NANO & GREEN 2009

Nano and Green Technology 2009 Conference and Symposium

COLLOIDS AND SURFACES, NANOPARTICLES, AND GREEN TECHNOLOGY 2009 - Emphasizing Emerging Science and Technologies, Materials, Applications, Commercialization and Business Opportunities

Javits Convention Center, New York, NY

November 17-19, 2009

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STIMULATING ENTREPRENEURIAL POTENTIAL

Nanotechnology is already transforming our lives with new technologies and products. As nanotechnology tools and devices are developed, nanoparticles and nano-engineered materials and systems will play increasingly important roles in a number of industrial sectors such as: energy, biotechnology, electronics and information technology, healthcare and medicine, and industrial products. New "green" technologies under development from fuel cells to catalysts for biofuels depend on nanoengineering.

The conference will focus on the use and synthesis of nanoengineered materials with an emphasis on biological applications including pharmaceuticals and devices. Cutting edge research from some of the world's leading colloid and nano scientists, technologists and business leaders will be presented in: colloids and surfaces, nanoparticles, and other industrial and green technologies. The program will provide attendees an unmatched look at the state-of-the-art in these emerging technologies and their path to the market place.

This unique meeting will bridge the gap between science, technology and commercialization and attract an international group of participants that represent the research, business, and investment communities.

PROGRAM

Tuesday, November 17, 2009

9 a.m. to 12.30 p.m. -Workshop I - NANO 101 –NANOPARTICLE MEASUREMENTS AND STANDARDS

Instructors: Dr. Debra Kaiser, *Chief, Ceramics Division, Materials and Engineering Laboratory,* **Dr. Robert F. Cook,** *Deputy Chief, Ceramics Division, Materials and Engineering Laboratory*, and **Ms. Clare M. Allocca**, *Chief, US Measurement System Office, National Institute of Standards and Technology (NIST). Gaithersburg, Maryland*

This workshop will address the essential role of measurement tools—standardized methods, reference materials and data, and instrumentation—in the development of nanomaterials for biological applications and "green" technologies. The focus will be on physico-chemical properties of nanoparticles, which must quantified in order to understand the benefits and potential hazards of nanoparticles to human and environmental health. Specific examples to be covered include measurements of nanoparticle size and size distribution by various methods, and measurements of forces between nanoparticles by scanning probe microscopy methods. Efforts to catalog measurement needs and relevant tools will also be addressed.

1.30 p.m. to 5 p.m. – Workshop II - NANO 102 – COLLOIDS AND SURFACES, NANOPARTICLE SYNTHESIS AND PROCESSING

The workshop will start with an overview of colloids and how they effect nanoparticle synthesis and processing. Synthesis and processing issues of nanomaterials including characterization, handling, agglomeration, and surface functionalization will be highlighted. Safe handling and utilization of nanostructured materials will also be reviewed. An attempt will be made to present selected case studies to illustrate the applications and health & safety related issues of engineered nanoparticulate materials.

Instructors: Prof. P. Somasundaran, *LaVon Duddleson Krumb Professor of Mineral Engineering and Director, NSF Center for Particulate and Surfactant Systems, Columbia University, New York City, NY;* **Prof. Brij Moudgil**, *Distinguished Professor and Alumni Professor of Materials Science and Engineering, and Director of Particle Engineering Research Center, University of Florida, Gainesville, FL* and **Dr. Thomas Abraham**, President, *iRAP*, Inc. (Stamford, CT, USA)

Wednesday, November 18, 2009

9.00 a.m. Conference Commences

Inaugural Conference Session

Introduction – "Faces and Places"
Dr. Thomas Abraham, Program Chairman and President, *iRAP*, Inc. (Stamford, CT, USA)

9.20 a.m. – 10.50 p.m.
Session I – Nanotechnology and Nanomaterials – Emerging Applications, Market Trends and Economic Impact

Session Chair and Moderator – Vincent Caprio, ***Vice President and Events Director, NanoBusiness Alliance, Shelton, CT***

Dr. Waguih Ishak**, *Division VP, Science and Technology and Director, Corning West Technology Center, Palo Alto, CA,*** "The Digital Society of the 21st Century" - *The Power of Photonics, Electronic, MEMS, and Biology and Their Impact on Connecting People to the Digital World"*

