

# Bart M. Bartlett

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## RESEARCH EXPERIENCE

University of California Berkeley  
Postdoctoral Fellow, July 2005–present  
Advisor: Professor Jeffrey R. Long

## EDUCATION

Massachusetts Institute of Technology, Cambridge, MA  
Ph.D. in Inorganic Chemistry, June 2005  
Advisor: Professor Daniel G. Nocera  
Thesis Title: Synthesis, Structure, and Magnetic Properties of Extended 2-D Triangular Lattices

Washington University in St. Louis, MO  
A.B. *summa cum laude* in Chemistry, May 2000  
Advisor: Professor William E. Buhro

## AWARDS AND HONORS

University of California President's Postdoctoral Fellow, 2005–present  
National Science Foundation Graduate Research Fellow, 2000–2003  
E. I. DuPont Graduate Fellowship Award, 2003  
Outstanding Teaching Assistant Award in Chemistry, 2000–2001  
John B. Ervin Scholar, 1996–2000  
Washington University Merit Scholar, 1996–2000  
Scholar in Arts and Sciences, 1997–2000  
American Chemical Society Scholar, 1998–2000  
Monsanto Scholar, 1996–1998  
International Science and Engineering Fair First-Place Grand Awards Winner, May 1996  
Washington University School of Medicine *Young Scientist Program*, 1995–1997

## TEACHING & MENTORING EXPERIENCE

UC Berkeley. Research mentor for undergraduate, Justin Wilson, Fall 2006–present  
UC Berkeley. Guest lecturer in Physics and Chemistry of Materials, Spring 2007  
MIT. Teaching assistant in Principles of Inorganic Chemistry I, Spring 2001  
MIT. Teaching assistant in Principles of Chemical Science, Fall 2000  
Washington University. Workshop tutor in General Chemistry II, Spring 2000  
Washington University. Workshop tutor in General Chemistry I, Fall 1999

## ACADEMIC SERVICE

UC Berkeley. Long Group Webmaster, 2007.

MIT. Underrepresented Minorities in Academic Chemistry Task Force Committee, 2002–2005

MIT. Chemistry Department Mediator with thirty-six hours of basic training in mediation according to Massachusetts General Laws, c. 233, sec. 23C, 2001–2005

MIT. Chemical Hygiene and Safety Committee, 2001–2005

MIT. Nocera Group Environmental Health and Safety Representative, 2001–2004

Washington University. Resident Advisor, 1998–2000

Washington University. French Summer Language Institute, Summer 1999

United States House of Representatives. Congressional Page, Fall 1994

## SCIENTIFIC PUBLICATIONS AND PRESENTATIONS

### Publications

13. Kozimor, S. A.; Bartlett, B. M.; Rinehart, J. D.; Long, J. R. The Magnetic Exchange Coupling in 5f/3d Heterobimetallic Complexes Synthesized From a Homoleptic Uranium Pyrazolate. Manuscript in preparation.

12. Shores, M. P.; Bartlett, B. M.; Nytko, E. A.; Nocera, D. G. On the Intelligent Design of  $S = 1/2$  Kagomé Antiferromagnets. Manuscript in preparation.

11. Bartlett, B. M.; Matan, K.; Lee, Y. S.; Nocera, D. G. Direct measurement of the Dzyaloshinsky-Moriya interaction in iron jarosite. Manuscript in preparation.

10. Helton, J. S.; Matan, K.; Shores, M. P.; Nytko, E. A.; Bartlett, B. M.; Yoshida, Y.; Takano, Y.; Qui, Y.; Chung, J.-H.; Nocera, D. G.; Lee, Y. S. Spin Dynamics of the Spin- $1/2$  Kagomé Lattice Antiferromagnet  $\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$ . Manuscript submitted to Phys. Rev. Lett.

