

Annual Research Summary

January - December 2008

**Kamat Research Group
University of Notre Dame**



Summer 2008

Prashant V. Kamat

Professor, Chemistry & Biochemistry
Concurrent Professor, Chemical & Biomolecular Eng.
Senior Scientist, Radiation Laboratory
Notre Dame, IN 46556-5674, USA

Tel. (574) 631-5411 Fax (574) 631-8068
E-mail: PKAMAT@nd.edu;
Website: <http://www.nd.edu/~pkamat>

2008 Activities/ Highlights

Research Group

Graduate Students

David Baker (Chem. Eng.)
Matt Becker (Physics - coadv. Bruce Bunker)
Clifton Harris (Chemistry)
Ian Lightcap (Chemistry)
Ben Meekins (Chem Eng.)
Sean Murphy (Chemistry - coadv. Libai Huang)
Brian Seger (Chem. Eng.)
Kevin Tvrdy (Chemistry)
Yunghai Yu (Chem. Eng. –coadv. Ken Kuno)

Undergraduate Students:

Spring 2008

Meghan Jebb (Chemistry, UND)
Patrick Brown (Chemistry, UND)
Sohaib Hashimi (Chemistry, UND)
Marius Koch (Univ. Bielefeld, Germany)

Summer 2008

Julia Edel (Summer REU)
Marius Koch (Univ. Bielefeld, Germany)
Graeme Williams (U. Waterloo)

Fall 2008

Blake Farrow (U. Waterloo)
Patrick Brown (Chemistry, UND)
Chris Rodriguez (CBE, UND)
Peter Lobaccaro (CBE, UND)
Rachael Staran (Chemistry, UND)

Spring 2009

Blake Farrow (U. Waterloo)
Patrick Brown (Chemistry, UND)
Chris Rodriguez (CBE, UND)
Peter Lobaccaro (CBE, UND)

Postdoctoral Research Associate:

Jin Ho Bang
Alexsandra Wojcik
Vidhya Chakrapani

Visiting Scientists

K. Vinodgopal and Julie Peller (Indiana Univ. N. W.)
Julie Peller (Indiana University, Northwest)
Roxana Nicolaescu (Serim Corporation)
Yun Hau Ng (Osaka University, Summer 2008)
Jun Zhang (Huazhong Normal University, Wuhan)

Awards/Fellowships/Recognition

Fellow of The Electrochemical Society (2008)

Executive Editor, The Journal of Physical Chemistry A/B/C (2008)

Student Awards

David Baker, Winner of 2008 Notre Dame Graduate Student poster presentation contest.

Winner of Graduate Student Poster Presentation, 2009 National Conf., American Indian Sci. & Eng. Soc. (AISES)

Tom Hawk (John Adams High School Senior), Winner 2008 Indiana Talent Search

2008 Siemens Westinghouse semifinalist.

Patrick Brown, 2008 Norbert Wiech award. This Award is given annually by the

Department of Chemistry and Biochemistry to recognize outstanding achievements of a junior.



Patrick Brown -Receipient of 2008 Norbert Wiech award

Professional Activities

- **Executive Editor** , Journal of Physical Chemistry A/B/C (2008- present)
- **Editorial Advisory Board:**
 - Langmuir (2000-present)
 - Interface (1999-present)
 - Electrochemical and Solid State Letters (September 2006-present)
 - International Journal of Photoenergy (2001-2008)
- **Committees.**
 - Awards and Honors Committee of the Electrochemical Society (2007-2011)
 - Treasurer: Fullerene, Nanotubes and Carbon Nanostructures Division, (2004-2008)
- **ND committees**
 - Member of the COS-COS
 - Awards Committee
 - ND Nano Executive Committee
- **Symposium Organizer.**
 - 2009 First International Symposium on Graphene.** (Spring Meeting of the Electrochemical Society, San Francisco)
 - 2009 Symposium on Metal and Semiconductor Nanoparticles** (Spring Meeting of the Electrochemical Society, San Francisco)
 - 2008 Symposium on Interfacial Electron Transfer and Solar Energy Conversion: From Molecules to Nanomaterials,** Spring meeting of the American Chemical Society, New Orleans.
 - 2008 Symposium on Metal and Semiconductor Nanoparticles** (Spring Meeting of the Electrochemical Society, Phoenix)

SEMINAR PRESENTATIONS (2007-1994)

Indian Association for Cultivation of Science, Kolkata, India, December 16-19, 2008.

- (i) *Solar energy - beyond the hype;*
- (ii) *Semiconductor nanocrystals as light harvesters*
- (iii) *Keys to succeed in research (A preparatory talk for young researchers)*

Indian Institutes of Science Education and Research, Trivandrum, India

Nanostructured materials for solar energy conversion and beyond, November 29, 2008.

National Institute for Interdisciplinary Science and Technology, Trivandrum

Harvesting light energy with semiconductor nanocrystals, November 28, 2008

Central Electrochemistry Research Institute, Karaikudi, India, Diamond

Jubilee Lecture, *Meeting clean energy challenge with nanotechnology, December 1, 2008.*

Rensselaer Polytechnic Institute, Materials Research Center, Troy, NY, *Solar cell by design, nanostructure assemblies as light harvesters, November 5, 2008.*

Institute for Organic Synthesis and Photoreactivity, National Research Council Campus, Bologna, Italy, *Harvesting Light Energy with Nanostructure Architectures.*

University of Michigan-Dearborn, Chemistry Department Colloquium, September 26, 2008, *Semiconductor Architectures for Next Generation Solar Cells*

Cornell University, Center for Nanoscale Systems, *Nanostructure architectures for next generation solar cells, September 18, 2008.*

Carnegie Mellon University, Chemical Engineering Department Colloquium, Pittsburgh, PA *Nanoscience opportunities for light energy conversion, May 1, 2008.*

University of Washington, Department of Chemistry Seminar, *Nanostructure Architectures for Light Energy Conversion. , April 30, 2008.*

Conference Presentations (2008)

US - North Africa Regional Workshop (NSF) on Nanostructured Materials and Nanotechnology. 2008. Tunis, Tunisia.. Kamat, P. V. Semiconductor nanostructure assemblies for next generation solar cells. **Invited**

235th American Chemical Society meeting, New Orleans, April 6-9, 2008.

