

SCOTT C. WARREN

Non-Equilibrium Energy Research Center
Dept. of Chemistry, Dept. of Chem. & Bio. Eng.
Northwestern University
Evanston, IL 60201

s-warren@northwestern.edu
<http://s-warren.com>
phone: 312-350-0862

EDUCATION

Ph.D. in Chemistry & Chemical Biology, Cornell University, 2007

Dissertation: Nanoparticle-block copolymer self-assembly

M.S. in Chemistry & Chemical Biology, Cornell University, 2004

B.A. in Chemistry with Honors, Whitman College, 2002

Honors Thesis: Improving efficiency in solar-powered water splitting

HONORS

- Research and mentoring profiled in: MRS Bulletin, 2011, C&E News, 2008; Nat. Mater., 2008, 2007; Cornell Chronicle, 2008, 2007; Nanowork, 2008; Science, 2006; MRS e-bulletin, 2006; Great Ideas (a publication of Cornell University), 2006; Cornell University Graduate News, 2005; Ithaca Times, 2004; Whitman Magazine, 2002
- IUPAC Prize for Young Chemists, Glasgow, Scotland, 2008/2009
- Prix Speciale du Doyen, "Dean's Special Prize," for directing and writing a successful European Commission Framework Programme 7 proposal to form NanoPEC, a \$6 million, 8-institution consortium for developing solar hydrogen production, EPFL, 2008
- Second Prize for Outstanding Contributed Talk, at the first European Science Foundation Conference on Nanotechnology for Sustainable Energy, Obergurgl, Austria, 2008
- Marilyn Emmons Williams Award, presented annually to the dean, administrator, faculty member, or student who has most contributed to promoting undergraduate research, Cornell Undergraduate Research Board, 2007
- The Tunis Wentink Prize, awarded annually in recognition of significant scientific contributions, Department of Chemistry & Chemical Biology, Cornell University, 2007
- MRS graduate student Silver Award, Boston, MA, 2006
- First-place poster, EPA Science to Achieve Results (STAR) conference, Washington, DC, 2006
- Pan-American Studies Institute Fellowship from the NSF to attend TEM workshop in Santiago, Chile, 2006
- EPA STAR fellowship, 2004-2007
- DOE undergraduate travel award to attend AAAS meeting in Boston, MA, 2002
- Energy Research Undergraduate Laboratory Fellowship from the DOE, 2000-2002

RESEARCH EXPERIENCE

Postdoctoral research with Bartosz Grzybowski, Northwestern University, 2011-Present

- Initiated a research project on spatially localized mechanochemistry.
- Exploring the use of plasmonic nanoparticles as a photovoltaic device.

Postdoctoral research with Michael Grätzel, Swiss Federal Institute of Technology and Avner Rothschild, Technion-Israel Institute of Technology, 2007-2011

- Organized, developed, and wrote a collaborative grant proposal on behalf of 8 laboratories from across Europe. Title: “Nanostructured Photoelectrodes for Energy Conversion” (NanoPEC). The proposal was successful and provides 4 million euros (6 million USD) over 3 years.
- Demonstrated the first plasmon-based water splitting system for enhanced solar-powered hydrogen production.
- Directed ongoing NanoPEC activities: coordinated the completion of deliverables, hired students, initiated collaborations, and led meetings.
- Developed a combined TEM and photoelectrochemical technique to enable structure-electrochemical correlations.
- Devised a silica-based sol-gel process that produces porous metal percolation networks. The nanocomposites have an electrical conductivity 6 orders of magnitude higher than other porous silica-based nanocomposites, opening the possibility for use as an electrode in high-current devices.
- Designed and taught a course at a winter school for graduate students: “Surface Science: Fundamentals, Properties, & Selected Applications,” Les Diablerets, Switzerland, 2009.

Graduate research with Ulrich Wiesner and Frank DiSalvo, Cornell University, 2002-2007

- Invented ordered mesoporous metals that self-assemble from metal nanoparticles and block copolymers. The materials exhibit the highest electrical conductivity yet reported for mesoporous materials derived from block copolymers.
- Developed a ligand chemistry for metal nanoparticles that imparts liquid-like properties to nanoparticles in the absence of a solvent.
- Discovered an environmentally friendly method for synthesizing monodisperse, electropositive metal nanoparticles.
- Used nanoparticle size to control nanoparticle placement in nanoparticle-block copolymer hybrids. Found that silica mesostructures disassemble into ordered structures.
- Mentored 11 undergraduate students in laboratory work by designing suitable research projects, teaching safe laboratory practices, and offering solutions to difficulties as they arose. All students continue scientific work in graduate school or industry.
- Instructed and supervised laboratory students in general chemistry and analytical chemistry courses. Developed lessons, taught a review section for hundreds of students, and tutored students one-on-one and in small groups.