9. Ofer, O.; Kerin, A.; Nytko, E. A.; Shores, M. P.; Bartlett, B. M.; Nocera, D. G.; Baines, C.; Amato, A. Ground state and excitation properties of the quantum kagomé system  $\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$  investigated by local probes. Los Alamos National Laboratory, Preprint Archive, Condens. Matt. **2006**, 1-5, arXiv:cond-mat/0610540.

8. Wang, C.-F.; Zuo, J.-L.; Bartlett, B. M.; Song, Y.; Long, J. R.; You, X.-Z. Symmetry-Based Magnetic Anisotropy in the Trigonal Bipyramidal Cluster  $[\text{Tp}_2(\text{Me}_3\text{tacn})_3\text{Cu}_3\text{Fe}_2(\text{CN})_6]^{4+}$ . *J. Am. Chem. Soc.* **2006**, 128, 7162-7163.

7. Shores, M. P.; Bartlett, B. M.; Nocera, D. G. Spin-Frustrated Organic-Inorganic Hybrids of Lindgrenite. *J. Am. Chem. Soc.* **2005**, *127*, 17986-17987.
6. Shores, M. P.; Nytko, E. A.; Bartlett, B. M.; Nocera, D. G. A Structurally Perfect  $S = 1/2$  Kagomé Antiferromagnet. *J. Am. Chem. Soc.* **2005**, *127*, 13462-13463.
5. Bartlett, B. M.; Nocera, D. G. Long-Range Magnetic Ordering in Iron Jarosites Prepared by Redox-Based Hydrothermal Methods. *J. Am. Chem. Soc.* **2005**, *127*, 8985-8993.
4. Nocera, D. G.; Bartlett, B. M.; Grohol, D.; Papoutsakis, D.; Shores, M. P. Spin Frustration in 2D Kagomé Lattices: A Problem for Inorganic Synthetic Chemistry. *Chem. Eur. J.* **2004**, *10*, 3850-3859.
3. Lourie, O.; Jones, C. R.; Bartlett, B. M.; Gibbons, P. C.; Ruoff, R. S.; Buhro, W. E. CVD Growth of Boron Nitride Nanotubes. *Chem. Mater.* **2000**, *12*, 1808-1810.
2. McCarter, J.; Bartlett, B.; Dang, T.; Schedl, T. On the Control of Oocyte Maturation and Ovulation in *Caenorhabditis elegans*. *Dev. Biol.* **1999**, *205*, 111-128.
1. McCarter, J.; Bartlett, B.; Dang, T.; Schedl, T. Soma-Germ Cell Interaction in *C.elegans*. Multiple Events of Hermaphrodite Germline Development Require the Somatic Sheath and Spermathecal Lineages. *Dev. Biol.* **1997**, *181*, 121-143.

#### Presentations

9. Bartlett, B. M.; Harris, T. D.; DeGroot, M. W.; Choi, H.-J.; Long, J. R. Influence of structure on anisotropy in single-molecule magnets. Gordon Research Conference: Renewable Energy & Solar Fuels, Ventura Beach, CA, January 2007.
8. Bartlett, B. M.; Harris, T. D.; DeGroot, M. W.; Choi, H.-J.; Long, J. R. Influence of structure on anisotropy in single-molecule magnets. Abstract of Papers, 232<sup>d</sup> ACS National Meeting, San Francisco, CA, September 2006.
7. Bartlett, B. M.; Harris, T. D.; DeGroot, M. W.; Choi, H.-J.; Long, J. R. Influence of structure on anisotropy in single-molecule magnets. University of California President's Postdoctoral Fellowship Spring Retreat, Lake Arrowhead, CA, April 2006.
6. Bartlett, B. M.; Nocera, D. G. The Dzyaloshinsky-Moriya interaction in Jarosites. Abstract of Papers, 229<sup>th</sup> ACS National Meeting, San Diego, CA, March 2005.
5. Bartlett, B. M.; Grohol, D.; Papoutsakis, D.; Nocera, D. G. Magnetic properties of new Jarosite analogs prepared by redox-based hydrothermal synthesis. Abstract of Papers, 224<sup>th</sup> ACS National Meeting, Boston, MA, August 2002.
4. Bartlett, B. M.; Jones, C. R.; Lourie, O.; Ruoff, R. S.; Buhro, W. E. Chemical vapor deposition growth of boron nitride nanotubes. Semiconductor Research Corporation Annual Review, Madison, WI, July 1999.