- Mega Trends
- Problems that Matter to the Society: Good Health, Good Communications, Good Entertainment. How can we prolong people's (healthy) life and improve the way they communicate with each other?
- The Convergence of Computers, Communications, and Consumer Electronics
- The Convergence of Nanotechnology, Biotechnology, Information Technology and Cognitive Sciences
- The Role of Innovation and R&D over the Next Decades

Dr. Samuel Brauer, *Principal, NanoTech Plus, LLC, Stamford, CT, and Dr. K. W. Lem and Dr. J. R. Haw (Dept of Materials Chemistry and Engineering, School of Chemical and Biological Engineering, College of Engineering, Konkuk University, Seoul, South Korea)*
"Soft Nanotechnologies - Types and Products, Materials, Industry and Market Trends"

- Materials - Polymers, nanosomes, and biological compounds
- Products using soft nanotechnology
- Major markets for soft nanotechnology: cosmetics and pharmaceuticals
- Major Players
- Industry trends: past, present and future.

Alton Parrish, *Senior Market Analyst, Innovative Research and Products, Durham, NC,* **"Emerging Markets for Nanotechnology and Hard Nanomaterials"**

- Nanomaterial Types and Applications
- Nanotechnology Market Segments
- Energy-related – Battery and Fuel Cells, Solar
- Electronics, Photonics and Magnetics

- Nano-enabled Packaging for Foods and Beverages

10.50 –11.10 a.m. Networking Break

11.10 a.m. – 12.40 p.m.

Session II – Emerging Developments in Colloid Science and Surface Modification Technologies Benefiting Nanotechnology Applications

Session Chair and Moderator – Dr. Philip H. Lippel, *Consultant, Chevy Chase, MD*

Prof. P. Somasundaran, *LaVon Duddleson Krumb Professor of Mineral Engineering and Director, NSF Center for Particulate and Surfactant Systems, Columbia University, New York City, NY,*
"Understanding and Tuning the Nanobiointerface for Emerging Applications"

- Functionalization for efficient extraction and delivery
- Modification of colloids (liposomes, nanoparticles) in food and consumer products
- Nanotoxicity and its mitigation

Dr. Robert F. Cook (and Frank W. DelRio, and Tae Joon Cho), *Deputy Chief, Ceramics Division, Materials Science and Engineering Laboratory, National Institute of Standards and Technology (NIST), Gaithersburg, MD,* **"Molecular Modification of Gold Nanoparticle Surfaces for Biomedical Applications"**

- Overview of gold nanoparticles and their enabling aspects for biomedical applications
- Molecular modifications of gold surfaces and nanoparticles
- Attachment of poly (ethylene glycol) (PEG) molecules to both flat and nanoparticle gold surfaces
- Comparison of measurements using scanning probe microscopy (SPM) and dynamic light scattering (DLS)
- Attachment of "Newkome" dendrimers to gold nanoparticles and stability of dendron modified particles
- Stability analyses using SPM, DLS, optical absorption spectroscopy, and X-ray photoelectron spectroscopy measurements
- Applications of PEG- and dendron-modified gold nanoparticles

Dr. Ganesh Skandan, *President and CEO, NEI Corporation, Somerset, NJ,* ***"Nanotechnology Implications for Improving Air Quality and Wastewater Remediation"***

- Removal of mercury from contaminated waters
- Removal of mercury from flue gas from power plants
- Intersection of Nanotechnology and the need for Cleaner Air and Water
- New treatment media for contaminated water
- New sorbent for mercury removal from flue gas
- Test data

12.40 – 1.45 p.m. Lunch Break

1.45 p.m. – 3.15 p.m.

Session III – Nanomaterials for Nanotechnology and Green Technology Applications

Session Chair and Moderator – Dr. Dana Durham, *Associate, Nanobiz, LLC., Pittstown, NJ*

Dr. George John, *Associate Professor of Chemistry, The City College of the City University of New York (CUNY), New York, NY,* **"Green Nanotechnology: Soft NanoMaterials from Crops"**

- The self-assembly of low molecular weight building blocks into nanoscale
- The building blocks currently used in supramolecular chemistry
- Chemicals and intermediates from renewable resources to generate soft materials Generating soft materials from agri-sources - simple organic transformations and by enzyme catalysis
- Hydrogels as delivery vehicles.
- Developed building blocks-to-assembled materials from crops