Undergraduate research with John Turner, National Renewable Energy Lab, summers 2000-2002

- Investigated surface treatments for a III-V semiconductor for solar-driven hydrogen production. Discovered a set of porphyrins that shift the conduction and valence band edges of GaInP₂ into the appropriate energy range for water splitting.

PEER REVIEWED PUBLICATIONS

1. S. C. Warren. Emerging trends in water photoelectrolysis. Photoelectrochemical hydrogen production. Editors: R. van de Krol, M. Grätzel. In press.
2. H. Dotan, K. Sivula, M. Graetzel, A. Rothschild, S. C. Warren. Probing the photoelectrochemical properties of hematite (α -Fe₂O₃) electrodes using hydrogen peroxide as a hole scavenger. *Energy Environ. Sci.* **4**, 958-964 (2011).
This was highlighted in the MRS Bulletin **36, 166 (2011).
3. E. Thimsen, F. Le Formal, M. Graetzel, S. C. Warren. Influence of plasmonic Au nanoparticles on the photoactivity of Fe₂O₃ electrodes for water splitting. *Nano Lett.* **11**, 35-43 (2011).
4. J. Lee, Y. S. Jung, S. C. Warren, M. Kamperman, S. M. Oh, F. J. DiSalvo, U. Wiesner. Direct access to mesoporous crystalline TiO₂/carbon composites with large and uniform pores for use as anode materials in lithium ion batteries. *Macromol. Chem. Phys.* **212**, 383-390 (2011).
5. H. Arora, Z. Li, H. Sai, M. Kamperman, S. C. Warren, U. Wiesner. Block copolymer directed nanoporous metal thin films. *Macromol. Rapid Commun.* **31**, 1960-1964 (2010).
6. M. Nedelcu, S. Guldin, M. C. Orilall, J. Lee, S. Huettner, E. J. W. Crossland, S. C. Warren, C. Ducati, P. R. Laity, D. Eder, U. Wiesner, U. Steiner, H. J. Snaith. Monolithic route to efficient dye-sensitized solar cells employing diblock copolymers for mesoporous TiO₂. *J. Mater. Chem.* **20**, 1261-1268 (2010).
7. Z. Li, H. Sai, S. C. Warren, M. Kamperman, H. Arora, S. Gruner, U. Wiesner. Metal nanoparticle-block copolymer composite assembly and disassembly. *Chem. Mater.* **21**, 5578-5584 (2009).
8. M. Kamperman, A. Burns, R. Weissgraeber, N. van Vegten, S. C. Warren, S. M. Gruner, A. Baiker, U. Wiesner. Integrating structure control over multiple length scales in porous high temperature ceramics with functional platinum nanoparticles. *Nano Lett.* **9**, 2756-2762 (2009).
9. S. C. Warren, U. Wiesner. Self-assembled ordered mesoporous metals. *Pure & Appl. Chem.* **81**, 72-84 (2009).
10. R. Oren, Z. Liang, J. S. Barnard, S. C. Warren, U. Wiesner, W. T. S. Huck. Organization of nanoparticles in polymer brushes. *J. Am. Chem. Soc.* **131**, 1670-1671 (2009).
11. M. Nedelcu, J. Lee, E. J. W. Crossland, S. C. Warren, M. C. Orilall, S. Guldin, S. Huttner, C. Ducati, D. Eder, U. Wiesner, U. Steiner, H. J. Snaith. Block copolymer directed synthesis of mesoporous TiO₂ for dye-sensitized solar cells. *Soft Matter* **5**, 134-139 (2009).
12. S. C. Warren, L. C. Messina, L. S. Slaughter, M. Kamperman, Q. Zhou, S. M. Gruner, F. J. DiSalvo, U. Wiesner. Ordered mesoporous materials from metal nanoparticle-block copolymer self-assembly. *Science* **320**, 1748-1752 (2008).
This was highlighted in C&E News **8, 26, 10 (2008) and *Nat. Mater.* **7**, 608 (2008).

