

Synergy in food, fuel and materials production

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Materials

Innovation in Brazil

- Successful areas
 - Food
 - Oil and gas
 - Fuels from biomass
 - Machinery
 - Transportation equipment
 - Chemicals and petrochemicals, polymers
 - Planted forest products, paper and cellulose
- Few achievements, in other areas
 - TI and communications ware
 - Lighting (including lasers)
 - Magnetic materials, semiconductors
- Intermediate cases
 - Health and well-being
 - Leisure

Which are “primary products”?

- Many commodities are competitive only thanks to large and continuing ST&I inputs.
- Soybeans: N fertilizers not required when inoculated seeds are used.
 - Atmospheric nitrogen is fixed.
- Ethanol in the Southeast: 40 years of intensive and continuing ST&I inputs
 - In Pernambuco: sugar cane variety diversification is starting only now.

Also, mistakes

- Biodiesel from castor oil
 - The intention: fostering castor bean plantation to increase income for poor farmers and settlers.
 - The mistake: castor oil is an important and valuable industrial raw material
 - Brasil was once the leading producer that today is Índia
 - Result: currently, biodiesel is made out of soybean oil.
 - In 2008, small producers could not find customers.
 - Summing up: goodwill and speeches do not create realities without good strategies and plans.

- **EU Votes To Halve Biofuels Targets**
- The European Union's industry committee has **voted to half its biofuels target for 2020**, reducing it from 10 % to 5 % of total road fuel in energy terms.

Against all expectations, the EU's industry committee voted to reduce its biofuels target by 50 % which, remarkably, would leave the **2020 target lower than the 5.75 % target for 2010!**

The parliamentary committee's vote follows a plethora of **bad publicity for biofuels**, with the main criticism being that its production has diverted **crops away from food**, thereby pushing up prices. It has also been argued that **forests have been destroyed in order to make way for the cultivation of biofuels crops.**

- http://nogger-noggersblog.blogspot.com/2008_11_23_archive.html
28 November 2008

- From the plantation: Ajinomoto produces 72 kton/year lysine in Valparaíso, SP, and 60 kton/year in Pederneiras, SP by sucrose fermentation. Another company makes 60 kton/year in Piracicaba. Lysine is used to make food supplements and surfactants.



**Also: polyester, cellulose, wax, yeast,
vitamin B-12 + 7 Gw electric power
capacity (2007)**

- Vision: a powerful source of food, fuel, materials, water and fertilizers. Planted area in 2007: **2 MHa.** Grazing area (largely underutilized): **80 MHa.**



Ethanol, butanol, polyethylene, polybutadiene, wax, green solvents, surfactants, nanosilica, cellulose, paper and pulp, microcrystalline cellulose, PHB-PLA and other thermoplastics.

Water and P/K fertilizers storage and recycling.

Later on: dimethylfuran, higher alcohol fuels, microalgae.

DDGS from corn

Dried Distillers Grains with Solubles---Coproduct of the ethanol production process, high nutrient feed valued by the livestock industry.

WHAT IS DDGS?

A third of the grain that goes into ethanol production comes out as DDGS. Each bushel of grain used in the ethanol-making process produces 2.7 gallons of ethanol; **18 pounds of DDGS** and 18 pounds of carbon dioxide.

Rich in cereal and residual yeast proteins, energy (oil), minerals and vitamins.

Is an excellent digestible protein and energy source for beef cattle.

Can comprise 20-30% of the ration DM.

Can also be used in turkey and swine applications.

Is a valuable feed for both feedlot and dairy cattle.

In North America, over 80% of DDGS is used in ruminant diets.

Also is fed to poultry.

Excellent nutritional value of DDGS in swine diets.

- <http://www.ecovation.com/about/about.html>
- Purdue University researchers (Risk et al., 1981) concluded that replacing all of the corn in a steer finishing diet with wet distillers' grains depresses the rate of gain but not feed efficiency. They suggested that wet distillers' grains could replace up to half of the grain without any effect on rate of gain.
 - Risk, J. E. 1981. Utilization, storage, and ensiling characteristics of brewers' and distillers' wet grains for beef cattle. M.S. thesis, Purdue University, West Lafayette, Indiana.
- http://www.archive.org/stream/nutritionalvalue00univ/nutritionalvalue00univ_djvu.txt
- Soy meal demand to decrease due to **competition with DDGS** derived from ethanol production from corn.
 - 11 maio 2007 . Gazeta Mercantil and Valor Econômico
- ...or else: increased offer of corn ethanol led to a decrease in soy meal (for food).