3. Bartlett, B. M.; Buhro, W. E. Chemical vapor deposition growth of boron nitride nanotubes. The PEW Undergraduate Research Symposium, Washington University, St. Louis, MO, November 1998.
2. Bartlett, B.; McCarter, J.; Schedl, T. Germline regulation of sheath contractile activity during the *C. elegans* ovulation motor program. Midwest Caenorhabditis elegans Meeting, Normal, IL, June 1996.
1. McCarter, J; Bartlett, B.; Dang, T.; Schedl, T. Germ cells may modulate the smooth muscle activity of the somatic gonad for ovulation in *C. elegans*. *The Worm Breeder's Gazette*, 14:2. 52-53. February 1, 1996.

#### GRANTS RECEIVED

1. Sigma Xi Scientific Research Society. Grant #42, awarded January 2001. \$1000 for the study entitled, "Spin-Frustration Effects on the Antiferromagnetic Coupling in Kagomé Lattice Systems."

#### REFERENCES

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## RESEARCH SUMMARY

Postdoctoral research, July 2005 – present

Single molecule magnets (SMMs), species that show bistability of their spin ground states, have generated much interest in the miniaturization of magnetic data storage devices. The first—and still best—example of a SMM is based on the oxo-bridged cluster,  $[\text{Mn}_{12}\text{O}_{12}(\text{O}_2\text{CCH}_3)_{16}(\text{H}_2\text{O})_4]$  ( $\text{Mn}_{12}$ ). The spin-reversal barrier depends on  $S^2|D|$ , where  $S$  is the total spin and  $D$  is the axial zero-field splitting (ZFS) parameter.  $\text{Mn}_{12}$  species show spin-reversal barriers,  $U_{\text{eff}}$ , ranging from 42 – 56  $\text{cm}^{-1}$ , depending on the exact solvate structure and choice of carboxylate bridging ligand. However, there is no systematic study of the correlation between the structure of  $\text{Mn}_{12}$  and  $U_{\text{eff}}$ . By heating  $\text{Mn}_{12}$  under vacuum, the four bound water molecules can be removed from the cluster, and current efforts are aimed at substituting a wide variety of ligands to directly probe the effect of structural and electronic perturbations on the observed spin-reversal barrier.

Rationally synthesizing new high spin species as potential SMMs based on the  $\text{Mn}_{12}$  family of clusters is challenging due to the structural variability in oxo-bridged compounds. We have prepared new SMMs with cyanide bridging ligands due to the ease in predicting both cluster geometry and exchange coupling interactions. Using a directed-assembly approach by judicious choice of blocking ligands, a wide variety of cyanide clusters exhibiting SMM behavior have been prepared. The face-centered cubic cluster,  $[\text{Tp}_8(\text{H}_2\text{O})_6\text{Cu}_6\text{Fe}_8(\text{CN})_{24}]^{4+}$ , shows the predicted  $S = 7$  ground state, with a small, negative ZFS,  $D = -0.16 \text{ cm}^{-1}$ . The trigonal bipyramidal cluster with the same metal cyanide linkages,  $[\text{Tp}_2(\text{Me}_3\text{tacn})_3\text{Cu}_3\text{Fe}_2(\text{CN})_6]^{4+}$ , has a much larger  $D$ -value of  $-5.7 \text{ cm}^{-1}$ . A key difference between these two clusters is the symmetry of the overall molecule. It is thought that the anisotropy of the cubic cluster may be diminished due to its higher symmetry, thus the interplay between single-ion anisotropy of the constituent metal centers and the overall shape anisotropy of the synthesized molecular clusters is the focus of current research.