13. H. Abe, F. Matsumoto, L. R. Alden, S. C. Warren, H. D. Abruña, F. J. DiSalvo. Electrocatalytic performance of fuel oxidation by Pt₃Ti nanoparticles. *J. Am. Chem. Soc.* **130**, 5452-5458 (2008).
14. J. Lee, M. C. Orilall, S. C. Warren, M. Kamperman, F. J. DiSalvo, U. Wiesner. Direct access to thermally stable and highly crystalline mesoporous transition-metal oxides with uniform pores. *Nat. Mater.* **7**, 222-228 (2008).
15. S. C. Warren, A. C. Jackson, Z. D. Cater-Cyker, F. J. DiSalvo, U. Wiesner. Nanoparticle synthesis via the photochemical polythiol process. *J. Am. Chem. Soc.* **129**, 10072-10073 (2007).
16. S. C. Warren, F. J. DiSalvo, U. Wiesner. Nanoparticle-tuned assembly and disassembly of mesostructured silica hybrids. *Nat. Mater.* **6**, 156-161 (2007).
This was highlighted by A. Balazs in *Nat. Mater.*, News and Views, "Nanocomposites: economy at the nanoscale," **6, 94-95 (2007).
17. S. C. Warren, M. J. Banholzer, L. S. Slaughter, E. P. Giannelis, F. J. DiSalvo, U. Wiesner. Generalized route to metal nanocrystals with liquid behavior. *J. Am. Chem. Soc.* **128**, 12074-12075 (2006).
This was highlighted in *Science*, Editor's Choice, "Flowing precious metals," **313, 1542 (2006).
18. C. Roychowdhury, F. Matsumoto, V. B. Zeldovich, S. C. Warren, P. F. Mutolo, M. Ballesteros, U. Wiesner, H. D. Abruña, F. J. DiSalvo. Synthesis, characterization, and electrocatalytic activity of PtBi and PtPb nanoparticles prepared by borohydride reduction in methanol. *Chem. Mater.* **18**, 3365-3372 (2006).

PATENTS

1. S. C. Warren, F. J. DiSalvo, U. Wiesner. Ordered metal-rich mesostructures from nanoparticle-block copolymer self-assembly. Patent pending, 2009.
2. S. C. Warren, F. J. DiSalvo, U. Wiesner. Sol-gel precursors and synthesis of functionalized nanostructures. Patent pending, 2008.

PRESENTATIONS AND POSTERS

1. S. C. Warren, E. Thimsen, M. Grätzel. Plasmonic near-field and scattering effects in Au/Fe₂O₃ nanocomposite electrodes. Oral presentation at the Challenges in Renewable Energy conference at MIT in Cambridge, MA, 2011.
2. S. C. Warren. Nanoparticle-based electrodes for sustainable energy. Invited presentation at the Technion-Israel Institute of Technology in Haifa, Israel, 2011.
3. S. C. Warren, E. Thimsen, F. Le Formal, M. Grätzel. Plasmon-based energy transfer in Au/Fe₂O₃ photoelectrodes for water splitting. Oral presentation at the fall MRS meeting in Boston, MA, 2010.
4. S. C. Warren, M. Grätzel. Mesoporous iron oxide for water photoelectrolysis. Poster presentation at the second European Science Foundation Conference on Nanotechnology for Sustainable Energy. Obergurgl, Austria, 2010.