Manioc

Starch for food, oil and paper industries and ethanol

New machinery

<http://www.abam.com.br/revista/revista8/colhedeira.php>

Prototype cost shared by 24 manioc starch industries: R\$158K

Manioc is an alternative for oil and hydrogen production

Recent: 25% reduction in energy input.

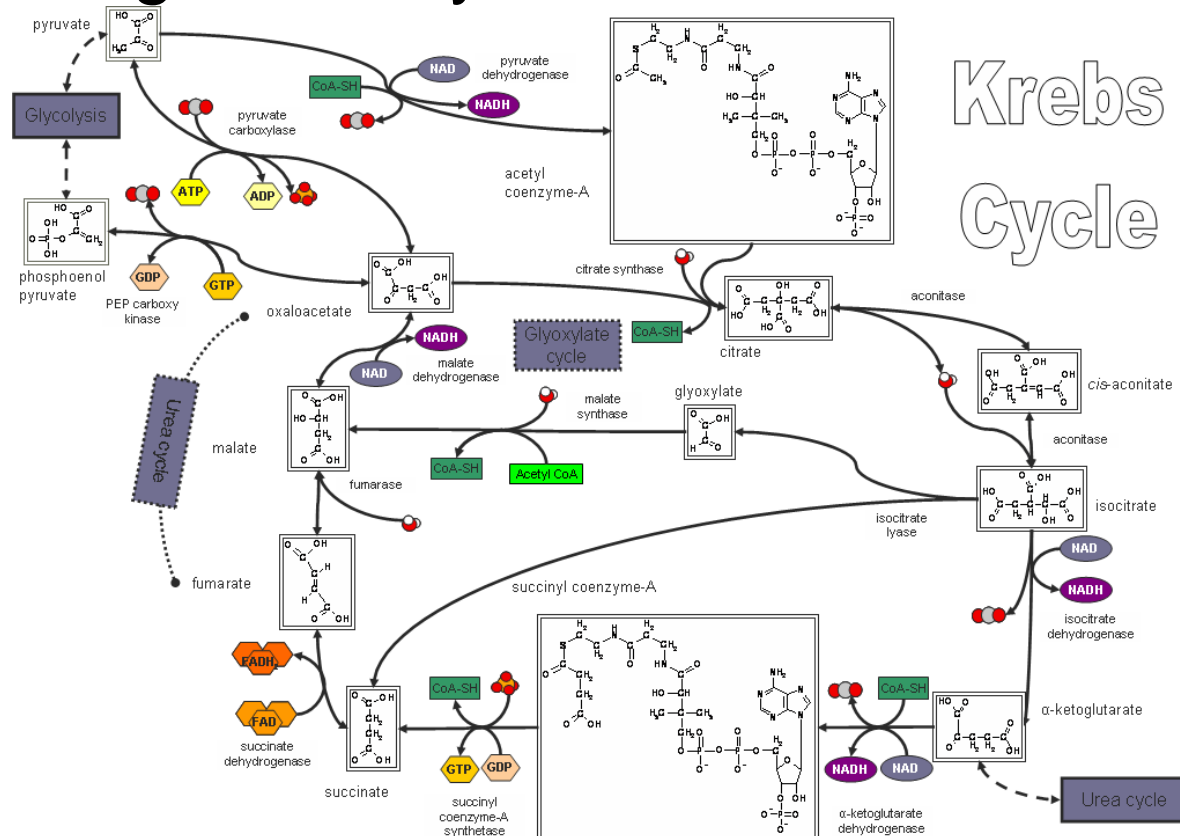
Three experimental plants in São Paulo: Botucatu, Tarumã and Flavel.

Fábio de Castro, Agência FAPESP
24/10/2007



Many possibilities: which is the best choice, at each time and place?

- Useful paradigm: **complexity** e.g. Krebs cycle
- Not so useful:
 - Excessive belief in the ability of oversimplified approaches to solve real-life problems.