Dr. Charles Brumlik, JD, *Principal, Nanobiz, LLC., Branchburg, NJ, "***Clean, Green & Sustainable - Where is the Business? "**

- Investments in clean and green nano
- Market issues in clean and green, *e.g.*, "cradle to cradle" design
- Nanotechnology and the environmental, *e.g.*, remediation
- Nanotechnology in energy, *e.g.*, photovoltaics
- Nanotechnology in solid state lighting, *e.g.*, LEDs

Prof. Shlomo Magdassi , Michael Grouchko and Alex Kamyshny, *Casali Institute of Applied Chemistry, The Institute of Chemistry, The Hebrew University of Jerusalem, Jerusalem, Israel*
"Low Cost Metallic Nanoparticles and Inkjet Printing of Conductive Patterns"

- New method for producing copper nanoparticles
- Novel air-stable Core-shell copper nanoparticles
- Inkjet printing of conductive pattern with nanoparticles
- Achieving conductivity at low temperatures
- Utilization in plastic electronics and opto-electronic devices

3.15p.m. – 3.30 p.m. Networking Break

3.30 p.m. – 5.00 p.m.

Session IV – The Intersection of Nanotechnology and Biology

Session Chair and Moderator – Vincent Caprio, ***Vice President and Events Director, NanoBusiness Alliance, Shelton, CT***

W. Y. Shih,[1]* W.-H. Shih,[1] H. Borghaei,[2] G. Adams, [2] *([1]Drexel University, Philadelphia, PA 19104, [2]Fox Chase Cancer Center, Philadelphia, PA 19111),* **"Rapid, Label-free, Multiplex Quantification of Immune Responses and Biomarkers in Serum"**

- Piezoelectric microcantilever sensor (PEMS) is a real-time, label-free sensor for cells, proteins, and DNA.
- It offers enhanced detection sensitivity through a unique elastic modulus change mechanism.
- Its rapid and multiplexed for detection in serum and other body fluids

- Its pg/ml sensitivity in serum protein detection is more than 100 times better than commercial ELISA
- It is also portable, and low cost.

Dr. Anil Diwan, *President and Chairman, NanoViricides, Inc., West haven, CT,*
"Nanoviricides - Novel Antiviral Agents Against HIV, Influenza, and Many Other Diseases"

- What is a nanoviricide : "Find-Encapsulate-Destroy" antiviral strategy
- FluCide(tm) - Pan-Influenza nanoviricide against pandemic, epidemic influenzas, bird flu, high path viruses
- HivCide(tm) - Anti-HIV nanoviricide was superior to oral HAART cocktail therapy in animal models
- Broad-spectrum nanoviricides - A low cost approach against Neglected Tropical Diseases

Dr. Anthony P. Green, *Vice President, Technology Communications, Life Sciences Group and Ben Franklin Director, The Nanotechnology Institute, Ben Franklin Technology Partners, Philadelphia, PA,* **"NextGen Therapies and Diagnostics: Nanoprobes, Nanosensors, Nanoparticles and Nanotextiles"**

- Nanotechnology is moving from "disruptive technology" to a "means to an end"
- Nanotechnology applications in all areas of life sciences:
  - Nanoprobes for intracellular investigation
  - Nanosensors for diagnostics
  - Nanoparticles for drug delivery
  - Nanotextiles for tissue engineering
- Barriers to commercialization

5.00 p.m. – 5.05 p.m.
Concluding Remarks and Announcements

5.30 p.m. to 8 p.m. Networking Reception and Dinner hosted by

Venue: Thai Select, 472 Ninth Ave. (between 36th and 37th St.), New York, only 3 blocks from Javits Convention Center.

Thursday, November 19, 2009

9.00 a.m. Conference Commences

9.00 –11.12 a.m.

Session V – Emerging Laboratory Technologies Related to Colloids, Nanoparticles, Nano-Engineered Materials and Green Technologies Potential for Commercialization

Session Chair and Moderator – Dr. Charles Brumlik, JD, *Principal, Nanobiz, LLC., Branchburg, NJ*

Formation of Organic Nanoparticles from Microemulsions for Pharmaceutical Applications, ***Dr. S. Magdassi and K. Margulis-Goshen,*** *Casali Institute for Applied Chemistry, The Hebrew University of Jerusalem, Jerusalem, Israel*

Reduction in particle size of organic molecules leads to enhanced dissolution and improved bioavailability. The main objective of our research is to develop a new method for preparation of water-insoluble organic nanoparticles, in a form of re-dispersible powder. The method is based on converting nanodroplets into nanoparticles of water insoluble materials, by evaporation of all volatile solvents from an oil-in-water microemulsion, containing a dissolved drug in the oil nanodroplets.