(i) Kamat, P. V., Kongkanad, A.; Tvrđy, K.; Takechi, K.; Kuno, M. Quantum Dot Solar Cells.

(ii) Kamat, P. V. Nanostructure Hybrid Architectures as Next Generation Photocatalysts.

Invited

(iii) Kamat, P. V., Brown, P.; Kongkanand, A. Carbon Nanotube- Semiconductor and TiO₂ Nanotube-Quantum Dot Architectures for Light Energy Conversion

(iv) Kamat, P. V.; Jebb, M.; Thomas K. G. Chromophore Functionalized Gold Nanoparticles and Nanorods **Invited**

Annual Meeting of the Electrochemical Society. 2008. Phoenix, AZ.

(i) Kamat, P. V.; Patrick, B.; Muszynski, R. Decorating carbon nanotubes and graphene with semiconductor and metal nanoparticles.

(ii) Kamat, P. V.; Kongkanand, A. Electron storage and charge equilibration in SWCNT-semiconductor nanoparticles. **Invited**

(iii) Baker, D.; Kamat, P. V. Deposition of CdS quantum dots on electrochemically etched TiO₂ nanotubes for solar cell applications. **Invited**

(iv) Kamat, P. V.; Tvrđy, K. Charge injection from excited CdSe into TiO₂.

DOE Solar Photochemistry Research Conference. 2008. Wintergreen, VA.

Kamat, P. V.; Kongkanand, A.; Tvrđy, K.; Brown, P.; Robel, I. Quantum dot solar cells modulation of photoresponse with particle size and I-D support architecture. **Invited**

1st International Conference from Nanoparticles & Nanomaterials to Nanodevices and Nanosystems (IC4N), Halkidiki, Greece, June 16-18, 2008

Kamat, P. V.; Baker, D.; Tvrđy, K.; Kongkanand, A. CdSe Quantum Dot – TiO₂ Nanotube Architectures for Solar Cells. **Invited**

Conference on Complex and Nanostructured Materials for Energy Applications, June 22-26, 2008, Michigan State University, Lansing, MI.

Kamat, P. V. Nanostructured Assemblies for Light Energy Conversion. **Invited**

International Conference on Electrochemical Power Systems (ICEPS-2008). Trivandrum, India.

Kamat, P. V. Nanostructure assemblies for next generation solar cells. **Invited**

Workshop on Nanoscience for Solar Energy Conversion, Trieste, Italy, November 26-29, 2008.

Kamat, P. V. Quantum Dot Solar Cells, Semiconductor Nanocrystals as Light Harvesters. **Invited**

Structure and Dynamics at Interfaces in Inorganic Nanostructures Workshop. 2008. Lawrence

Livermore Laboratory, Berkeley, CA. Kamat, P. V. Quantum dot solar cells. Tuning the photoresponse with semiconductor nanocrystals and interfacial architectures. **Invited**

Research Papers:

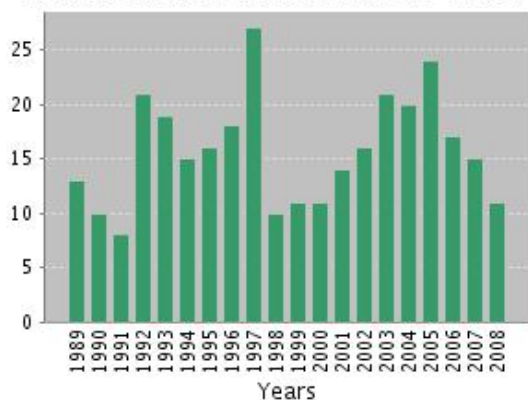
1. Harris, C. T.; Kamat, P. V., *Photocatalysis with CdSe Nanoparticles in Confined Media: Mapping Charge Transfer Events in the Subpicosecond to Second Timescales*. **ACS Nano**, 2009. 3, in press.
2. Koch, M.; Nicolaescu, R.; Kamat, P. V., *Photodegradation of Polythiophene Based Polymers. Excited State Properties and Radical Intermediates*. **J. Phys. Chem. B**, 2009. 113, in press (doi:10.1021/jp08141u).
3. Seger, B.; Kamat, P. V., *Electrocatalytically Active Graphene-Platinum Nanocomposites. Role of 2-D Carbon Support in PEM Fuel Cells*. **J. Phys. Chem. C** 2009. , submitted.
4. Tvrđy, K.; Kamat, P., *Substrate driven photochemistry of CdSe Quantum Dot Films: Charge Injection and Irreversible Transformation on Oxide Surfaces*, . **J. Phys. Chem. C**, 2009. 113, in press.
5. Baker, D. R.; Kamat, P. V., *Photosensitization of TiO₂ Nanostructures with CdS Quantum Dots. Particulate versus Tubular Support Architectures*. **Advanced Functional Materials**, 2009 in press.
6. Kamat, P. V., *Quantum Dot Solar Cells. Semiconductor Nanocrystals as Light Harvesters*. **J. Phys. Chem. C**, 2008. 112, 18737-18753. (Centennial Feature Article)
7. Kamat, P. V., *Book Review of Organic Nanostructures*. **J. Am. Chem. Soc.**, 2008. 130, 14020-14020.
8. Matsunaga, Y.; Takechi, K.; Akasaka, T.; Ramesh, A. R.; James, P. V.; Thomas, K. G.; Kamat, P. V., *Excited State and Photoelectrochemical Behavior of Pyrene Linked Phenyleneethynylene Oligomer*. **J. Phys. Chem. B**, 2008. 112, 14539-14547.
9. Williams, G.; Seger, B.; Kamat, P. V., *TiO₂-Graphene Nanocomposites. UV-Assisted Photocatalytic Reduction of Graphene Oxide*. **ACS Nano**, 2008. 2, 1487-1491.
10. Brown, P.; Kamat, P. V., *Quantum Dot Solar Cells. Electrophoretic Deposition of CdSe-C₆₀ Composite Films and Capture of Photogenerated Electrons with nC₆₀ Cluster Shell*. **J. Am. Chem. Soc.**, 2008. 130, 8890-8891.
11. Muszynski, R.; Seger, B.; Kamat, P., *Decorating Graphene Sheets with Gold Nanoparticles*. **J. Phys. Chem. C**, 2008. 112, 5263 - 5266.
12. Brown, P. R.; Takechi, K.; Kamat, P. V., *Single-Walled Carbon Nanotube Scaffolds for Dye-Sensitized Solar Cells*. **J. Phys. Chem. C**, 2008. 112, 4776-4782.
13. Kongkanand, A.; Tvrđy, K.; Takechi, K.; Kuno, M. K.; Kamat, P. V., *Quantum Dot Solar Cells. Tuning Photoresponse through Size and Shape Control of CdSe-TiO₂ Architecture*. **J. Am. Chem. Soc.**, 2008. 130, 4007 - 4015.
14. Wan, J.; Ferreira, A.; Xia, W.; Chow, C. H.; Takechi, K.; Kamat, P. V.; Guilford Jones, I.; Vullev, V. I., *Solvent Dependence of the Charge-Transfer Properties of a Quaterthiophene-Anthraquinone Dyad*. **J. Photochem. A**, 2008. 197, 364-374.
15. Takechi, K.; Kamat, P. V.; Avira, R. R.; Jyothi, K.; Ramaih, D., *Harvesting Infrared Photons with Croconate Dyes* **Chem. Mater.**, 2008. 20, 265 - 272.
16. Zhang, Z.; Meisel, D.; Kamat, P.; Kuno, M., *Layer-by-layer self-assembly of colloidal gold-silica multilayers*. **J. Chem. Ed.**, 2008.