Krebs
Cycle

Limitations to growth

- Plant nutrient input
- Water input
- Plagues and pests
- Changes in local conditions and crop migration
- Residue utilization
- Materials for plant protection, food collection and storage
- **Climate change**
 - *Magda A. de Lima, Bruno J. R. Alves, Parcerias Estratégicas 27 (2008) 73*

Fertilizers

- Potassium (KCl) and urea lead the list of Brazilian imports
 - 2005: 1 US\$ Bi KCl
 - Largely ignored by govt planners
- Multiple solutions are required for the K, N and P needs
 - Loss reduction and improved use
 - Diversification of sources including reuse and recycling
- Oligoelements

N: Haber-Bosch AND rhizobia

- Haber–Bosch
 - Source of protein feed for ca. 2 billion people
 - Making N fertilizers requires 1.9% of the global energy production
- Should we treat nitrate and ammonia-rich effluents and sewage:
 - as valuable raw materials?
 - or as harmful contaminants?
- Solution: membranes, separation processes

Increasing the yields

- Fertilizer **encapsulation and controlled release**
 - Decreased usage of non-renewable supplies
 - K, P ores
 - Decreased leaching of nutrients towards rivers and ponds
 - Lower eutrophication levels
 - Lower number of applications
 - Decreased field work

Fertilizer and encapsulation

- 20090011027 Modifying Drug Release in Suspensions of Ionic Resin Systems
- 20080296024 Procedures and Compositions for Reservoir Protection
- 20080281003 Process for preparing a functionalised polyHIPE polymer
- 20080257000 Plant Nutrient Reduction System
- 20080250715 Process and apparatus for carbon capture and elimination of multi-pollutants in fuel gas from hydrocarbon fuel sources and recovery of multiple by-products
- 20080236033 Slow-release floating fertilizer
- 20080173212 Novel mineral composition
- 20070261453 Plant Nutrient Based on O,P-Ethylene (Bis) Hydroxyphenyl Glycines
- 20070261337 Novel mineral filler composition

<http://appft1.uspto.gov>

Targets

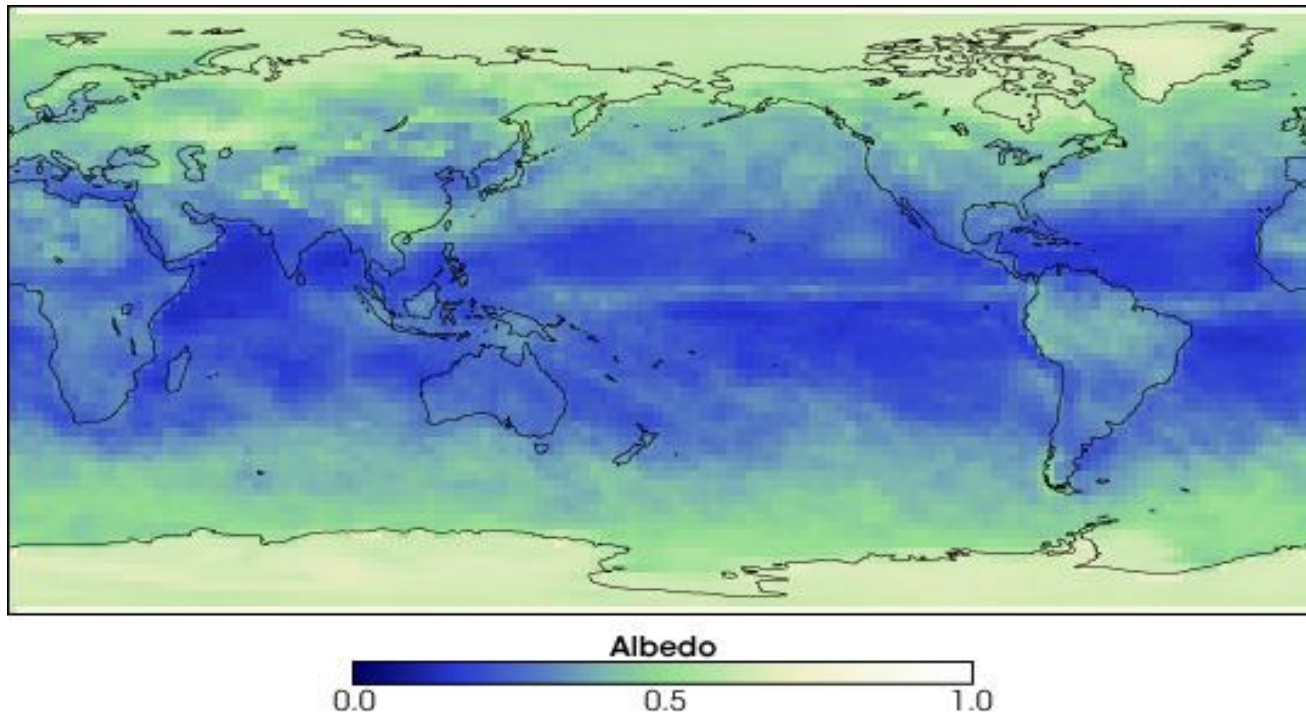
- Decreased use of renewable and non-renewable natural resources
- Decreased dependence on imports
- Decrease pollution
- Increased soil preservation
- Decreased carbon emission
- Increased carbon fixation

Can we decrease solar energy uptake?