At the first stage, a water-immiscible drug is dissolved in a suitable volatile organic solvent, and an oil-in-water microemulsion is spontaneously formed by mixing it with water and proper surfactants and co-solvents. The resulting microemulsion is a thermodynamically stable liquid, in which the size of the oil droplets is usually below 30 nm ,is formed without any special equipment. At the second stage the microemulsion is directly converted into easily dispersible powder by Spray Drying or Lyophilization, which are common in the pharmaceutical industry.

A Proof of concept was achieved for several hydrophobic molecules, and the process can be tailored to a variety of water insoluble drugs.For example, powders composed of nanoparticles of propylparaben (antibacterial agent) Simvastatin (antihyperlipidemic drug) were obtained. The particles were either amorphous or crystalline, at the size range of 10-50 nm, and easily dispersed in water to yield almost transparent solutions.

The simplicity and low cost of the process make very attractive for potential use in the pharmaceutical industry.

Facile Production of Multi-functional Nanoparticles for Drug Delivery, Imaging, and Targeting, ***Dr. Robert K. Prud'homme,*** *Chemical Engineering Dept., Princeton University, Princeton, NJ*

Nanoparticle formulations of hydrophobic drugs present unique opportunities for treatment of solid tumor cancers, for delivery of drugs by aerosol administration, and as a route to novel vaccine adjuvants. The common requirements of these applications are precise control of particle size and surface functionality. For cancer therapy particles in the size range of 100-200 nm passively pass through defects in the vasculature in tumors and deposit by "enhanced permeation retention". In addition to delivery, the ability to monitor the fate of the nanoparticles is also of important since anti-cancer agents are invariably toxic to healthy tissue. Our process --Flash NanoPrecipitation – a controlled precipitation process that produces stable nanoparticles at high concentrations using amphiphilic diblock copolymers to direct self-assembly enables the production of composite nanoparticles that enable simultaneous imaging and delivery. Uniform particles with tunable sizes from 50-500 nm can be prepared in an economical and scalable manner. The key to the process is the control of time scales for micromixing, polymer self-assembly, and particle nucleation and growth. The PEG protective layer creates long-circulating particles and the inclusion of PEG chains with terminal ligands allows drug targeting. The incorporation of gold nanoparticles, magnetic nanoparticles, or fluorophores into the composite particle enables imaging by x-ray, MRI, or confocal microscopy, respectively. The incorporation of up converting phosphor crystals into the composite nanoparticles enables a highly efficient form of photodynamic therapy.

In addition to hydrophobic compounds, peptide drugs can also be incorporated into block copolymer protected nanoparticles.

Magnetic Nanophosphors for MRI Contrast Enhancement and Fluorescent Labeling, *Dr. Rameshwar Bhargava, Adosh Mehta, Aleksey Ekimov, Mahantesh Navati and Manu Bhat,* *Nanocrystals Technology, Briarcliff Manor, NY*

Magnetic nanoparticles are considered an ideal agent for a wide range of applications such as contrast enhancement in magnetic resonance imaging (MRI), targeted drug delivery, drug localization by magnetic field etc. Materials engineering of nanoparticles with multifunctional features that combine magnetism, fluorescence, and surface functionalization is emerging as a major field in diagnosis and therapy. We have synthesized magnetic nanophosphors (MNPs), characterized their magnetic and luminescent properties, and used them as contrast enhancing agents in the study of MRI of cancerous tumor in mice. Significant enhancement in contrast is observed suggesting that an early detection of cancerous-tumor is now feasible using MNPs. This breakthrough of MNPs is expected to impact the targeted drug delivery platform for therapeutic applications. The role of MNPs in the near future could be extended as a magnetic carrier for targeted drug delivery. This would open the door for reducing the dosage and efficacy in therapeutics. Several applications of this breakthrough in nano-biotechnology will be discussed.

