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ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Bioenergetics (with details from "Energy in Nature and Society" by V. Smil)

Dear All:

I want to wish all of you a great 2010. It is now time to begin thinking of our next ESA annual meeting to be held June 22-24 at the University of North Carolina; abstracts are due March 1. I hope we will have a number of great abstracts illustrating the pervasiveness of electrostatics.

Recall the President's Messages of the Jan/Feb 09 and Mar/Apr 09 ESA Newsletter, where a discussion was made of the relationship between DNA, proteins, and electrostatic interactions crucial for protein structures and functions during the development of a life from its inception. Continuing here onto electrostatics, energy, metabolism and CO_2, it is amazing to know about bioenergetics and its various aspects. It can be realized that no energy conversion is more immediately essential for human existence than the continuing oxidation of foodstuffs or lipid reserves. Three kinds of nutrients can be metabolized to yield energy: carbohydrates, lipids, and proteins (if other nutrients are in short supply). Energy released by their oxidation is partially conserved in ATP, the principal energy carrier, the key link between cellular metabolism (degradation of nutrient substrates) and anabolism (biosynthesis of complex substances), locomotion (muscle contraction) and active transport of metabolites against the concentration gradient. The energetic advantages of oxidation is interesting: lactic acid fermentation liberates 195kJ for each molecule of glucose, alcoholic fermentation yields 232kJ, but complete oxidation of sugar releases 2.8MJ. The biochemistry of these sequential, enzymatically catalyzed reactions is amazing: glycolysis of glucose or glycogen takes place in the cytoplasm and produces pyruvic acid. Nicotinamide adenine dinulcletide (NAD) is the electron carrier (NADH), and pyruvic acid is the precursor compound for anaerobic respiration (the pathway that ends in lactic acid), alcohol fermentation (producing ethanol and CO_2), and aerobic respiration, the tricarboxylic acid (citric acid) cycle. This cycle, taking place inside the mitochondria, converts a variety of organics (fatty acids and amino acids) to CO_2 and transfers the released electrons down the electron transport chain, producing large amounts of ATP and reducing oxygen to water. The maximum energy gain is 38 mol of ATP for each mol of glucose broken in prokaryotic cells, an overall free energy change of about -2.8MJ. With -31kJ/mol available from each ATP transformation to ADP, the overall efficiency of the whole sequence would be about 42%. In eukaryotic cells, the net ATP gain is a bit smaller - two moles are needed to move NADH from the cytoplasm - but because the free energy of the compound may be as high as -50kJ/mol in mammalian cells, the overall efficiency may be over 60%. Respiration of fatty acids yields a maximum of 44ATP/mol, but as oxidized compounds have a higher energy content than glucose (around 3.4MJ/mol), the peak efficiencies are about 60%.

(cont'd. on page 2)

President's Message (cont'd.)

The intensity of ATP generation is great. A 60kg man with a daily consumption of roughly 12MJ (~700g) of carbohydrates would make and use no less than 70kg of ATP (assuming production of 36 molecules of ATP for every digested hexose molecule), more than his weight. This ratio, 1g ATP for each gram of dry body mass, is miniscule compared to intensities achieved by respiring bacteria and their dominance in many instances. Azotobacter, breaking down carbohydrates while fixing large amounts of N_2, produces 7000g of ATP for each gram of dry mass. While the sun's luminosity is immense (390YW (Y=1024W)), with 200nW/g average power intensity, it is less than the daily metabolism of school children (3mW/g of body weight), 15000 times the power intensity of the sun, and Azotobacter reaches up to 100W/g, 500 million times the Sun's rate. ATP-driven energy conversions are as or more awesome in their intensity than the Sun's performance in its overall magnitude and these conversions derive, in part, from electrostatic interactions in the cells. I am sure you will have some comments on this and I look forward to hearing from you as always (and I am very grateful to a very good positive comment on the coal & electrostatics from one of you).