Can we increase the albedo?

Planet	Geometric Albedo	Bond Albedo
Mercury	0.138	0.119
Venus	0.84	0.75
Earth	0.367	0.29
Moon	0.113	0.123
Mars	0.15	0.16
Pluto	0.44-0.61	0.4

- The bond albedo is the total radiation reflected from an object compared to the total incident radiation from the Sun.



- On average, the Sun shines on Earth 341 watts of energy per square meter of surface area. The Sun beams more energy to our planet every hour than humanity uses in a whole year.
- If Earth was covered in ice like a giant snowball, its albedo would be about 0.84, meaning it would reflect most (84 percent) of the sunlight that hit it. On the other hand, **if Earth was completely covered by a dark green forest canopy**, its albedo would be about 0.14, meaning most of the sunlight would get absorbed and **our world would be far warmer than it is today (???)**.
- <http://earthobservatory.nasa.gov/IOTD/view.php?id=5484> Posted May 10, 2005



Cool roofs

- Americans spend about US\$40 billion annually to air-condition buildings: 1/6 of all electricity generated in the country.
 - <http://www.energystar.gov/>
- Significant energy savings are achieved by using reflective and emissive roofs and coatings.

Company Name	Brand	Model	Type	Initial Solar Reflectance	Solar Reflectance after 3 years*	Low Slope?	Steep Slope?	Warranty (years)**
BASF Corporation	Fluoroceram	Green 815G774	Coating	0.28	0.25	N	Y	35
BASF Corporation	Fluoroceram	Green 815G774	Coating	0.28	0.25	N	Y	35
BASF Corporation	Fluoroceram	Marine Green 815G136	Coating	0.32	0.31	N	Y	35
BASF Corporation	Fluoroceram	Marine Green 815G136	Coating	0.32	0.31	N	Y	35
BASF Corporation	Fluoroceram	Parchment 815T116	Coating	0.35	0.37	N	Y	35
BASF Corporation	Fluoroceram	Parchment 815T116	Coating	0.35	0.37	N	Y	35
BASF Corporation	Fluoroceram	Red 815R130	Coating	0.33	0.33	N	Y	35
BASF Corporation	Fluoroceram	Red 815R130	Coating	0.33	0.33	N	Y	35
BASF Corporation	Fluoroceram	Red 815R153	Coating	0.42	0.4	N	Y	35
BASF Corporation	Fluoroceram	Red 815R153	Coating	0.42	0.4	N	Y	35
BASF Corporation	Fluoroceram	Sand 815T940	Coating	0.43	0.43	N	Y	35
BASF Corporation	Fluoroceram	Sand 815T940	Coating	0.43	0.43	N	Y	35
BASF Corporation	Fluoroceram	Silver 818A11	Coating	0.45	0.47	N	Y	35
BASF Corporation	Fluoroceram	Silver 818A11	Coating	0.45	0.47	N	Y	30
BASF Corporation	Fluoroceram	Tan 815T702	Coating	0.35	0.34	N	Y	35
BASF Corporation	Fluoroceram	Tan 815T702	Coating	0.35	0.34	N	Y	35
BASF Corporation	Fluoroceram	Terra Cotta 815R195	Coating	0.32	0.34	N	Y	35
BASF Corporation	Fluoroceram	Terracotta 815R195	Coating	0.32	0.34	N	Y	35
BaySystems North America, LLC	EverSil	ES580	Coating	0.74	0.71	Y	Y	10
BaySystems North America, LLC	Evercoat	EC 700	Coating	0.81	0.64	Y	N	10
BaySystems North America, LLC	Evercoat	EC500	Coating	0.86	0.62	Y	N	10
BaySystems North America, LLC	Evercoat	EC5400	Coating	0.86	0.66	Y	N	10

White pigments

- The **albedo** or "whitening" was seen by many alchemists as **the climax of their work.**
- As Jung put it: "From the darkness of the unconscious comes the light of illumination, the *albedo*."