Silica nanoparticles Containing Aqueous Oxidising and Antimicrobial Products, *Dr. Jaime Rocha Gomes* and Frederico Maia (*University of Minho, Department of Textile Engineering, Guimarães, Portugal, **Ecoticket.Ecological Applications of Nanoparticles, 4710 Braga, Portugal)***

Silica nanoparticles are known by their innocuous effect and their biocompatibility. We present nanoparticles of silica, produced through a modified Stöber method, whereby hydrophilic water soluble products can be immobilized.

We have synthesized nanoparticles of silica with hydrogen peroxide, peracetic acid, amines, dyes and coated particles with silver from silver salts. These nanoparticles were prepared by sol-gel, using an inorganic precursor of silica, and characterized by SEM, EDS and TEM. The evaluation of the peroxide immobilized was also made by redox titration.

The produced nanoparticles were applied to textiles substrates and show good affinity to the natural fibers and good wash fastness. Companies that will be interested in this technology are detergent and stain remover manufacturers, toothpaste manufacturers and chemical suppliers to textiles companies.

Production of Biotechnological Lipid A-phosphate Analogues with Antagonistic Effects in Chronic Inflammation and Allergies, *Dr. H. H. Paradies@ and K. Zimmermann§ (@Institut Charles Gerhardt de Montpellier, ICGM, Montpellier cedex 5, France, §The Symbio Herborn Group Inc., Institute for Microecology, Herborn, Germany)*

A process is disclosed for the production and therapeutic application of non-endotoxin biological materials isolated and cultured from selected individual strains form patients, which have been afflicted with acute or chronic infections, and can be found in fess, sputum, urine, or specific areas of infection. The isolated and selected e.g. Gram-negative enterobacteriaceae (*E. coli)* are freed from enterotoxins, adhesions, and entero-hemolysines, or *eae* gene sequences, EHEC, EPEC, or molecules associated with endotoxicity (EP 1 341 546, 2002, PCT; WO 02/28424 A2, 2002; US 09/971,557 pending). It also possesses beneficial effects in clinical therapy against chronic inflammatory diseases e.g. radiation damages in tumor therapy by improving the cellular immune system, and decreasing resistance to antibiotics. It has been demonstrated that the growth of enteric bacteria can be affected by acute or chronic diseases: (i) bacterial and viral

infections in response to foreign and resistant invaders; (ii) environmental conditions; (iii) reactions to food (*Salmonella);* (iv) rheumatism and allergic reactions to mites, pollens and animal hair. This congenial system is built from unique chemical entities and assembles into a number of distinct superstructures.

11.12 –11.30 a.m. Networking Break

11.30 a.m.–1.20 p.m.

Session VI – Emerging Laboratory Technologies Related to Colloids, Nanoparticles, Nano-Engineered Materials and Green Technologies Potential for Commercialization

Session Chair and Moderator – Dr. Samuel Brauer, *Principal, NanoTech Plus, LLC, Stamfor, CT*

Economical Green Synthesis of Nanoporous Silica, Enabling Material to Clean Environment, *Dr. I. Sokolov*, *Department of Physics, Department of Chemical and Biomolecular Science, Nanoengineering and Biotechnology Laboratories Center (NABLAB), Center for Advanced Materials Processing, Center for the Environment, Clarkson University, Potsdam, NY*

We describe a novel material, nanoporous silica, which can be used for cleaning various contaminations and pollutants. One gram of this material has more surface area than an entire football field. Thus, it can adsorb a substantial amount of various compounds. Different nanoporous silica materials have been known for decades. Here we describe a novel economical green-chemistry synthesis of the nanoporous silica, which makes the suggested cleaning economically meaningful.

Green Mineral Beneficiation Technology – Development of Environmentally Benign Bioreagents and Bioprocessing for Mineral Beneficiation, ***Dr. K. A. Natarajan,*** *Department of Materials Engineering, Indian Institute of Science, Bangalore, India*

Environmentally benign and cost effective biotechnological processes to beneficiate difficult and complex ores such as hematite-alumina-silica, low grade bauxites and multimineral sulfides have been developed based on microbially-induced flotation and flocculation. Mineral-specific bioreagents such as bioproteins and exopolysaccharides were biochemically synthesized through growth of bacteria such as *Paenibacillus polymyxa*, Sulfate Reducing Bacteria, *Bacillus subtilis* and yeasts in the presence of various minerals. Utility of such as bioreagents in the separation of alumina from hematite, silica from bauxite, iron ores and limestone, sphalerite from galena as well as arsenopyrite from pyrite and chalcopyrite is demonstrated. The laboratory-demonstrated biobeneficiation processes pave the way for development of green mineral beneficiation technologies which are cost effective, energy-efficient and environmentally benign.