Ph.D. research, January 2001 – June 2005

Spin frustration gives rise to unusual magnetic properties on triangular-based lattices of exchanged-coupled moments. The kagomé lattice, made of corner-sharing triangles of magnetic ions, represents the ideal prototype in which to study spin frustration. For classical spins, spin frustration engenders an infinite number of degenerate ground states. For quantum spins, the theoretically predicted spin liquid phase in the kagomé lattice models the scatterless hole transport in resonance valence bond theory of high- $T_c$  superconductors.

Jarosite, a mineral having the formula  $\text{KFe}_3(\text{OH})_6(\text{SO}_4)_2$ , shows antiferromagnetic 3-D long-range order (LRO) despite possessing the 2-D kagomé lattice of  $S = 5/2 \text{ Fe}^{3+}$  ions. It has long been shown that purely 2-D magnetic systems cannot display LRO. Jarosites have escaped precise magnetic characterization over the past three decades due to the difficulty of preparing materials in pure and crystalline form. These materials suffer from having magnetic ion site vacancies and are prepared only as powders. A series of pure iron jarosites (formula  $\text{AFe}_3(\text{OH})_6(\text{TO}_4)_2$ ,  $\text{A} = \text{Na}^+, \text{K}^+, \text{Rb}^+, \text{NH}_4^+, \text{H}_3\text{O}^+, \text{Ag}^+, \text{Tl}^+$ , and  $1/2 \text{ Pb}^{2+}$ ;  $\text{T} = \text{S}$  or  $\text{Se}$ ) has been prepared stoichiometrically pure through the use of a redox-based hydrothermal synthetic strategy. This synthetic method allows us to grow single crystals from which we fully characterize the structure and magnetic properties. Iron jarosites show signature spin frustrated behavior, indicated by a large Curie-Weiss constant,  $\Theta \approx -800 \text{ K}$ , with a transition temperature,  $T_N$  narrowly ranging from 56 – 65 K. High-field magnetization experiments demonstrate (and subsequent neutron scattering experiments confirm) that the

observed LRO can be attributed to a canted spin structure developed from the Dzyaloshinsky-Moriya (DM) interaction. Although the DM interaction energy is only  $1.2 \text{ cm}^{-1}$ , this is large enough to give rise to a 3-D magnetic structure, precluding the ability to study the ground state physics of a purely 2-D frustrated spin system.

The DM interaction scales as  $S^2$ , thus copper hydroxy-bridged triangular species have been prepared and characterized both structurally and magnetically. The kagomé compound clinoatacamite,  $\text{Cu}_2(\text{OH})_3\text{Cl}$ , show nearest-neighbor antiferromagnetic coupling, but 3-D long-range ferromagnetic order due to the presence of magnetic  $\text{Cu}^{2+}$  between the layers. The analogous compound Herbertsmithite,  $\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$ , presents the hallmark of an  $S = 1/2$   $\text{Cu}^{2+}$  compound possessing the kagomé lattice. This compound has magnetically isolated layers, and we find no evidence for magnetic ordering to temperatures down to 2 K, despite strong nearest-neighbor antiferromagnetic coupling, indicated by  $\Theta \approx -300$  K. Herbertsmithite displays no spin-gap in the excitation spectrum at low temperature, a signature of quantum spin liquid.

#### Undergraduate research, February 1998 – July 2000

Boron nitride nanotubes are expected to exhibit electronic properties that are insensitive to tube diameter and chirality, unlike their carbon analogues. Additionally, chemical derivatization of BN can be facilitated by its more reactive bonds. BN nanotubes have been prepared from by chemical vapor deposition (CVD) growth at  $1000 \text{ }^\circ\text{C}$  from the precursor borazine,  $\text{B}_3\text{N}_3\text{H}_6$ , with catalytic NiB or  $\text{Ni}_2\text{B}$  microparticles. XRD, EDS, and EELS demonstrate nanotube purity, and SEM and TEM show that the resulting tubes are multi-walled.