<http://alch3my.tribe.net/>



The Exceptional Effects of Nanostructured Aluminum Phosphate Particles on the Performance Characteristics of a New White Pigment

Fernando Galembeck, Maria do Carmo V.M. da Silva,
Renato Rosseto, Ádamo C. M. A. dos Santos and Gilmar O. Pinheiro

Can we make a white pigment out of aluminum phosphate?

- Yes, white pigment based on hollow particle formation.
 - Orthophosphate, polyphosphate
- Particle voids may be preformed, or formed during paint drying.
 - An emerging property
- Outcome of a rare nanostructure formation process.

Free of environmental and toxicological problems

- **Soft chemistry**
- Wet-chemistry under mild conditions
- Zero-effluents
- Residues can be safely discarded
 - composting

Performance tests

- 50% TiO₂ replacement on formulas of testing laboratories
 - DL Labs, Inc. 74 Kent Street Brooklyn, New York
 - Stonebridge Technical Services. 6223 Linden Road, Fenton, MI, USA
- 50% TiO₂ replacement on premium formulations.

To sum up

- Ability for TiO_2 replacement
- Absence of UV absorption and catalytic resin photo-oxidation
- Abundant raw materials
 - ??in 2008??
- Environmentally friendly process and product
- Jointly managed by Bunge PI (São Paulo) and Bunge Biphor LLC (White Plains, NY)



Many applications, sophisticated approaches

- **US Patent 7339728 - Low-emissivity coatings having high visible transmission and low solar heat gain coefficient**

- Low-emissivity coatings that are highly reflective to infrared radiation. The coating includes three infrared-reflection film regions, which may each include silver.

Quotes 75 USPTO patents and 36 foreign patents

...

6650478, Optical filter for a window
Issued on: 11/18/2003, DeBusk , et al.

6680134, Transparent substrate provided with a heat-reflective multilayer stack
Issued on: 01/20/2004, Maurer , et al.

6830791, Glass panel
Issued on: 12/14/2004, Misonou, et al.

6838159, High transmittance, low emissivity coatings for substrates
Issued on: 01/04/2005, Eby, et al.

6855369, Transparent laminate, method for producing the same, and plasma display panel
Issued on: 02/15/2005, Nakamura, et al.

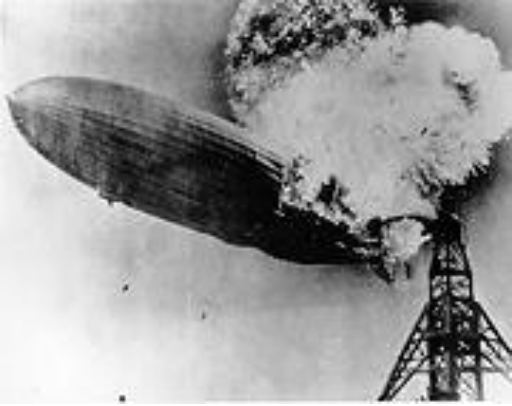
6919133, Thin film coating having transparent base layer
Issued on: 07/19/2005, Hartig, et al.

6992826 Devices based on an array of light-filtering channels with surface plasmon interference filters
Issued on: 01/31/2006, Wang

INFRA-RED-REFLECTIVE PAINT

- **AKZO NOBEL AEROSPACE COATINGS, Leicester**, Unit 1, Meridian West, Meridian Business Park, Leicester, Leicestershire, LE3 2WX, *Tel: +44 116 223 4123, Fax: +44 116 223 4139, e-mail: info@anac.com, Web site: www.anac.com, Regional Manager UK & Ireland: Andrew Richardson, Military Business Development Manager: Robert Walker, Customer Operations Manager: Alice Talbot*
- **INDESTRUCTIBLE PAINT CO LTD, Birmingham**, 25 Pentos Drive, Sparkhill, Birmingham, West Midlands, B11 3TA, *Tel: +44 121 702 2485, Fax: +44 121 778 4338, e-mail: sales@indestructible.co.uk, Web site: www.indestructible.co.uk, NCAGE Code: K3054, ISO 14001, Managing Director: B Norton, Sales Manager: G Armstrong*
- **PAINT SERVICES GROUP LTD, Haslemere**, Weydown Road, Haslemere, Surrey, GU27 1BT, *Tel: +44 1428 651246, Fax: +44 1428 661471, e-mail: info@paintservices.com, Web site: www.paintservices.com, ISO 9001, General Manager: Keith O Dell*
- <http://www.bdec-online.com/bd-p2/bd-p2944.htm>