17. Seger, B.; Kongkanand, A.; Vinodgopal, K.; Kamat, P. V., *Platinum Dispersed on Silica Nanoparticles for PEM Fuel Cells*. **J. Electroanal. Chem.**, 2008. 621, 198-204.
18. Hasobe, T.; Fukuzumi, S.; Kamat, P. V.; Murata, H., *Fullerene-Based Supramolecular Nanoclusters with poly[2-methoxy-5-(2'-ethylhexyloxy)-p-phenylenevinylene] (MEH-PPV) for Light Energy Conversion*. **Jap. J. Appl. Phys.**, 2008, 47 1223-1229.
19. Kamat, P. V., *Book Review of Organic Nanostructures*. **J. Am. Chem. Soc.**, 2008. 130, 14020-14020.

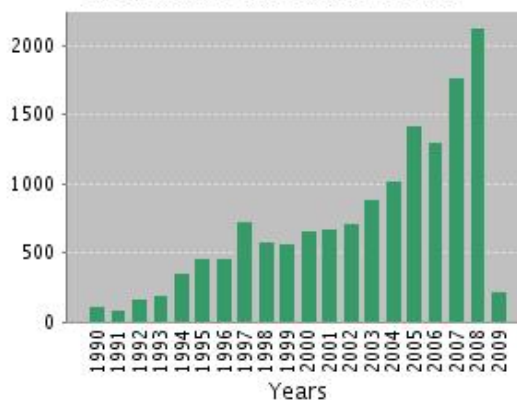
ACS Nanotube Video on Graphene-TiO₂ nanocomposites.
ACS NANO 2008, 2 1487

Publication Analysis

Published Items in Each Year



Citations in Each Year



(Source Web of Science)

Quantum Dot Solar Cells. Semiconductor Nanocrystals as Light Harvesters

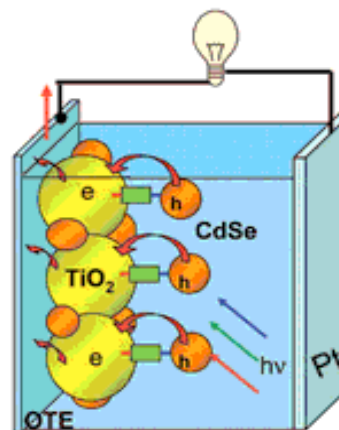
Prashant V. Kamat

J. Phys. Chem. C, 2008, 112 (48), pp 18737-18753

DOI: [10.1021/jp806791s](https://doi.org/10.1021/jp806791s)

Abstract

The emergence of semiconductor nanocrystals as the building blocks of nanotechnology has opened up new ways to utilize them in next generation solar cells. This paper focuses on the recent developments in the utilization of semiconductor quantum dots for light energy conversion. Three major ways to utilize semiconductor dots in solar cell include (i) metal–semiconductor or Schottky junction photovoltaic cell (ii) polymer–semiconductor hybrid solar cell, and (iii) quantum dot sensitized solar cell. Modulation of band energies through size control offers new ways to control photoresponse and photoconversion efficiency of the solar cell. Various strategies to maximize photoinduced charge separation and electron transfer processes for improving the overall efficiency of light energy conversion are discussed. Capture and transport of charge carriers within the semiconductor nanocrystal network to achieve efficient charge separation at the electrode surface remains a major challenge. Directing the future research efforts toward utilization of tailored nanostructures will be an important challenge for the development of next generation solar cells.