5. S. C. Warren, M. Grätzel. Mesoscopic α -iron oxide for water photoelectrolysis. Invited oral presentation at the spring MRS meeting in San Francisco, CA, 2010.
6. S. C. Warren, F. J. DiSalvo, U. Wiesner. An ordered mesoporous metal from nanoparticle-block copolymer self-assembly. Oral presentation at the APS March meeting in Portland, OR, 2010.
7. S. C. Warren, F. J. DiSalvo, U. Wiesner. A mesoporous metal from nanoparticle-block copolymer self-assembly. Invited poster presentation at IUPAC's World Chemistry Congress in Glasgow, Scotland, 2009.
8. S. C. Warren. Writing a FP-7 proposal: maximizing your chances for success. Invited oral presentation delivered to Swiss post-docs, professors, and industry leaders. EPFL, 2009.
9. S. C. Warren, H. Sai, U. Wiesner. An ordered mesoporous metal from nanoparticle-block copolymer self-assembly. Oral presentation at the First International Conference on Multifunctional, Hybrid, and Nanomaterials. Tours, France, 2009.
10. S. C. Warren, K. Sivula, M. Grätzel. Hematite photoanodes for water photoelectrolysis. Invited oral presentation at the fall MRS meeting in Boston, MA, 2008.
11. S. C. Warren, K. Sivula, M. Grätzel. IEA-HIA update: hematite photoanodes. Oral presentation at the DOE hydrogen working group meeting in Honolulu, HI, 2008.
12. S. C. Warren, F. J. DiSalvo, U. Wiesner. Fuel cell electrodes from nanoparticle-block copolymer self-assembly. Oral presentation at the first European Science Foundation Conference on Nanotechnology for Sustainable Energy. Obergurgl, Austria, 2008.
13. U. Wiesner, S. C. Warren, F. J. DiSalvo. Assembly and disassembly of polymer nanoparticle composites. Oral presentation at the spring ACS meeting in New Orleans, LA, 2008.
14. S. C. Warren, F. J. DiSalvo, U. Wiesner. Synthesis, properties, and self-assembly of metal nanoparticle-based ionic materials. Invited oral presentation at the Polymer Outreach Program, Cornell University, 2007.
15. S. C. Warren, F. J. DiSalvo, U. Wiesner. Self-assembly of mesostructured electrode architectures. Invited oral presentation at the Fuel Cell Symposium, Cornell University, 2007.
16. S. C. Warren. Self-assembly approaches to fuel cell electrodes. Invited oral presentation at the Wentink Award symposium, Cornell University, 2007.
17. S. C. Warren. The assembly and disassembly of catalytic nanoparticle architectures. Invited oral presentation at EPFL, 2006.
18. S. C. Warren, F. J. DiSalvo, U. Wiesner. The influence of nanoparticle characteristics on the assembly and disassembly of nanoparticle-block copolymer mesostructured hybrids. Invited oral presentation and poster presentation at the fall meeting of the MRS in Boston, MA, 2006.
19. S. C. Warren, F. J. DiSalvo, U. Wiesner. Nanoparticle assembly for efficient fuel cell electrode architectures. Poster presentation at the EPA STAR Fellow's Conference in Washington, DC, 2006.
20. S. C. Warren, M. J. Banholzer, L. S. Slaughter, F. J. DiSalvo, U. Wiesner. Inducing flow in solventless metal nanoparticles via ligation of a thiol-containing ionic liquid. Oral presentation at the fall meeting of the ACS in San Francisco, CA, 2006.
21. S. C. Warren, F. J. DiSalvo, U. Wiesner. Morphology control and anisotropic structure formation in mesostructured silica-block copolymer hybrids. Oral presentation at the fall meeting of the ACS in San Francisco, CA, 2006.