Electrostatics, blasts,
atmospheric electricity



The first dust explosion that was outlined in a world literature occurred in 14 December 1785 in Italy. Turin Science Academy noticed that it was an explosion of flour dust in the centre of Turin. According to literature all building was destroyed - reported by Rafal Porowski from HQ of SFS. <http://www.ppoz.pl/wwwold/current.htm>

“...current geophysical research has not yet disclosed effective models for atmospheric cloud electrification.”

Helsdon Jr., J. H.; Gattaleeradapan, S.,
Farley, R. D.; Waits, C. C. *J. Geophys. Res.*
2002, *107*, 4630.

Many important topics

- **Maxwell-Wagner effect**
- **Costa Ribeiro (thermodielectric) effect**
- **Charge separation by electrosmosis or junction/sedimentation/streaming potentials**
- **Electrets**
- **Charging under ionizing radiation**
 - Ionization, electret formation
- **Interfacial polarization, thermally stimulated currents (TSCs)**
- **Tribochemical effects**
 - **100 kV electrons emitted during the cleavage of NaF** (G. Heinicke, Tribochemistry, Hanser, München 1984)

Contact charging of insulators

- Contact charging between insulators was one of the earliest manifestations of electrical science.
- Yet **reproducible experiments remain a challenge.**
- A generally agreed upon theory of insulator-insulator charging **remains elusive.**
 - *G.S.P. Castle, J. Electrostatics 1997*

Electrons or ions?

by Harper:

“...the charging of insulators comes from a transfer of electrons, of ions, or of both?”

Montgomery: ***always*** electrons

Loeb: ***generally*** electrons

Henry ***feels*** that the question is ***still an open one***.

I (Harper) am of the opinion...that the carriers are ***never*** electrons ... in an insulator.”

Adrian G. Bailey, J. Electrostatics 2001

Electrostatic charging: an old but still unsolved problem

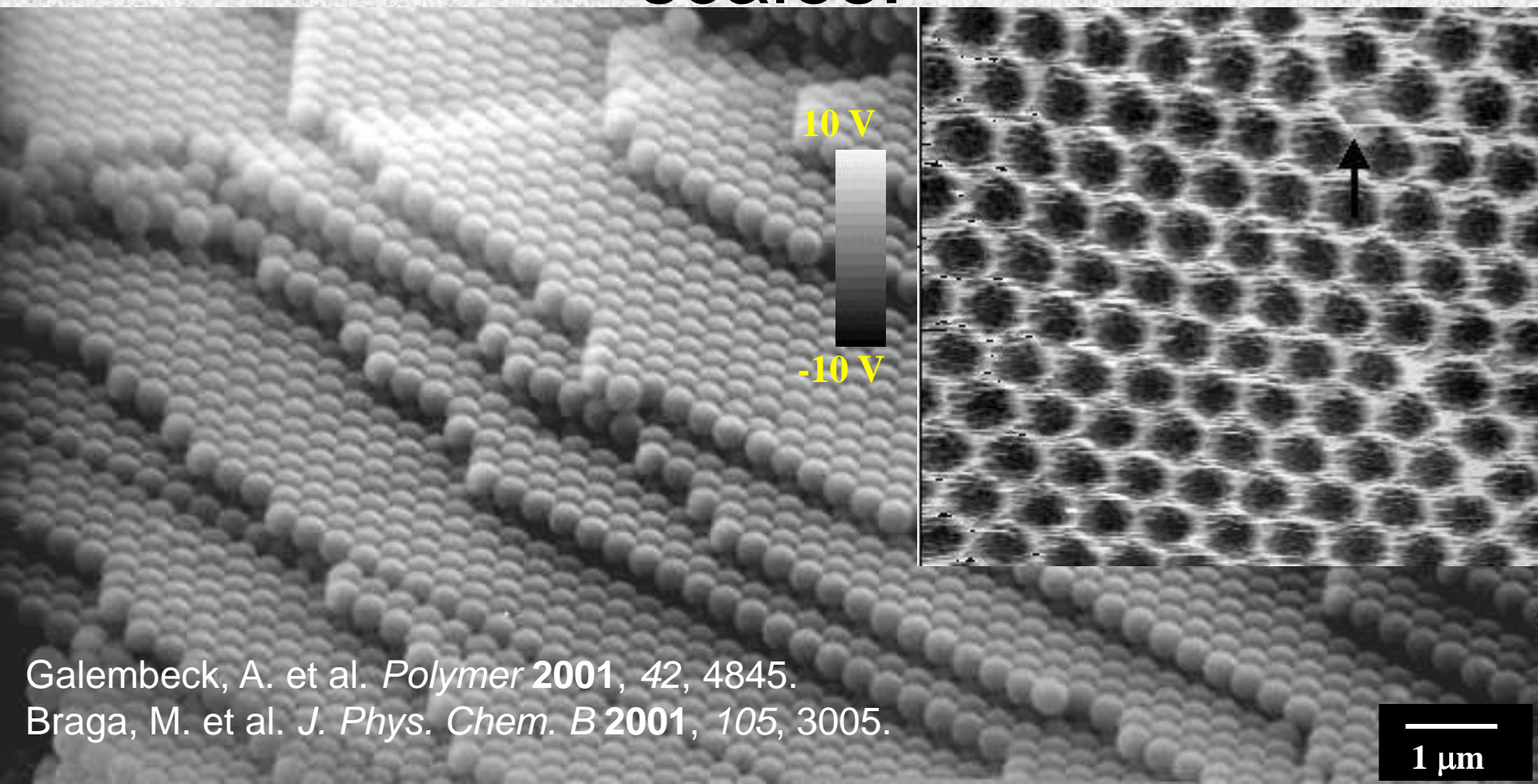
“Surprisingly, although electrostatic charging is well known, it remains among the most poorly understood areas of solid-state physics.”

