May/Jun 2016 • No. 236

ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Our society remains committed to its mission to promote electrostatics through publications, scholarly conferences, students participation and education The fourth Joint Electrostatics Conference organized by the Electrostatic Society of America (ESA) on Purdue University (PU) campus in West Lafayette was a great success. Thank you ESA and the other sponsoring societies; Institute of Electrostatic Japan (IEJ), the IEEE Industry Applications Society (IAS) Electrostatic Processes Committee (EPC), and La Societé Francaise d'Electrostatique (SFE), and Purdue University. In specific, thank you Prof. Touchard, Prof. Okubo and Prof. Takashima; ESA executives and the ESA council members for your support.

The following bullets briefly summarize the technical and non-technical activities of the conference at a glance. It was all possible due to the enormous efforts from both the technical program chair Prof. Keith Forward and the conference general chair Prof. Raji Sundararajan. Thank you Raji and Keith for your excellent work.

• Conference was attended by people around the world representing more than 14 countries. There were 32 student presentations spread in both poster and oral sessions, making up 1/3rd of the program. Keynote and invited talks enriched the attendees, covering many aspects of fundamentals and applications of electrostatics. Thanks to all the authors/presenters/session chairs/ judges and the audience for creating a rich scientific forum over 3 full days with a truly diverse international representation.

• Both on-campus and off campus housing facilities were arranged by Raji providing great options for everyone based on their needs and budgets. A wide variety of food selections for lunches, mixed with an Indian spicy flavored lunch on Wednesday, were worth the walking. Thanks to PU dining hall coordinators.

• Prof. Kaz Adamiak from the University of Western Ontario, London, Canada received the Lifetime Achievement Award for his outstanding contributions to the field of Electrostatics, especially in the field of computational electromagnetics. Congratulations Kaz - we missed you at the meeting.

• This year photos were taken by Tejas, Vishwa and compiled by Rajnish from PU. The link to these photos is *http://electrostatics.us/esa/2016/page_01.htm*. Thank you all for this great work and helping everyone during the conference.

• Mystic Tan Inc., and Trek Inc. sponsorships are much appreciated and were used towards the student paper awards. This year, ESA provided additional funds to support the large participation of students. I would like to thank the ESA executives, council members, Dan Lacks (past president) and Kelly Robinson for your help in establishing these new funds to support the students' participation.

• In parallel with the poster session we had a great electrostatics demo session thanks to Mark Horenstein, Bill Vosteen and Kelly Robinson. A special thanks to Kelly for organizing the session.

• The conference officially ended on Thursday evening. Mark made the evening joyful with his slide show presentation of dropping cats, organizing simple games for everyone, and filling in for the ESA president (it is me!) telling jokes. Thank you Mark.

• Thank you Raji for organizing the Chicago trip which was wonderful and memorable. We all had a great time.

I am very happy to share this good news - next year we are going to meet in Ottawa, the Capital city of Canada. Poupak Mehrani from University of Ottawa, and Shubho Banerjee from Rhodes College, Memphis have volunteered to chair the 2017 ESA conference and the technical program respectively. Thank you Poupak and Shubho.

I would like to thank Steve Cooper, Mark Zaretsky, and Maciej Noras for their hard work in financially keeping the society healthy, timely publications of ESA Newsletters with resourceful information, and chairing the awards nomination committee. Special thanks to Kelly for filling in for Steve Cooper.

(cont'd. p. 2)

President's Message (cont'd.)

Finally, I would like to invite you to get involved with ESA, and share your vision through e-mails, newsletter articles, website, conferences, and special events like the demos.

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

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Maciej Noras, Univ. of North Carolina
Executive Council:
David Go, Univ. of Notre Dame
Poupak Mehrani, Univ. of Ottawa
Rajeswari Sundararajan, Purdue Univ.