TiO₂-Graphene Nanocomposites. UV-Assisted Photocatalytic Reduction of Graphene Oxide

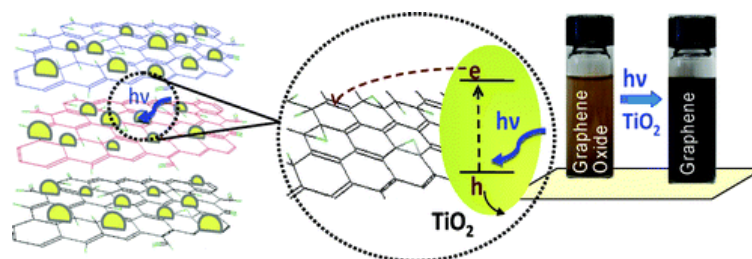
Graeme Williams, Brian Seger and Prashant V. Kamat

ACS Nano, 2008, 2 (7), pp 1487-1491

DOI: [10.1021/nm800251f](https://doi.org/10.1021/nm800251f)

Abstract

Graphene oxide suspended in ethanol undergoes reduction as it accepts electrons from UV-irradiated TiO₂ suspensions. The reduction is accompanied by changes in the absorption of the graphene oxide, as the color of the suspension shifts from brown to black. The direct interaction between TiO₂ particles and graphene sheets hinders the collapse of exfoliated sheets of graphene. Solid films cast on a borosilicate glass gap separated by gold-sputtered terminations show an order of magnitude decrease in lateral resistance following reduction with the TiO₂ photocatalyst. The photocatalytic methodology not only provides an on-demand UV-assisted reduction technique but also opens up new ways to obtain photoactive graphene-semiconductor composites.



Excited-State and Photoelectrochemical Behavior of Pyrene-Linked Phenyleneethynylene Oligomer

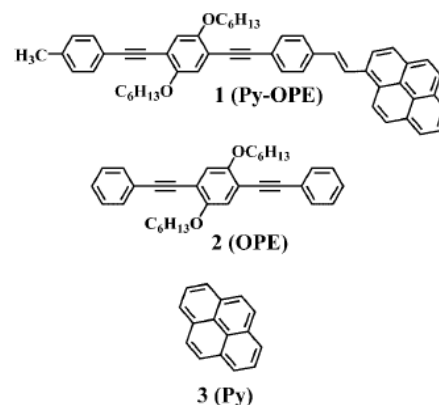
Yoichiro Matsunaga, Kensuke Takechi, Takeshi Akasaka, A. R. Ramesh, P. V. James, K. George Thomas and Prashant V. Kamat

J. Phys. Chem. B, 2008, 112 (46), pp 14539-14547

DOI: [10.1021/jp805878c](https://doi.org/10.1021/jp805878c)

Abstract

An oligophenyleneethynylene (OPE), 1,4-bis(phenyleneethynyl)-2,5-bis(hexyloxy)benzene (**2**), is coupled with pyrene to extend the conjugation and allow its use as a light-harvesting molecule [Py-OPE (**1**)]. The absorption and emission maxima of **1** are red-shifted compared to those of **2**. Similar differences in the singlet and triplet excited-state properties are evident. The fluorescence yield of **2** in toluene is 0.53, which is slightly less than the value for the parent OPE (**2**) of 0.66. The excited singlet and triplet of **1** as characterized from transient absorption spectroscopy exhibit lifetimes of 1.07 ns and 4.0 μ s, respectively, in toluene. When **1** was cast as a film on a glass electrode (OTE) and excited with a 387-nm laser pulse, we observed the formation of excitons that decayed within a few picoseconds. When **1** was cast as a film on a SnO₂-modified conducting glass electrode (OTE/SnO₂), a small fraction of excitons dissociated to produce a long-lived charge-separated state. The role of the SnO₂ interface in promoting charge separation was inferred from the photoelectrochemical measurements.



Quantum Dot Solar Cells. Electrophoretic Deposition of CdSe-C₆₀ Composite Films and Capture of Photogenerated Electrons with nC₆₀ Cluster Shell

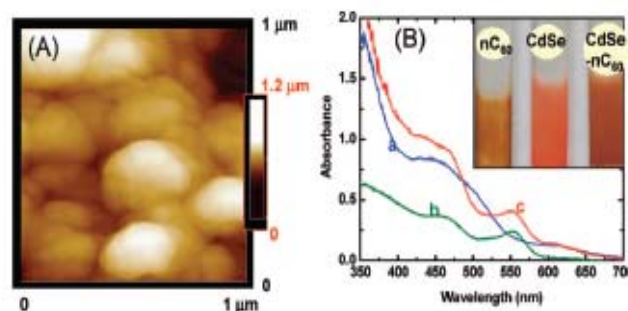
Patrick Brown and Prashant V. Kamat

J. Am. Chem. Soc., 2008, 130 (28), pp 8890-8891

DOI: [10.1021/ja802810c](https://doi.org/10.1021/ja802810c)

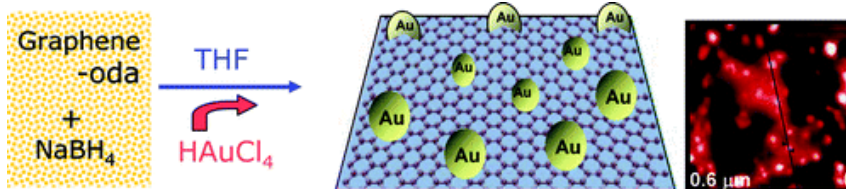
Abstract

Encapsulation with a nC₆₀ cluster shell facilitates capture of photogenerated electrons from CdSe quantum dots following visible light excitation. Electrophoretic deposition of CdSe-C₆₀ composite clusters on optically transparent electrodes (OTE/SnO₂) produce photoactive films that exhibit photoelectrochemical activity. The observed photoconversion efficiency (IPCE) of ~4% is significantly greater than those observed with CdSe or nC₆₀ films.