Thank you.

Have a pleasant & productive time.
Yours for the Friendly Society,

Raji Sundararajan,
ESA President

ESA Award Nominations

One of the important aspects of the ESA is to acknowledge and honor those who have contributed significantly to the knowledge base of electrostatics and/or to the functioning of our friendly society. A preliminary listing of the awards may be found on our website, *http://www.electrostatics.org/esaawards.html* , with more detailed descriptions, as well as nomination forms, to follow. In the meantime, please contact our awards chairperson, John Gagliardi, *gagliard@camden.rutgers.edu*

Calendar

- ESA-2010, June 22-24, 2010, Univ. of North Carolina, Charlotte, NC Contact: Maciej Noras, Tel: 704-687-3735, *mnoras@uncc.edu,* website: http://www.electrostatics.org
- SFE 2010, Aug 30 - Sept 1, 2010, Montpellier, France, Contact: SFE2010 Organizing Committee, Tel: +33 4 67 14 34 85, *sfe2010@univ-montp2.fr,* website: http://www.electrostatics.org (abstracts due by Dec 31, 2009)
- IEEE-IAS 2010 Annual Meeting, Electrostatic Processes Committee, Oct. 3-7, 2010, Houston, Texas, website: http://www.ewh.ieee.org/soc/ias/2010/home.htm
- IEEE-DEIS CEIDP 2010, Oct. 17-20, 2010, Purdue University, West Lafayette, Indiana, Contact: Rajeswari Sundararajan, Tel: +1 765 494 6912, *rsundara@purdue.edu,* website: http://ewh.ieee.org/soc/dei/ceidp/ceidp2010.htm (abstracts due by Feb. 15, 2010)
- Electrostatics 2011, 13th Int'l. Conf. on Electrostatics, April 10-14, 2011, Bangor University, Wales, UK, Contact: Dawn Stewart, Tel: +44 (0)20 7470 4800, *dawn.stewart@iop.org*, website: http://www.electrostatics2011.org

ESA OFFICERS

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2010 Annual Meeting of the Electrostatics Society of America

University of North Carolina, Charlotte. June 22-24, 2010

CALL FOR PAPERS

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 sessions include:

I. Atmospheric and space applications
II. Biological and medical applications
III. Breakdown and discharge
IV. Flows, forces, and fields
V. Materials behavior and processing
VI. Measurement and instrumentation
VII. Particle control and charging
VIII. Safety and hazards

Abstract submission: Abstracts should be submitted online, at http://www.electrostatics.org

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

Registration and housing information: Will be posted online, at http://www.electrostatics.org

Important dates

March 1, 2010	Abstract submission deadline
March 17, 2010	Notification of paper acceptance
May 15, 2010	Final manuscripts due
June 22, 2010	Conference begins (1 PM)
June 24, 2010	Conference ends after evening banquet (Banquet: 7 PM – 10 PM)

Contact information

For questions regarding the technical program and abstract submission, contact the Technical Chair:
Prof. Daniel Lacks, Case Western Reserve University, daniel.lacks@case.edu, (216) 368-4238

For all other questions, contact the General Chair:
Prof. Maciej Noras, University of North Carolina-Charlotte, mnoras@uncc.edu, (704) 687-3735

Current Events

The Adventure of the Incredible Sparking Car

Arthur Sundeen, Design News
http://www.designnews.com/article/195751-The_Adventure_of_the_Incredible_Sparking_Car.php?rssid=20027&text=sherlock+ohms

Back in the early '80s I was an electrical design engineer for an automobile manufacturer. One day the experimental engineering garage called on me to diagnose and remedy a strange, periodic snapping noise that surfaced during the development of a new vehicle.

Peering down into the dark, I confirmed that the noise was emanating from a large, arcing spark down low in the engine compartment. The arc was crossing between a small, metal in-line oil filter can and the vehicle's grounded chassis frame some distance away. The spark was big, fat and loud. It was at least two inches long and occurred about once a second whenever the engine was running.