Calendar

- STEP-2, 2nd Int'l Workshop on Static-Tribo-Electricity of Powder, August 4-6, 2016, Compiègne, France, *http://www.t.soka.ac.jp/powder/STEP2/index.html*
- SFE-2016, August 29-31, 2016, Poitiers, France, *http://sfe2016.conference.univ-poitiers.fr/en/* Contact: Thierry Paillat (*thierry.paillat@univ-poitiers.fr*)or Gérard Touchard (*gerard.touchard@univ-poitiers.fr*)
- 38th Annual EOS/ESD Symposium, Sept. 11-16, 2016, Garden Grove, California *https://www.esda.org/events/eosesd-symposia/symposia/?utm_content=ed5cad18ba077c3aeb23013de9cbe3a9&utm_campaign=2016%20Symposium%20Call%20for%20Papers&utm_source=Robly.com&utm_medium=email* Contact: *info@esda.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*
- CEIDP, Conf. on Elec. Insul. & Diel. Phen., Oct. 16-19, 2016, Toronto, Canada, *http://sites.ieee.org/ceidp/2016-ceidp-info/* Contact: Resi Zarb, *rzarb@irispower.com*
- Electrostatics 2017, April 10-13, 2017, Frankfurt/Main, Germany, *http://www.dechema.de/en/electrostatics2017.html* Contact: Nadja Strein, *strein@dechema.de*
- ESA 2017 Annual Meeting, June 2017, University of Ottawa, Ottawa, Ontario, Canada *http://www.electrostatics.org* Contact: Poupak Mehrani, *poupak.mehrani@uottawa.ca*

Current Events

Novel environmentally friendly advertising display uses low power electrostatics and recyclable ink

The Tony Davies High Voltage Laboratory (TDHVL) at the University of Southampton has developed a novel electrostatic technique for the SPABRINK Eu project partnership. The project uses dielectrophoretic forces produced at the surface of a polymer foil to pin coloured ink powder particles in position to form an image.

According to Project Leader Balázs Ring of ATEKNEA Solutions Ltd,, Hungary, "The SPABRINK project uses an innovative combination of existing and new technologies. The technology will allow remotely controlled printing of large area adverts like bill boards. The printed image can be wiped off and the ink can be re-used after separation. The end result is a new advertising tool that is controlled remotely to display different images periodically without creating waste. It will only use energy during image change and could be powered by a battery and solar panel".

The SPABRINK technology uses a seven coloured powder printer deposited onto an electrostatic surface through a novel piezoelectric ceramic printing head developed by CERC (Hungary). A special electrode structure in the foil creates intense electrostatic fields at the surface to pin the powder in position on a vertical surface for viewing. The goal of this project is to produce a cost effective and environmentally friendly Real-time Outdoor Media tool which can give the same visual effect as a paper based billboard, but without the use of pre-printed paper with one-time-use ink and glue. The SPABRINK consortium includes four media partners Studio Itinerante Arquitectura S.L. (SIARQ), ImpactMedia S A, X-Treme Holding BV and Index Kommunikációs Kft. (Hungary) who will market and use the technology.

Professor Paul Lewin of TDHVL said "This project has presented a range of unusual challenges that have been successfully tackled by the Southampton team; our expertise in high voltage engineering and electrostatic phenomena has contributed to the development of a novel printing technology that could find wide application around the world."

(from *http://www.pressbox.co.uk/Media/Novel_environmentally_friendly_advertising_display_uses_low_power_electrostatics_and_recyclable_ink_1608160.html*)

Harnessing the energy of small bending motions

David L. Chandler

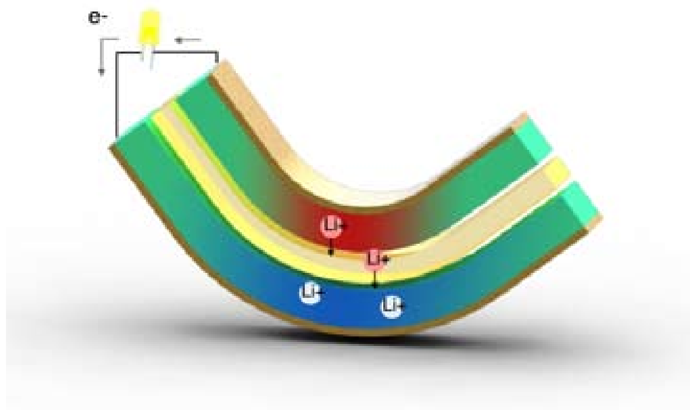
For many applications such as biomedical, mechanical, or environmental monitoring devices, harnessing the energy of small motions could provide a small but virtually unlimited power supply. While a number of approaches have been attempted, researchers at MIT have now developed a completely new method based on electrochemical principles, which could be capable of harvesting energy from a broader range of natural motions and activities, including walking.