Decorating Graphene Sheets with Gold Nanoparticles

Ryan Muszynski, Brian Seger, and Prashant V. Kamat



J. Phys. Chem. C, 2008, 112 (14), pp 5263-5266

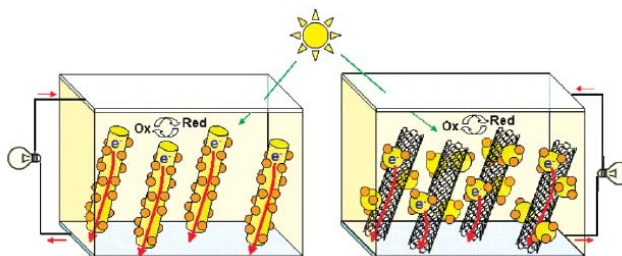
DOI: [10.1021/jp800977b](https://doi.org/10.1021/jp800977b)

Abstract

Renewed interest in graphene architectures has opened up new avenues to utilize them in electronic and optoelectronic applications. The desire to design graphene-metal nanohybrid assemblies has led us to explore a solution-based approach of chemical reduction of AuCl_4^- ions in graphene suspensions. The gold particles anchored on octadecylamine functionalized graphene are readily suspendable in THF medium. The dependence of particle stability on the graphene concentration and SEM analysis indicate that the gold nanoparticles are well dispersed on graphene sheets. Transient absorption spectroscopy measurements suggest that the ultrafast disappearance of plasmon absorption and its recovery are unaffected by the presence of graphene.

Single-Walled Carbon Nanotube Scaffolds for Dye-Sensitized Solar Cells

Patrick Brown, Kensuke Takechi, and Prashant V. Kamat



J. Phys. Chem. C, 2008, 112

DOI: [10.1021/jp7107472](https://doi.org/10.1021/jp7107472)

Abstract

The influence of single-walled carbon nanotube (SWCNT) architectures for facilitating charge transport in mesoscopic semiconductor films has been probed using a $\text{TiO}_2/\text{Ru(II)}$ trisbipyridyl complex system. Both transient absorption and emission measurements indicate that the SWCNT network in the film has no noticeable influence on the charge injection process from the excited Ru(II) trisbipyridyl complex into TiO_2 particles. However, it plays an important role in improving the charge separation, as the rate of back electron transfer between the oxidized sensitizer (Ru(III)) and the injected electrons becomes slower in the presence of the SWCNT scaffold. The beneficial aspect of charge collection by SWCNT has been further explored by carrying out photoelectrochemical measurements. The dye-sensitized solar cells constructed using this SWCNT scaffold show an improvement in the photocurrent generation. However, this improvement in photocurrent generation is neutralized by a lower photovoltage as the apparent Fermi level of the TiO_2 and SWCNT composite becomes more positive than that of pristine TiO_2 .

Quantum Dot Solar Cells. Tuning Photoresponse through Size and Shape Control of CdSe–TiO₂ Architecture

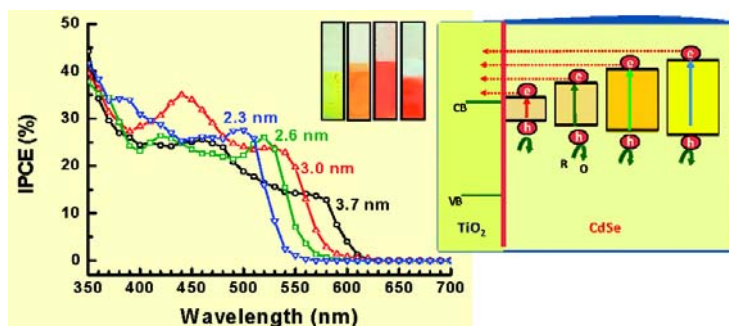
Anusorn Kongkanand, Kevin Tvrdy, Kensuke Takechi, Masaru Kuno, and Prashant V. Kamat

J. Am. Chem. Soc., 2008, 130 (12), pp 4007–4015

DOI: [10.1021/ja0782706](https://doi.org/10.1021/ja0782706)

Abstract

Different-sized CdSe quantum dots have been assembled on TiO₂ films composed of particle and nanotube morphologies using a bifunctional linker molecule. Upon band-gap excitation, CdSe quantum dots inject electrons into TiO₂ nanoparticles and nanotubes, thus enabling the generation of photocurrent in a photoelectrochemical solar cell. The



results presented in this study highlight two major findings: (i) ability to tune the photoelectrochemical response and photoconversion efficiency via size control of CdSe quantum dots and (ii) improvement in the photoconversion efficiency by facilitating the charge transport through TiO₂ nanotube architecture. The maximum IPCE (photon-to-charge carrier generation efficiency) obtained with 3 nm diameter CdSe nanoparticles was 35% for particulate TiO₂ and 45% for tubular TiO₂ morphology. The maximum IPCE observed at the excitonic band increases with decreasing particle size, whereas the shift in the conduction band to more negative potentials increases the driving force and favors fast electron injection. The maximum power-conversion efficiency $\leq 1\%$ obtained with CdSe–TiO₂ nanotube film highlights the usefulness of tubular morphology in facilitating charge transport in nanostructure-based solar cells. Ways to further improve power-conversion efficiency and maximize light-harvesting capability through the construction of a rainbow solar cell are discussed.

Book Review of Organic Nanostructures.

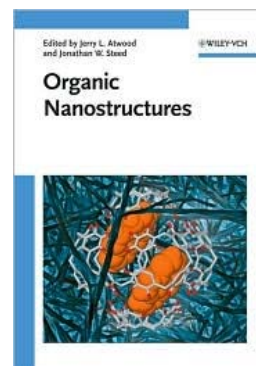
Prashant V. Kamat

J. Am. Chem. Soc., 2008, 130 (42), p 14020

DOI: [10.1021/ja807116w](https://doi.org/10.1021/ja807116w)

Organic Nanostructures. Edited by Jerry L. Atwood (University of Missouri-Columbia, USA) and Jonathan W. Steed (University of Durham, U.K.). Wiley-VCH GmbH & Co. KGaA: Weinheim.