In place of a conventional, vacuum-boosted brake system, this particular vehicle incorporated an experimental hydraulically boosted power brake system. It required an additional hydraulic plumbing from the engine-driven power steering pump to the brake booster system. The plumbing included a fluid filter inserted in-line to the pump's rubber, high-pressure feed hose. The metal filter housing was suspended by the insulated hose a distance away from the chassis frame.

I quickly concluded that a two-inch-long spark equated to at least a couple hundred thousand volts. My first thought was: "How do you get that kind of voltage with a car's 12V system?" I found it particularly confounding because the vehicle, which used a diesel engine, didn't even have a high voltage ignition system!

I was familiar with generating very high voltages and their principles of operation, having built my own Van de Graaff generator and Tesla coil as a kid. I concluded that, somehow, we had inadvertently produced the "hydraulic" equivalent of a conventional mechanical Van de Graaff generator, which consists of three main parts: an insulated motor-driven electron transport belt, a metal electron collector brush connected to the high voltage metal dome at one end of the belt and a source of electrons applied to the opposite end of the drive belt.

In my conceptual "hydraulic" equivalent, the moving, non-conducting hydraulic fluid and insulated rubber hoses were the electron transport mechanism. The metal filter can and its internal metal filter element made up the electron collector. The engine-driven hydraulic pump and drive belt were the source of electrons to the fluid.

Since the engine-driven pump was of an all-metal construction, and was grounded to the engine and the chassis frame, it was difficult at first to envision how the pump could be a source of electrons. However, I substantiated my suspicion that the pump was the electron source when I attached a grounded test lead to the pump by rubbing it against the pump's belt-driven pulley and caused the arcing to stop. When the engine was stopped, a conductivity check confirmed that the pulley was grounded in this non-operational state.

I then concluded that the pump's spinning pulley and internal rotor assembly were electrically "floating" inside the grounded pump housing, due to the hydrodynamic action of the bearings and rotor and the insulated seals inside the insulated hydraulic fluid. The actual electron source probably resulted from the triboelectric friction of the rubber drive belt on the pulley.

Grounding the filter can housing to the vehicle frame eliminated the arcing symptoms. Upon further reflection, grounding the filter can only provided a good sink for the electrons, and there was still a large circulation of those electrons in the hydraulic fluid. I wonder what, if any, detrimental effects that electron flow would have had on the fluid and the system's other parts. As I recall, this configuration of power brake booster vehicle never made it into a production vehicle.

Martian lightning

Jenny Lauren Lee, Science News
http://www.sciencenews.org/view/generic/id/44890/title/Martian_lightning

Scientists say they have seen the first direct evidence of lightning on Mars, in the form of electrical discharges during a Martian dust storm. The finding has implications for human travel to the Red Planet and for studying possible origins of life on Mars, the authors say in a paper to appear in Geophysical Research Letters.

It has been thought that lightning might be possible on Mars. Bits of dust rubbing against each other in one of the planet's famous dust devils could charge up the particles the same way that running on a carpet charges up socks. All that charge could then be discharged in a zap, either as lightning or a shock.

But catching Martian lightning in the act was difficult: The lightning bursts were too small to distinguish from the energy emanating from the planet itself. And the dust storms themselves obscured the faint glow that might have been visible from just above the red planet.

To "see" the lightning, researchers from the University of Michigan and colleagues used a new detector that can dis-

tinguish microwave radiation emanating from natural objects like dirt and rocks from a burst of lightning. Radiation from natural objects, including Martian rocks, is relatively constant; radiation from lightning displays changes in the distribution of frequencies of light.

Using a 34-meter-diameter radio telescope in the California desert, for about five hours a day for 12 days between May 22 and June 16, 2006, the researchers found no signs of the variable radiation, except during a period of two or three hours. At that time a Martian dust storm was on the side of Mars facing the scientists' detector. "Every time we moved off Mars the [signal] went away. Then we moved it back and it came back again," says Christopher Ruf of the University of Michigan in Ann Arbor, one of the study's authors.