Carboranethiol Isomers Providing Molecular Protection of Silver Surfaces - Potential for Nano-enabled Sensors, ***Dr. Tomás Base, Jonathan Bould, Michael G.S. Londesborough****, Academy of Sciences of the Czech Republic, Institute of Inorganic Chemistry, Husinec-Rez, Czech Republic*

We have shown recently that carboranethiol species, functionalized inorganic clusters with rigid icosahedral geometry, can be immobilized on gold surfaces. These species exhibit particularly high stability towards heating, X-ray radiation, and chemical substitution, and these features make them good candidates for the molecular protection of silver surfaces against corrosion by hydrogen sulfide. The ability of these species to block the corrosion by H_2S in accelerated tarnishing tests, and a comparison with various organic thiols will be presented. Aside to the remarkable capacity for the protection of silver surfaces, we have recently investigated that several metallaborane clusters can selectively and reversibly

uptake and release small molecules of gases such as O_2, CO, SO_2, CO_2 and others, and can potentially be used as sensors.

Food and Cosmetic Thickeners from Sugar-based NanoGels: A Biorefinery Approach, ***Swapnil Rohidas Jadhav* and Dr. George John,** *Department of Chemistry, The City College of New York, and The Graduate School and University Center of The City University of New York, New York, NY*

Utilizing biorefinery concept for converting crop-based resources to functional materials is a cynosure of new manufacturing paradigm. The present study focus of developing sugar-based low molecular weight gels (NanoGels) by biocatalysis exemplifies the above approach. The underexplored sugar alcohols (e.g. mannitol and sorbitol) were quantitatively converted to amphiphiles by one step enzyme-mediated regioselective transesterification reaction and with minimal purification protocol. The resulting amphiphiles were studied for their self-assembling behavior in organic liquids. Intriguingly the short chain amphiphiles $\{(CH_2)_{4\text{-}8}\}$ exhibited an unprecedented capability to gel nearly all kinds of oils (including vegetable oils). The efficiency of the short chain sugar amphiphiles as an alternative structuring agents for vegetable oils compared to existing oil structuring agents was studied. In addition, effect of chiral and structural variations in sugar amphiphiles on microstructure formation (responsible for immobilization of organic liquid) was also investigated. Since the developed amphiphiles being short chain molecules eliminates increment of hyperchloesteromic long chain fatty acid to the oil during structuring. Thus, the sugar-based amphiphiles and the assembled NanoGels are potential healthy oil thickening agents and may find potential applications in food and cosmetic industry.

Simple Preparation Methods of ZnO of Various Sizes and Morphologies, ***Zorica Crnjak Orel*[1], Marko Bitenc[1], Yuri M. Strzhemechny[2]** *([1]National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia; [2]Texas Christian University, Fort Worth, Texas, USA)*

ZnO as a powder or film was prepared from non-hazardous "green" initial chemicals, based on zinc salts and urea, by solvothermal homogenous precipitation at low reaction temperature (< 363 °K) in water/polyol based mixture. The main advantages are cost-effective preparation by using simple lab technique (open reactor with constant stirring) with scale-up possibilities, fast ZnO particle growth (up to few hours) and a good control of particles sizes and morphologies, which influence the material properties. Possible applications of the ZnO particles prepared by our methods are in the fields of solar cells, UV absorbers, UV lasers and other light emitting devices, catalysts, etc.

Regarding various reaction conditions the ZnO particles could be formed in hexagonal rod-like and microspherical porous particles, where the length of rod-like particles could be tuned between nano (below 100 nm) and micro scale (up to 8 μm). The specific surface area of microspheres is over 50 m^2/g.

The nano rod-like particles have strong green luminescence emission at ~570 nm (2.17 eV) while the bigger rod-like particles have beside green emission also strong UV emission at ~ 390 nm (3.18 eV).

1.20 –1.25 p.m.
Concluding Remarks

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