chemistry. Flies exposed to an electric field showed increased levels of octopamine (similar to noradrenaline in humans) which indicates stress and aggression. The flies also showed decreased levels of dopamine, meaning they would be more responsive to external stimuli. As well as having consequences for flies used in laboratories, the results also have implications for flies in their natural environment.

"We are particularly interested in how electric fields could be used in pest control," says co-author Dr Christopher Jackson, also of Southampton. "Meshes that can generate static electric fields could be put across windows of houses or green houses to prevent insects like fruit flies or even mosquitoes entering, yet allow air movement." "It also raises questions of how pollinating species like bees could be affected by power lines, which have stronger electric fields."

(from *http://www.southampton.ac.uk/news/2015/07/electric-fields-signal-no-flies-zone.page?*)

Electrospray Solves Longstanding Problem in Langmuir-Blodgett Assembly

Amanda Morris

In the 1930s, Irving Langmuir and his colleague Katharine Blodgett were working long days in the General Electric Company's research laboratory. Together, they discovered that by spreading molecules with volatile organic solvents on the surface of water, they could create a one-molecule-thick film and use it as an anti-reflective coating for glass. Later named Langmuir-Blodgett assembly, this thin-film fabrication technique became popular for creating molecule or nanoparticle monolayers and is commonly used until this day.

Since Langmuir-Blodgett assembly was first reported more than 80 years ago, numerous applications have been demonstrated. Yet the technique itself and the accompanying procedure have remained largely unchanged.

Now Northwestern Engineering's Jiaxing Huang has advanced this old technique. By electrospraying materials on water's surface, he has found a way to avoid the use of toxic organic solvents while making Langmuir-Blodgett assembly more efficient, easier to standardize, and safer to scale up.

"The use of organic spreading solvents causes a lot of problems, especially when people use this technique to assemble thin films of nanomaterials," said Huang, associate professor of materials science and engineering at the McCormick School of Engineering. "Nanoparticles are usually hard to disperse and can even be damaged by the solvents, leading to poor quality of the final monolayer thin films."

Compared to other thin-film fabrication techniques, Langmuir-Blodgett assembly has unique advantages, including its fine control over the packing density in the monolayer, which can stack up to form films with precise number of layers. This only works, however, if the nanoparticles are well dispersed in both the spreading solvents and on the water's surface.

"This is quite challenging," Huang said. "It requires a very delicate balance of surface properties for nanoparticles to be well dispersed on water's surface and in those water-hating solvents."

"There are also other problems," said Hua-Li Nie, a former visiting scholar in Huang's lab from Donghua University and the paper's first author. "Nanoparticles made of polymers, organic compounds, or biological materials tend to be damaged in organic spreading solvents."

"These volatile organic solvents also pose a safety hazard," Huang added. "It becomes problematic when we think about manufacturing."

Using a water-soluble, benign solvent, such as ethanol, to spread the nanoparticles avoids all of these problems except one: the solvent mixes with water, causing the particles to sink.

"People have come up with many tricks to deal with this problem of sinking particles," Huang said. "One way is to very gently disperse ethanol on water's surface to avoid excessive mixing, but there is still a lot of wasted material."

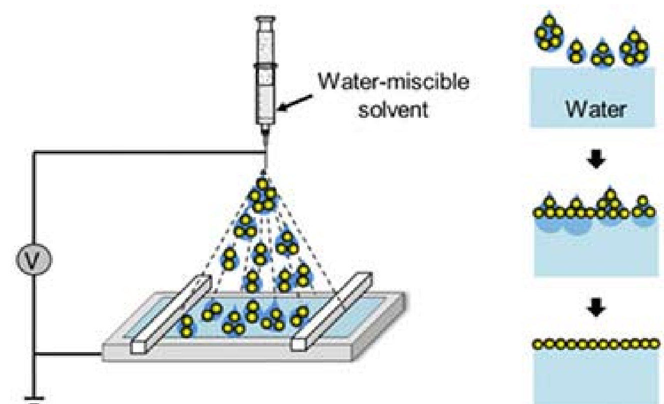
Huang's group even used this strategy to demonstrate Langmuir-Blodgett assembly of graphene oxide sheets, which was featured on the cover of JACS in 2009.

Huang discovered that he could prevent the solvent from mixing with the water by applying it with an aerosol spray. The spray breaks the solvent, which contains the nanoparticles, into millions of smaller droplets.

"If you reduce the size of the droplets to the micron range, they won't 'bombard' the water's surface," Huang said. "Think about a humidifier: the water droplets float around because they are not very sensitive to gravity."

More importantly, because of their very small volume, by the time the droplets spread on the water, they are consumed immediately. "Mixing with water is suppressed because there's nothing left to mix," Huang said.

With electrospray, one does not have to rely on "skillful hands" to perform good Langmuir-Blodgett assembly. Huang said electrosprays can be automated



Using an elecrospray can spread a water-soluble solvent with nanoparticles onto water's surface without mixing.

to standardize and scale up this technique for manufacturing. Not only would this save time and money, it is also much safer. Many of the popularly used organic spreading solvents, such as chloroform, are toxic. This requires the water trough to be kept in a controlled environment, which can be costly to construct and maintain as well as dangerous. Now researchers can choose any type of benign liquid as a solvent.

"We've broadened the landscape for Langmuir-Blodgett assembly," Huang said. "A very simple idea — reducing the droplet's size — has solved a long-standing problem for an old but popular technique."

(from *http://www.mccormick.northwestern.edu/news/articles/2015/08/electrospray-solves-longstanding-problem-in-langmuir-blodgett-assembly.html?*)

Researchers identify electrifying solution to sticky problem

Inspired by the limitations of biomimetic glues in wet environments, scientists from Nanyang Technological University, Singapore (NTU Singapore) have invented a glue that will harden when a voltage is applied to it. This opens a plethora of commercially promising advances such as: 1) using the adhesive to glue metal panels under water, for example, in underwater pipe repairs, 2) replacing sutures when there is a need to join body tissues together during surgery, 3) tailoring the properties of the adhesive to be more gel-like or rubber-like which would work well in vibrating or damp environments

"We had to find a way to make glue which cures (hardens) when we want it without being affected by the environmental conditions, so electricity was the best approach for us. The hardness of our glue can be adjusted by the amount of time we apply a voltage to it, which we call electrocuring." This unique electrocuring property allows Voltaglue to be customized for different applications.

"For example, if we are gluing metal panels underwater, we want it hard enough to stick for a long time. However, for medical applications, we want the glue to be more rubber-like so it wouldn't cause any damage to the surrounding soft tissues," Assistant Professor Steele explained.

Voltaglue is developed using hydrogels consisting of carbon molecules called carbenes grafted onto tree-shaped plastic known as dendrimers. Upon contact with electricity, the reactive carbenes, which are capable of hooking onto any surface nearby, are released. The amount of "hooks" created depends on how long electricity is applied and how many carbenes are present. Another distinct feature of the new glue is that it could be made reversible.

Glues which can cure and be subsequently un-cured through electricity would be the industry's "Holy Grail", as automakers and shipyards will be able to assemble and dissemble parts with ease, minimizing the need for fixation by bolts, nuts and screws. Moving forward, Steele and his team of 11 researchers are working to improve their new electrocuring glue so it can harden in just a few seconds, compared to about 30 seconds now; and also working on a way to undo the process.

(excerpted from *http://www.rdmag.com/news/2015/08/researchers-identify-electrifying-solution-sticky-problem*)

Be at war with your vices, at peace with your neighbors, and let every new year find you a better man.
Benjamin Franklin

supplied by Glenn Schmeig

ESA Information

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