The new system, based on the slight bending of a sandwich of metal and polymer sheets, is described in the journal Nature Communications, in a paper by MIT professor Ju Li, graduate students Sangtae Kim and Soon Ju Choi, and four others.

Most previously designed devices for harnessing small motions have been based on the triboelectric effect (essentially friction, like rubbing a balloon against a wool sweater) or piezoelectrics (crystals that produce a small voltage when bent or compressed). These work well for high-frequency sources of motion such as those produced by the vibrations of machinery. But for typical human-scale motions such as walking or exercising, such systems have limits. "When you put in an impulse" to such traditional materials, "they respond very well, in microseconds. But this doesn't match the timescale of most human activities," says Li, who is the Battelle Energy Alliance Professor in Nuclear Science and Engineering and professor of materials science and engineering. "Also, these devices have high electrical impedance and bending rigidity and can be quite expensive," he says.

By contrast, the new system uses technology similar to that in lithium ion batteries, so it could likely be produced inexpensively at large scale, Li says. In addition, these devices would be inherently flexible, making them more compatible with wearable technology and less likely to break under mechanical stress.

While piezoelectric materials are based on a purely physical process, the new system is electrochemical, like a battery or a fuel cell. It uses two thin sheets of lithium alloys as electrodes, separated by a layer of porous polymer soaked with liquid electrolyte that is efficient at transporting lithium ions between



the metal plates. But unlike a rechargeable battery, which takes in electricity, stores it, and then releases it, this system takes in mechanical energy and puts out electricity. When bent even a slight amount, the layered composite produces a pressure difference that squeezes lithium ions through the polymer (like the reverse osmosis process used in water desalination). It also produces a counteracting voltage and an electrical current in the external circuit between the two electrodes, which can be then used directly to power other devices.

Because it requires only a small amount of bending to produce a voltage, such a device could simply have a tiny weight attached to one end to cause the metal to bend as a result of ordinary movements, when strapped to an arm or leg during everyday activities. Unlike batteries and solar cells, the output from the new system comes in the form of alternating current (AC), with the flow moving first in one direction and then the other as the material bends first one way and then back.

This device converts mechanical to electrical energy; therefore, "it is not limited by the second law of thermodynamics," Li says, which sets an upper limit on the theoretically possible efficiency. "So in principle, [the efficiency] could be 100 percent," he says. In this first-generation device developed to demonstrate the electrochemomechanical working principle, he says, "the best we can hope for is about 15 percent" efficiency. But the system could easily be manufactured in any desired size and is amenable to industrial manufacturing process.

The test devices maintain their properties through many cycles of bending and unbending, Li reports, with little reduction in performance after 1,500 cycles. "It's a very stable system," he says.

Previously, the phenomenon underlying the new device "was considered a parasitic effect in the battery community," according to Li, and voltage put into the battery could sometimes induce bending. "We do just the opposite," Li says, putting in the stress and getting a voltage as output. Besides being a potential energy source, he says, this could also be a complementary diagnostic tool in electrochemistry. "It's a good way to evaluate damage mechanisms in batteries, a way to understand battery materials better," he says.

In addition to harnessing daily motion to power wearable devices, the new system might also be useful as an actuator with biomedical applications, or used for embedded stress sensors in settings such as roads, bridges, keyboards, or other structures, the researchers suggest.

(excerpted from *http://news.mit.edu/2016/harnessing-energy-bending-motions-0106*)

Power walk: Footsteps could charge mobile electronics

Adam Malecek

When you're on the go and your smartphone battery is low, in the not-so-distant future you could charge it simply by plugging it into your shoe. An innovative energy harvesting and storage technology developed by University of Wisconsin–Madison mechanical engineers could reduce our reliance on the batteries in our mobile devices, ensuring we have power for our devices no matter where we are.

In a paper published Nov. 16, 2015, in the journal Scientific Reports, Tom Krupenkin, a professor of mechanical engineering at UW–Madison, and J. Ashley Taylor, a senior scientist in UW–Madison's Mechanical Engineering Department, described an energy-harvesting technology that's particularly well suited for capturing the energy of human motion to power mobile electronic devices. The technology could enable a footwear-embedded energy harvester that captures energy produced by humans during walking and stores it for later use.