Lightning as an explanation for the results makes sense, says geophysicist Phil Christensen of Arizona State University in Tempe. "I can't think of a better explanation," he says. "They found it to be in a dust storm, and that's exactly where you'd expect it."

Lightning on Mars is probably fainter and more diffuse than the lightning commonly observed on Earth, says Nilton Renno, another author of the study. "The atmosphere [on Mars] is much less dense," he says. Instead of forks of lightning, Martian lightning bursts would cover a wider area and would have a "faint glow" like the light in a neon tube.

Lightning's mirror image, but much bigger

(excerpted from R&D Magazine, http://www.rdmag.com/News/2009/08/Lightning-s-mirror-image,-but-much-bigger/

With a very lucky shot, scientists have captured a one-second image and the electrical fingerprint of huge lightning that flowed 40 miles upward from the top of a storm. These rarely seen, highly charged meteorological events are known as gigantic jets, and they flash up to the lower levels of space, or ionosphere. While they don't occur every time there is lightning, they are substantially larger than their downward striking cousins. "Despite poor viewing conditions as a result of a full moon and a hazy atmosphere, we were able to clearly capture the gigantic jet," said study leader Steven Cummer, an electrical and computer engineer at Duke University in North Carolina.

Images of gigantic jets have only been recorded on five occasions since 2001. The Duke University team caught a one-second view and magnetic field measurements that are now giving scientists a much clearer understanding of these rare events. "This confirmation of visible electric discharges extending from the top of a storm to the edge of the ionosphere provides an important new window on processes in Earth's global electrical circuit," said Brad Smull, program director in NSF's Division of Atmospheric Sciences, which funded the research. "Our measurements show that gigantic jets are capable of transferring a substantial electrical charge to the lower ionosphere," Cummer said. "They are essentially upward lightning from thunderclouds that deliver charge just like conventional cloud-to-ground lightning. What struck us was the size of this event." It appears from the measurements that the amount of electricity discharged by conventional lightning and gigantic jets is comparable, Cummer said.

But the gigantic jets travel farther and faster than conventional lightning because thinner air between the clouds and ionosphere provides less resistance. Whereas a conventional lightning bolt follows a six-inch channel and travels about 4.5 miles down to earth, the gigantic jet recorded by the scientists contained multiple channels and traveled about 40 miles upward. "Given that reservoirs of electric charge in thunderstorms are the sources for both lightning and gigantic jets, and that both events involve contact between these reservoirs and a very large conducting surface, it is not surprising that their charge transfers are comparable," Cummer said.

Scientists don't know what conditions or what types of storms are conducive to gigantic jet formation. It has been difficult in the past to obtain images of gigantic jets because they occur so quickly that cameras have to be trained on them at the precise moment they occur. Cummer caught the gigantic jet almost by accident. The equipment had been set to capture another phenomenon known as sprites, which were first photographed in 1989. Sprites are electrical discharges that occur above storm clouds and are colored red or blue, with jellyfish-like tendrils hanging down.

Electrostatics
Society of America

30 Shalimar Drive
Rochester, NY 14618

ESA Information

ESA Home Page: http://www.electrostatics.org

Rajeswari Sundararajan
ECET-Dep't. Purdue Univ.
Knoy Hall of Tech.
401 N. Grant Street
West Lafayette, IN 47907
765-494-6912
rsundara@purdue.edu

Steve Cooper
Secretary/Treasurer
540 Morton Rd.
Athens, GA 30605
706-255-5518
steve@steve-cooper.com

Mark Zaretsky
Newsletter Editor
30 Shalimar Drive
Rochester, NY 14618
585-588-6351
mark.zaretsky@kodak.com

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Call for Papers Inside