“Most researchers believe that insulator charging is a surface phenomenon.”

Schein LB

Recent progress and continuing puzzles in electrostatics.
Science, 316, 1572-1573 (2007).

Recent findings: any apparently “neutral” solid displays an electrization pattern at the macro, micro and nano scales.



Galembeck, A. et al. *Polymer* **2001**, 42, 4845.

Braga, M. et al. *J. Phys. Chem. B* **2001**, 105, 3005.

1 μm

A new mechanism

- Atmospheric water is a sink and source of ions for the electrization of insulators.
- Main charge carriers are hydronium - $\text{H}^+(\text{H}_2\text{O})_n$ - and hydroxonium - $\text{OH}^-(\text{H}_2\text{O})_n$ - ions derived from water.
- A new generation of devices, materials and safety procedures.
- Can we collect and store the electricity from the atmosphere?

Gouveia, R. F.; Costa, C. A. R.; Galembeck, F. *J. Phys. Chem. B* **2005**, *109*, 4631.

Gouveia, R. F.; Costa, C. A. R.; Galembeck, F. *J. Phys. Chem. C* **2008**, *112*, 17193.

Soares, L. C.; Bertazzo, S.; Burgo, T. A. L.; Baldim, V.; Galembeck, F. *J. Braz. Chem. Soc.* **2008**, *19*, 277.

Bulk water stores electricity

542

Langmuir 2009, 25, 542–547

Can Water Store Charge?

Kate Ovchinnikova and Gerald H. Pollack*

Department of Bioengineering, Box 355061, University of Washington, Seattle, Washington 98195

Received July 28, 2008. Revised Manuscript Received September 25, 2008

Previous work from this and other laboratories has demonstrated large pH gradients in water. Established by passing current between immersed electrodes, pH gradients between electrodes were found to disappear slowly, persisting for tens of minutes after the current had been turned off. We find here that these pH gradients reflect a genuine separation of charge: at times well after disconnection of the power supply, current could be drawn through a resistor placed between the charging electrodes or between pairs of electrodes positioned on either side of the midline between original electrodes. In some experiments, it was possible to recover the majority of charge that had been imparted to the water. It appears, then, that water has the capacity to store and release substantial amounts of charge.

If...

- ...we really learn about electrostatic phenomena,
- we should be able to have better control of atmospheric electricity.
- Perhaps, we could devise useful techniques for storm control and for capturing energy from the atmosphere.

Conclusion

- Large unprecedented problems should make us ready to face our unawareness of seemingly familiar problems and to make bold projects.
- Facing climate change problems requires adequate and effective policies, together with responsible entrepreneurship.