"Human walking carries a lot of energy," Krupenkin says. "Theoretical estimates show that it can produce up to 10 watts per shoe, and that energy is just wasted as heat. A total of 20 watts from walking is not a small thing, especially compared to the power requirements of the majority of modern mobile devices." Krupenkin says tapping into just a small amount of that energy is enough to power a wide range of mobile devices, including smartphones, tablets, laptop computers and flashlights. For example, a typical smartphone requires less than two watts. However, traditional approaches to energy harvesting and conversion don't work well for the relatively small displacements and large forces of footfalls, according to the researchers. "So we've been developing new methods of directly converting mechanical motion into electrical energy that are appropriate for this type of application," Krupenkin says.

The researchers' new energy-harvesting technology takes advantage of "reverse electrowetting," a phenomenon that Krupenkin and Taylor pioneered in 2011. With this approach, as a conductive liquid interacts with a nanofilm-coated surface, the mechanical energy is directly converted into electrical energy. The reverse electrowetting method can generate usable power, but it requires an energy source with a reasonably high frequency — such as a mechanical source that's vibrating or rotating quickly. "Yet our environment is full of low-frequency mechanical energy sources such as human and machine motion, and our goal is to be able to draw energy from these types of low-frequency energy sources," Krupenkin says. "So reverse electrowetting by itself didn't solve one of the problems we had."

To overcome this, the researchers developed what they call the "bubbler" method, which they described in their Scientific Reports study. The bubbler method combines reverse electrowetting with bubble growth and collapse. The researchers' bubbler device — which

A shoe sole with an embedded energy harvester sits next to a first practical footwear energy harvester developed by the UW–Madison researchers' startup company, InStep NanoPower, and Vibram. PHOTO: UW–MADISON COLLEGE OF ENGINEERING contains no moving mechanical parts — consists of two flat plates separated by a small gap filled with a conductive liquid. The bottom plate is covered with tiny holes through which pressurized gas forms bubbles. The bubbles grow until they're large enough to touch the top plate, which causes the bubble to collapse. The speedy, repetitive growth and collapse of bubbles pushes the conductive fluid back and forth, generating electrical charge. "The high frequency that you need for efficient energy conversion isn't coming from your mechanical energy source but instead, it's an internal property of this bubbler approach," Krupenkin says.

The researchers say their bubbler method can potentially generate high power densities — lots of watts relative to surface area in the generator — which enables smaller and lighter energy-harvesting devices that can be coupled to a broad range of energy sources.

The proof-of-concept bubbler device generated around 10 watts per square meter in preliminary experiments, and theoretical estimates show that up to 10 kilowatts per square meter might be possible, according to Krupenkin. "The bubbler really shines at producing high power densities," he says. "For this type of mechanical energy harvesting, the bubbler has a promise to achieve by far the highest power density ever demonstrated."

Krupenkin and Taylor are seeking to partner with industry and commercialize a footwear-embedded energy harvester through their startup company, InStep NanoPower. Their harvester could directly power various mobile devices through a charging cable, or it could be integrated with a broad range of electronic devices embedded in a shoe, such as a Wi-Fi hot spot that acts as a "middleman" between mobile devices and a wireless network. The latter requires no cables, dramatically cuts the power requirements of wireless mobile devices, and can make a cellphone battery last 10 times longer between charges.

(excerpted from *http://news.wisc.edu/power-walk-footsteps-could-charge-mobile-electronics/*)

Nanotubes assemble! Rice introduces 'Teslaphoresis'