2008. xviii + 352 pp. \$200. ISBN 978-3-527-31836-0.



Solvent dependence of the charge-transfer properties of a quaterthiophene-anthraquinone dyad

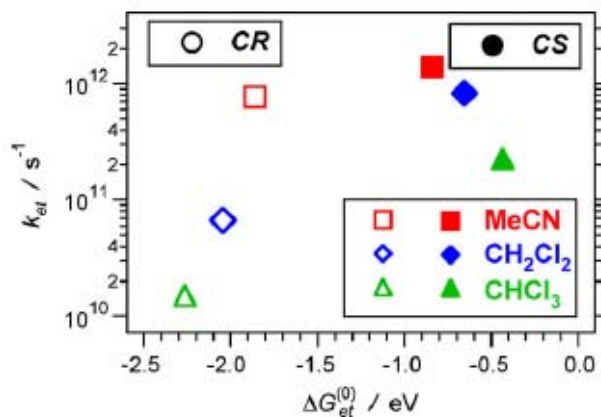
Jiandi Wan, Amy Ferreira, Wei Xia, Chak Him Chow, Kensuke Takechi, Prashant V. Kamat, Guilford Jones II, Valentine I. Vullev

J. of Photochem. and Photobio. A: Chem. 2008, 197, pp 364-374

DOI: [10.1016/j.jphotochem.2008.01.016](https://doi.org/10.1016/j.jphotochem.2008.01.016)

Abstract

An electron donor-acceptor dyad (quaterthiophene-anthraquinone) mediates ultrafast intramolecular photoinduced charge separation and consequent charge recombination when in polar or moderately polar solvents. Alternatively, non-polar media completely impedes the initial photoinduced electron transfer by causing enough destabilization of the charge-transfer state and shifting its energy above the energy of the lowest locally excited singlet state. Furthermore, femtosecond transient-absorption spectroscopy reveals that for the solvents mediating the initial photoinduced electron-transfer process, the charge recombination rates were slower than the rates of charge separation. This behavior of donor-acceptor systems is essential for solar-energy-conversion applications. For the donor-acceptor dyad described in this study, the electron-transfer driving force and reorganization energy place the charge-recombination processes in the Marcus inverted region.



Harvesting Infrared Photons with Croconate Dyes

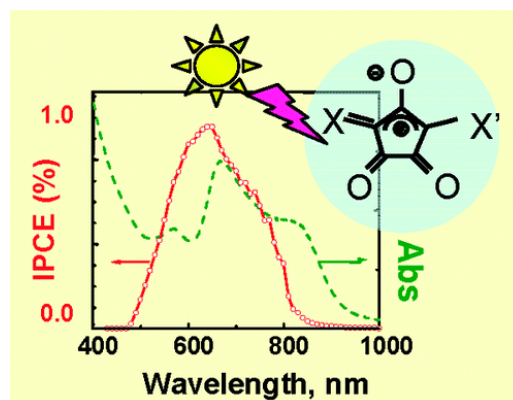
Kensuke Takechi, Prashant V. Kamat, Rekha R. Avirah, Kuthanapillil Jyothish, and Danaboyina Ramaiah

Chem. Mater., 2008, 20 (1), pp 265-272

DOI: [10.1021/cm7018668](https://doi.org/10.1021/cm7018668)

Abstract

Excited-state properties of the croconate dyes were investigated with an aim to utilize them as light harvesting assemblies in the infrared (IR) region ($\lambda_{\max} \sim 865$ nm and $M^{-1} \text{ cm}^{-1} = (1.4-4.2) \times 10^5 M^{-1} \text{ s}^{-1}$). The excited singlet of the monomeric dye quickly deactivates (lifetime 4-7 ps) without undergoing intersystem crossing to generate triplet. The triplet excited-state produced via triplet-triplet energy transfer method show relatively long life (lifetime 7.2 μs). The dye molecules when deposited as thin film on optically transparent electrodes or on nanostructured TiO₂ film form H-aggregates with a blue-shifted absorption maximum around 660 nm. The excitons formed upon excitation of the dye aggregates undergo charge separation at the TiO₂ and SnO₂ interface. The H-aggregates in the film are photoactive and produce anodic current (IPCE of 1.2% at 650 nm) when employed in a photoelectrochemical cell. Spectroscopic and photoelectrochemical experiments that highlight the usefulness of croconate dyes in IR light harvesting applications are described.



Layer-by-layer Self-Assembly of Colloidal Gold-Silica Multilayers

Zhenyuan Zhang, Dan Meisel, Prashant Kamat, Masaru Kuno

J. Chem. Educator, 2008, 13 (3), pp153-157

DOI: [10.1333/s00897082135a](https://doi.org/10.1333/s00897082135a)

Abstract

Strategies to obtain self-assembled monolayers (SAMs) of molecular entities as well as the underlying chemical principles leading to their formation have been described in the Journal. Here we adopt similar principles to self-assemble monolayers of gold nanoparticles (NPs) in a layer-by-layer fashion. The gold particles provide the functionality of component atoms in what would otherwise constitute a conventional lattice. Several successive Au NP monolayers, each separated by a silica layer, are then added to create a three dimensional (3D) multilayer. During the assembly, the student tests the effect of the medium's dielectric constant on the extinction spectrum of individual NP monolayers. Shifts in the plasmon band peak position illustrate the control one has over the optical and electrical properties of the 3D structure. Next, the student demonstrates through additional extinction measurements that no more than one Au NP monolayer is deposited at each step of the assembly when reaction conditions are judiciously chosen. Variations in the layer-by-layer deposition conditions may then be attempted to directly modify the extinction of the final structure. The entire experiment illustrates the construction of 3D assemblies of nanostructured materials whose intralayer- and interlayer- interparticle electronic and spectroscopic interactions can be controlled.