22. S. C. Warren, M. R. Perkins, F. J. DiSalvo, U. Wiesner. General route to metal-silica-block copolymer mesostructured hybrids with high metal loadings. Oral presentation at the fall meeting of the ACS in San Francisco, CA, 2006.
23. S. C. Warren, F. J. DiSalvo, U. Wiesner. Nanoparticle-tuned assembly and disassembly of mesostructured silica hybrids. Oral presentation at the Cornell Center for Materials Research Postdoc/Grad Symposium, 2006.
24. S. C. Warren, F. J. DiSalvo, U. Wiesner. Assembly and disassembly of catalytic nanoparticle architectures. Oral presentation at the Cornell Chemistry Graduate Summer Symposium, 2006.
25. S. C. Warren, F. J. DiSalvo, U. Wiesner. A retrosynthetic approach to anisotropic nanostructure formation. Poster presentation at the Polymer Outreach Program symposium, Cornell University, 2006.
26. S. C. Warren, F. J. DiSalvo, U. Wiesner. Disassembly of block copolymer-silica nanoparticle hybrids. Oral and poster presentations at the U.S.-Japan Nanohybrids Workshop in Monterey, CA, 2006.
27. S. C. Warren, F. J. DiSalvo, U. Wiesner. Block copolymer-nanoparticle hybrids: size-dependent assembly. Oral presentation at the New York Complex Matter Workshop, Syracuse University, 2005.
28. S. C. Warren, F. J. DiSalvo, U. Wiesner. Development of a generalized ligand chemistry for the synthesis of nanoparticle-based catalysts. Oral presentation at the Cornell Chemistry Graduate Summer Symposium, 2005.
29. S. C. Warren, M. J. Banholzer, A. C. Jackson, F. J. DiSalvo, U. Wiesner. Size-induced demixing of nanoparticles from block copolymers. Oral presentation at the fall meeting of the ACS in Washington, DC, 2005.
30. S. C. Warren, F. J. DiSalvo, U. Wiesner. Towards a nanostructured fuel cell electrode. Oral presentation at the Cornell Center for Materials Research Postdoc/Grad Symposium, 2005.
31. S. C. Warren, M. J. Banholzer, A. C. Jackson, M. E. Mattmann, U. Wiesner, F. J. DiSalvo. Towards a block copolymer structured mesoporous fuel cell electrode. Poster presentation at the Polymer Outreach Program symposium, Cornell University, 2005.
32. S. C. Warren, F. J. DiSalvo, U. Wiesner. One-pot synthesis approaches to reformer catalysts and fuel cell electrode materials. Oral presentation at the fall meeting of the MRS in Boston, MA, 2004.
33. S. C. Warren, F. J. DiSalvo, U. Wiesner. A new generation of materials for fuel cells and the hydrogen economy. Poster presentation at the fall meeting of the EPA STAR Fellow's Conference in Washington, DC, 2004.
34. S. C. Warren, M. E. Mattmann, U. Wiesner, F. J. DiSalvo. Towards a block copolymer structured mesoporous fuel cell electrode. Poster presentation at the Gordon Research Conference for fuel cells in Providence, RI, 2004.
35. S. C. Warren, J. A. Turner. Increasing efficiency in photoelectrochemical hydrogen production. Poster presentation at the meeting of the AAAS in Boston, MA, 2002.

NON-PEER REVIEWED PUBLICATIONS

1. S. C. Warren. Dissertation: Nanoparticle-block copolymer self-assembly. Cornell University, Ithaca, NY (2007).
2. S. C. Warren, F. J. DiSalvo, U. Wiesner. Morphology control and anisotropic structure formation in mesostructured silica-block copolymer hybrids. *Polymer Preprints* **95**, 241-242 (2006).
3. S. C. Warren, M. J. Banholzer, L. S. Slaughter, F. J. DiSalvo, U. Wiesner. Inducing flow in solventless metal nanoparticles via ligation of a thiol-containing ionic liquid. *PMSE Preprints* **47**, 858-859 (2006).
4. S. C. Warren, M. R. Perkins, F. J. DiSalvo, U. Wiesner. General route to metal-silica-block copolymer mesostructured hybrids with high metal loadings. *Polymer Preprints* **95**, 380-381 (2006).
5. S. C. Warren, M. J. Banholzer, A. C. Jackson, F. J. DiSalvo, U. Wiesner. Size-induced demixing of nanoparticles from block copolymers. *PMSE Preprints* **93**, 810-811 (2005).
6. K. C. Varner, S. C. Warren, J. A. Turner. Photoelectrochemical systems for hydrogen production. *Proceedings of the 2002 U.S. DOE Hydrogen Program Review*.
7. S. C. Warren, J. A. Turner. Increasing efficiency in photoelectrochemical hydrogen production. *Journal of Undergraduate Research* **II**, 75-79 (2002).
8. A. Bansal, T. Deutsch, J. E. Leisch, S. C. Warren, J. A. Turner. Photoelectrochemical systems for hydrogen production. *Proceedings of the 2001 U.S. DOE Hydrogen Program Review*.
9. S. C. Warren. Honors Thesis: Improving efficiency in solar-powered water splitting. Whitman College, Walla Walla, WA (2001).

REFERENCES

Professor Ulrich Wiesner
Cornell University
Department of Materials Science and Engineering
ubw1@cornell.edu
607-255-3487

Professor Frank DiSalvo
Cornell University
Department of Chemistry and Chemical Biology
fjd3@cornell.edu
607-255-7238

Professor Michael Graetzel
Swiss Federal Institute of Technology, Lausanne
Institute of Chemical Sciences and Engineering
michael.graetzel@epfl.ch
+41 (0)21-693-3112

Professor Bartosz Grzybowski
Northwestern University
Department of Chemistry, Department of Chemical and Biological Engineering
grzybor@northwestern.edu
847-491-3024