Mike Williams

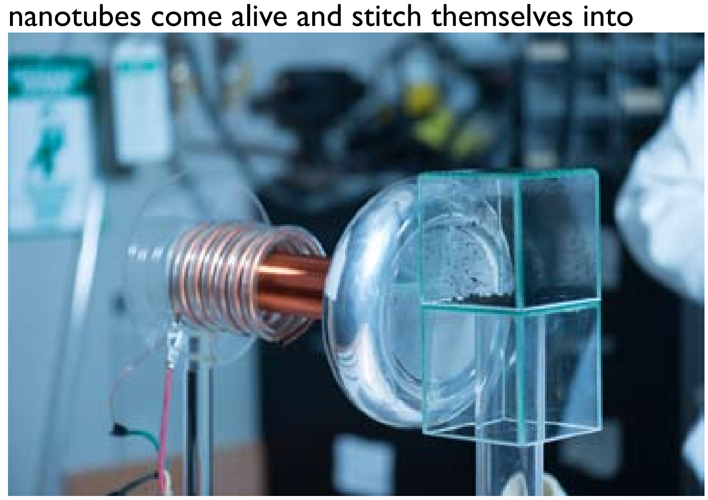
Scientists at Rice University have discovered that the strong force field emitted by a Tesla coil causes carbon nanotubes to self-assemble into long wires, a phenomenon they call "Teslaphoresis." The team led by Rice chemist Paul Cherukuri reported its results in ACS Nano. Cherukuri sees this research as setting a clear path toward scalable assembly of nanotubes from the bottom up.

The system works by remotely oscillating positive and negative charges in each nanotube, causing them to chain together into long wires. Cherukuri's specially designed Tesla coil even generates a tractor beam-like effect as nanotube wires are pulled toward the coil over long distances.

This force-field effect on matter had never been observed on such a large scale, Cherukuri said, and the phenomenon was unknown to Nikola Tesla, who invented the coil in 1891 with the intention of delivering wireless electrical energy. "Electric fields have been used to move small objects, but only over ultrashort distances," Cherukuri said. "With Teslaphoresis, we have the ability to massively scale up force fields to move matter remotely."

The researchers discovered that the phenomenon simultaneously assembles and powers circuits that harvest energy from the field. In one experiment, nanotubes assembled themselves into wires, formed a circuit connecting two LEDs and then absorbed energy from the Tesla coil's field to light them.

Cherukuri realized a redesigned Tesla coil could create a powerful force field at distances far greater than anyone imagined. His team observed alignment and movement of the nanotubes several feet away from the coil. "It is such a stunning thing to watch these nanotubes come alive and stitch themselves into



Nanotube assemblies are drawn to the source of a Tesla field in an experiment at a Rice University lab. (Credit: Jeff Fitlow/Rice University) wires on the other side of the room," he said.

Nanotubes were a natural first test material, given their heritage at Rice, where the HiPco production process was invented. But the researchers envision many other nanomaterials can be assembled as well.

Lindsey Bornhoeft, a biomedical engineering graduate student at Texas A&M University, said the directed force field from the bench-top coil at Rice is restricted to just a few feet. To examine the effects on matter at greater distances would require larger systems that are under development. Cherukuri suggested patterned surfaces and multiple Tesla coil systems could create more complex self-assembling circuits from nanoscale-sized particles.

Cherukuri and his team self-funded the work, which he said made it more meaningful for the group. "This was one of the most exciting projects I've ever done, made even more so because it was an all-volunteer group of passionate scientists and students. But because Rice has this wonderful culture of unconventional wisdom, we were able to make an amazing discovery that pushes the frontiers of nanoscience."

The teammates look forward to seeing where their research leads. "These nanotube wires grow and act like nerves, and controlled assembly of nanomaterials from the bottom up may be used as a template for applications in regenerative medicine," Bornhoeft said. "There are so many applications where one could utilize strong force fields to control the behavior of matter in both biological and artificial systems," Cherukuri said. "And even more exciting is how much fundamental physics and chemistry we are discovering as we move along. This really is just the first act in an amazing story."

(excerpted from *http://news.rice.edu/2016/04/14/nanotubes-assemble-rice-introduces-teslaphoresis/*)

Bee-sized drones use static electricity to perch like bats

Engineers have invented tiny drones that use the power of static cling to attach themselves under almost any surface — wood, glass and even leaves. That could enable them to observe an area from a high vantage point while consuming almost no power, allowing them to work for much longer before recharging their batteries.

Flying "microbots" like the RoboBee, invented by researchers at Harvard University, have a lot of advantages over bigger drones, says Robert Wood, an engineering professor at the university's John A. Paulson School of Engineering and Applied Sciences. "They're agile, they can fit into small nooks and crannies, you can have a lot of them operating simultaneously to have greater coverage," he said in a video explaining the new development, "but the drawback is they're very inefficient at flying." Because of that, drones weighing less than two kilograms can't usually fly longer than an hour.