Platinum dispersed on silica nanoparticle as electrocatalyst for PEM fuel cell

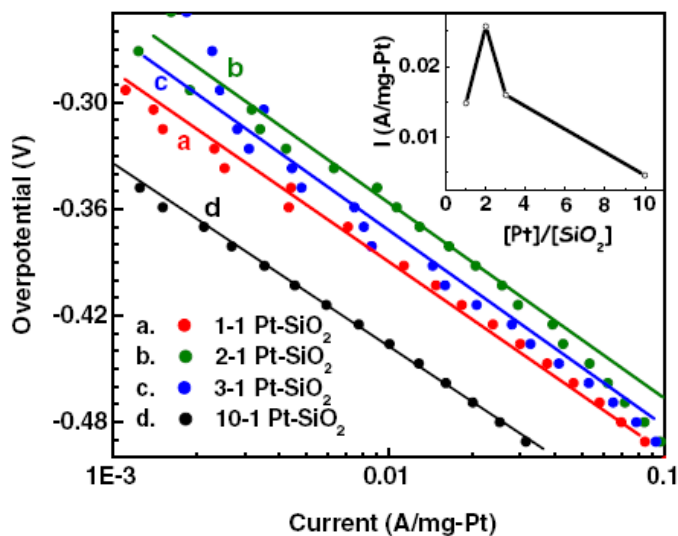
Brian Seger, Anusorn Kongkanand, K. Vinodgopal and Prashant V. Kamat

J. of Electroanal. Chem., 2008, 621, pp 198-204

DOI: [10.1016/j.jelechem.2007.09.037](https://doi.org/10.1016/j.jelechem.2007.09.037)

Abstract

Colloidal silica has been employed as a support material to disperse Pt and develop Pt-SiO₂ composites with electrocatalytic properties. The Pt-SiO₂ particles of ratio 1:1 and 2:1 show superior performance towards oxygen reduction reaction (ORR) as these composite particles form an interconnected particle-network and maximize the available electrochemically active area. Upon increasing the Pt content we observe decreased activity as a result of aggregation of particles. The performance of Pt-SiO₂ composite particles in H₂-fuel cell are compared with Pt-black catalyst.



Fullerene-Based Supramolecular Nanoclusters with Poly[2-methoxy-5-(2'-ethylhexyloxy)-*p*-phenylenevinylene] for Light Energy Conversion

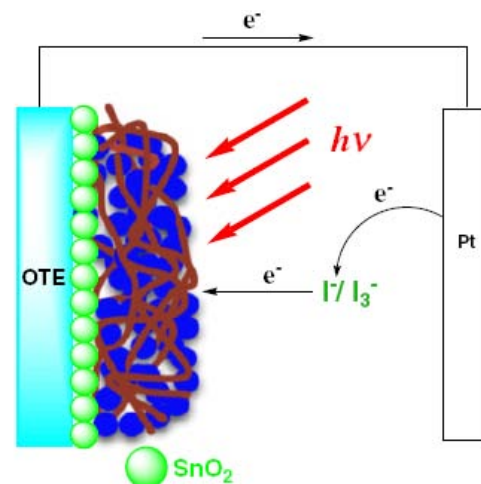
Taku Hasobe, Shunichi Fukuzumi, Prashant V. Kamat, and Hideyuki Murata

Jpn. J. Appl. Phys., 2008, 47 (2), pp1223-1229

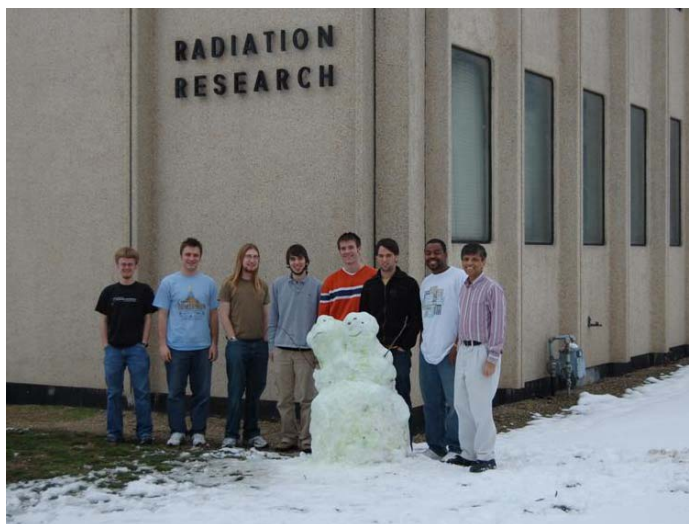
DOI: [10.1143/jjap.47.1223](https://doi.org/10.1143/jjap.47.1223)

Abstract

Organized composite molecular nanoassemblies of fullerene and poly[2-methoxy-5-(2'-ethylhexyloxy)-*p*-phenylenevinylene] (MEH-PPV) prepared in acetonitrile/toluene mixed solvent absorb light over the entire spectrum of visible light. The highly colored composite clusters can be assembled as a three-dimensional array onto nanostructured SnO₂ films by electrophoretic deposition approach. The composite cluster films exhibit an incident photon-to-photocurrent efficiency (IPCE) as high as 18%, which is significantly higher than that of a molecular assembly composed of 5,10,15,20-tetrakis(3,5-di-*tert*-butylphenyl)-21*H*,23*H*-porphyrin (H₂P) and C₆₀ prepared in the same manner (4%). The maximum IPCE value increases to 25% at an applied bias potential of 0.2 V vs saturated calomel reference electrode (SCE). The power conversion efficiency of a MEH-PPV and C₆₀ assembly-modified electrode is determined to be 0.24%. The photocurrent generation properties observed with MEH-PPV and C₆₀ clusters demonstrate the synergy of these systems towards yielding efficient photoinduced charge separation within these composite nanoclusters.



OTE: Optically Transparent Electrode



Wintertime at Notre Dame with two-headed snowman!

In the Press

Green Technology

Achieve a Sustainable Future with Green Technology. Create Innovation for New Energy.

◀ [Easy Ways to Reduce Energy Consumption](#) | [Main](#) | [Biofuel Market Forecast: Ethanol Margins, Corn Prices](#) ▶

NanoParticles TiO₂ Improve Solar Cell Efficiency

Univ of NotreDome researchers experiment with nanotechnology to evaluate the effectiveness of solar cell conversion. Professor Prashant V. Kamat is leading this research effort on nanotech and [light energy conversion](#), and shares this [recent presentation](#) (PP5), "Meeting the Clean Energy Challenge with Nanotechnology." ...

... "The researchers added single-walled carbon nanotubes to a film made of titanium-dioxide nanoparticles, doubling the efficiency of converting ultraviolet light into electrons when compared with the performance of the nanoparticles alone." ...

Via Technology Review: [Nanotechnology for Solar Cell Efficiency](#)



http://www.greentecholog.com/2007/03/nanoparticles_tio2_improve_solar_cell_efficiency.html



Posted: March 6, 2008

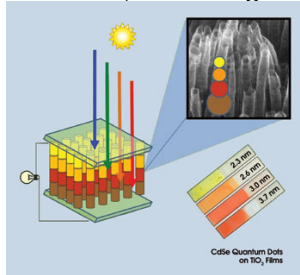
Catching a rainbow - quantum dot nanotechnology brightens the prospects for solar energy (*Nanowerk Spotlight*)

Harnessing the power of the sun to replace the use of fossil fuels holds tremendous promise. One way to do this is through the use of solar, or photovoltaic, cells. Large-scale installation already show the technical feasibility of this technology although the major problem of photovoltaic solar energy - its relative inefficiency - still needs to be overcome to make the cost of electricity produced by solar cells equal or less than electricity produced by nuclear or fossil fuels. Until now, solar cells that convert sunlight to electric power have been dominated by solid state junction devices, often made of silicon wafers. Efforts are being made in laboratories worldwide to design ordered assemblies of semiconductor nanostructures, metal nanoparticles and carbon nanotubes for constructing next generation solar energy conversion devices.



Nanophotonics | May 2008
Putting All of the Sunshine to Work in Solar Cells

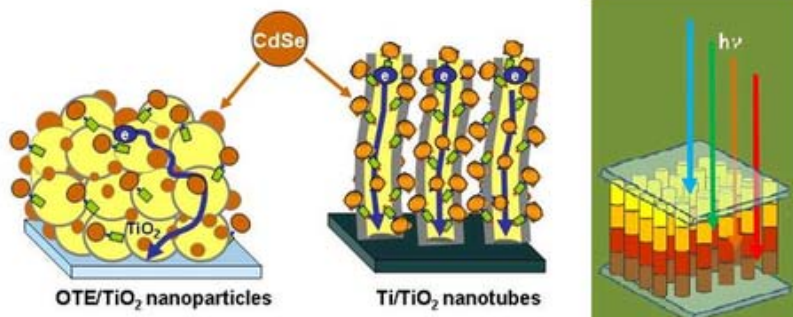
Despite extensive research and development, solar cells still fall woefully short of perfection. Commercially available units convert only about 15 percent of the light that falls on them into electricity. Now a team from the University of Notre Dame in Indiana, led by professor Prashant V. Kamat, has deposited quantum dots of various sizes onto TiO₂ nanotubes. The resulting device generated photocurrent with conversion efficiency conservatively estimated by the group to be at least 1 percent. Nonetheless, the technology could form the basis for new solar cells, according to Kamat.



This is an artist's rendering of a "rainbow" solar cell. Quantum dots of various sizes absorb blue, green and red light at different depths. Shown in the inset is a rendering of the quantum dots attached to nanoscale tubes of TiO₂.

Quantum Dots May Lead to Rainbow Solar Cell

By Lisa Zyga



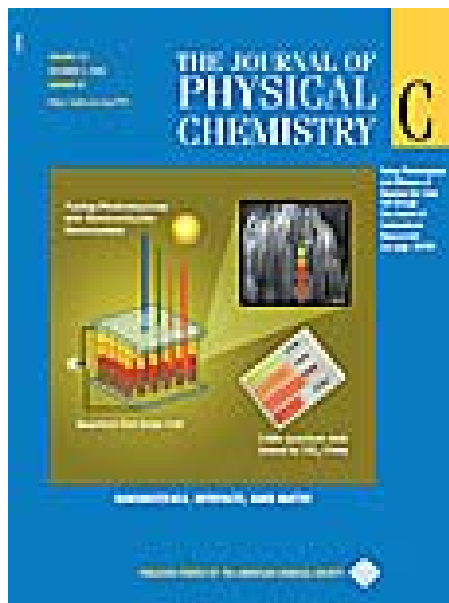
Electron transport through a structure of nanoparticles (left) and more ordered nanotubes (center) is shown. At right, different wavelengths of light can be absorbed by different-sized quantum dots layered in a "rainbow" solar cell. Image credit: Kongkanand, et al.

Toolbox

- Rating:
- Bookm
- Save a
- Print
- Email
- Blog It
- Digg It
- del.icio
- Slashd
- Stumbl
- A A A +

©2008 ACS

The group of researchers from the University of Notre Dame, Anusorn Kongkanand, Kevin Tvrdy, Kensuke Takechi, Masaru Kuno, and Prashant Kamat, have published their study in a recent issue of the *Journal of the American Chemical Society*. Their research was funded by the Office of Basic Energy Sciences of the Department of Energy.



Cover Page, J. Phys. Chem C 2008 Issue No 48 pp 18737–18753
 DOI: [10.1021/jp806791s](https://doi.org/10.1021/jp806791s) (Centennial Feature Article)