Flying animals such as birds, bats, bees and butterflies conserve energy by stopping and perching from time to time. But the way they do it, by latching on to things with feet and claws, for example, is difficult to apply to drones.

Previous perching robots developed by scientists and engineers have used spines to stick to certain kinds of surfaces or magnets to attach to certain metals. That limits the kinds of places they can attach to, and may make it difficult for the robot to take off again.

Woods and his team came up with a different approach — they equipped the RoboBee with an electrode patch that allows it to use static electricity to stick to surfaces, the way a balloon sticks to a wall after you rub it on your hair. A foam patch keeps it from bouncing off the surface as it attaches. Detaching is simple — the robot just cuts power to the electrode so it no longer sticks.

"The low disengagement forces are really important because they enable future prototypes of the robot to land somewhere and not only stay there and

The RoboBee uses electrostatic attraction to stick itself under almost any surface, including wood, glass and even leaves. (Harvard University) use the high vantage point for observation, but also to reposition itself and return to an operator with collected data," said Moritz Alexander Graule, first author of a study describing the research,

The RoboBee has a wingspan of just 36 millimetres and weighs less than 100 milligrams including the patch — about the mass of a small bumblebee. In order to generate enough static electricity to stick to a surface, it uses just a thousandth of the energy required to hover for the same length of time.

At the moment, the patch is attached to the top of the RoboBee, so it can only land and perch on ceilings and under overhangs, like a bat. But the team is working on a design that will allow future versions to perch on any surface.

(excerpted from *http://www.cbc.ca/news/technology/robobee-perch-1.3589578*)

Flowers give off electrical signals to bees

Elizabeth Shockman

Bumblebees use a lot of tools to find nectar in flowers like visual cues and chemical signs. But, as it turns out, they're also able to detect weak electrical signals that flowers give off. "We're not talking about color, we're talking about a static electrical field — the same thing as when you charge up a balloon on your head," explains biomechanics engineer Gregory Sutton. "There is a static electrical charge that pulls on the hair on your head and the static electric charge on a flower's petals pulls on the hair on the bumblebee, and that allows the bumblebee to tell how much charge is on a flower's petals."

Sutton and sensory biophysics researcher Erica Morley recently reported their findings about bees' ability to sense electric signals in Proceedings of the National Academy of Sciences. "What we found in bees is that they're using a mechanic receptor," Morley says. "It's not a direct coupling of this electrical signal to the sensory system. They're using mechanical movement of hair in a very non-conductive medium. Air doesn't conduct electricity very well — it's very resistive. So these hairs have moved in response to the field, which then causes the nerve impulses from the cells at the bottom of the hair."

Sutton and Morley made their discovery after putting bees through an experiment. They built 10 flowers with the same shape, size and smell. They put sugar water on some of the flowers and then added small static electric fields to those flowers. On the rest of the flowers, they put bitter water and no electric field. They let the bees loose among the flowers and kept moving the flowers around so the bees couldn't learn the location of the sugar water.

"As they forage, they start to go to the flowers with the sugar water 80 percent of the time," Sutton says. "So you know they've figured out the difference between the two sets of flowers. The last step is you just turn off the voltage and then check to see if they can continue telling the difference. And when we turned off the voltage, they were unable to tell the difference. And that's how we knew it was the voltage itself that they were using to tell the difference between the flowers."

Sutton says flowers' electrical charge is distributed on the plant's petals. "It's a very small electrical field, which is why we're quite astounded that bees can actually detect it," Sutton says. "[And] there is different charge distribution at different locations on the petals of different species of flowers. So two flowers of the same species will have a similar electric field, whereas two flowers of a different species will have different electric fields."

Scientists say bees are capable of remembering locations, so Sutton and Morley think bees use electric fields more for identification purposes than for navigation or locating flowers. "They're not competing for attention — the flowers are identifying themselves like an advertising brand," Sutton says. "The buttercup is telling the bee, 'I'm a buttercup,' using its scent, using its shape, using its color. And the electric field is another way that the flower is branding itself so that bees can very easily identify it from far away … The bee remembers the location where the flowers are. The electric field is more for identification instead of location."

(excerpted from *http://www.pri.org/stories/2016-06-26/flowers-give-electrical-signals-bees*)

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