

Dr. Prasad S. Lakkaraju

Professor, Chemistry and Biochemistry Department
Georgian Court University, 900 Lakewood Drive
Lakewood, NJ 08701 USA

1. Education: Ph. D, Chemistry Department, Indian Institute of Technology, Madras, India.
M. Sc (Chemistry)- First Division with Distinction, Andhra University, India.
B. Sc (Chemistry major, Mathematics and Physics minors) - First Division, Andhra University, India.

Five most significant professional accomplishments, honors, and awards

- Received the Virginia Graham Award for teaching excellence from Georgian Court University (GCU) in May 2016. This award is presented annually by GCU to a faculty member who has performed exceptionally in the areas of teaching. Scholarship is also given consideration for this award.
- Served as a member of the Scientific Advisory Board for a carbon dioxide renewable energy technologies startup called Liquid Light Chemicals from its inception till the acquisition of the company by Belgium based Avantium;
- Served as a member of the National Science Foundation CBET electrocatalyst FY 2016 panel;
- Performed three sabbatical research projects at Princeton University;
- Received visiting professor appointments twice to teach at Princeton University.

2. Current Employment:

(a) I am currently working as a professor of chemistry at Georgian Court University (GCU), Lakewood, NJ.

In May 2016, I was the recipient of the **Virginia Graham '36 Award for Teaching Excellence** given by GCU. This award is given at the Commencement each year to one faculty member for his/her outstanding contributions to teaching. Scholarship as related to undergraduate research is also relevant for the award.

Ranks and positions held:

(a) At Georgian Court University

Sep. 2003- *till date* - Professor

May 2006 - December 2011 Chair, Department of Chemistry and Biochemistry, the department is responsible for mentoring undergraduates majoring in chemistry, biochemistry and natural sciences.

May 2004 - May 2007 Director of GIST (Girls Involved in Science and Technology) program – an outreach program for female and minority high school students.

Sep.1999 – Aug.2003 Associate Professor

Aug. 1995 – Aug. 1999 Assistant Professor

(b) Visiting professor and Visiting Research Collaborator appointments at Department of Chemistry, Princeton University, NJ

Duration: Sep 2002 – till date

Conduct research in the area of photo-electrochemical reduction of carbon dioxide into alcohols in collaboration with Dr. Andrew B. Bocarsly at Princeton University. This research program is funded by the National science Foundation.

September 2008- January 2009 – Visiting Professor, Chemistry Department, Princeton University, NJ. Teach a course in physical chemistry and pursue collaborative research.

Sep. 2002- Aug. 2003 Visiting Associate Professor and Visiting Research Scientist (on sabbatical from GCU). Taught a Class in physical chemistry and performed research in the area of Magnetic Resonance Imaging (MRI) and Nuclear Magnetic Resonance (NMR) spectroscopy with Professor W. S. Warren.

(c) Member, Scientific Advisory Board, Liquid Light Chemicals, a start-up company located in Monmouth Junctions, NJ. This company (LLchemicals.com) has secured about \$15M of funding thus far and has close to fifty patents on technologies related to the conversion of carbon dioxide into chemicals such as formic acid, oxalic acid and ethylene glycol.

3. Grants Received:

1. Active Grant: Liquid Light Chemicals Grant: “C2 Chemicals and Fuels from CO₂”, a project for undergraduate research at Georgian Court University. Award amount \$28, 000.
2. Chemistry, Biochemistry and Physics Departments faculty joint grant awarded by State of New Jersey, Equipment Leasing program for \$650,000 to purchase instrumentation for Undergraduate Education and Research in spectroscopy, June 2014, Faculty members involved: Eduard Bitto, Andrew Weber, Pari Murthy, Prasad Lakkaraju and Beth Schaefer. This grant has resulted in the establishment of Sister Mary Peter Coakley Spectroscopy lab at GCU.
3. Liquid Light Chemicals Grant: “Chemicals and Fuels from CO₂”, a project for undergraduate research at Georgian Court University, September 2013- May 2014. Award amount \$15, 000.
4. First Energy Foundation grant for \$10,000 awarded for the proposal “Girls Involved in Science and Technology: A Summer Science program for Lakewood Public School Students at Georgian Court University”. Grant received in 2006.
5. Verizon Foundation grant for \$3,500 awarded for the proposal “Girls Involved in Science and Technology: A Summer Science program for Lakewood Public School Students at Georgian Court University”. Grant received in 2006.
6. Provident Bank Foundation grant for \$3,000 awarded for the proposal “Girls Involved in Science and Technology: A Summer Science program for Lakewood Public School Students at Georgian Court University”. Grant received in 2006.
7. Geraldine R. Dodge foundation grant for \$15,000 awarded for the proposal “Girls Involved in Science and Technology: A Summer Science program for Lakewood Public School Students at Georgian Court University”. Grant received in 2005.

8. Pfizer Undergraduate Endeavors in Science (PURE) grant for \$10,000 awarded for the proposal: "In Silico chemistry: Acquisition of Gaussian 2003 Software for Undergraduate Research in Structure-Reactivity Relationship" grant received in 2004.
9. Johnson & Johnson special capital equipment grant for \$10,000 awarded to purchase an Electrochemical Analyzer from Bioanalytical Systems. Grant received in 2004.
10. The Independent College Fund of NJ, \$10,000 grant received fall of 2003 for pre-college science education in the summer of 2004.
11. CHE030011 "Numerical Simulations of NMR Spectra and MR Images" proposal for 20,000SU on IBM P690 supercomputer funded by the National Center for Supercomputing Applications, University of Illinois, June 2003.
12. CHE030011 "Numerical Simulations of NMR Spectra and MR Images" proposal for 10,000SU funded by the National Center for Supercomputing Applications, University of Illinois, January 2003.
13. Royal Society of Chemistry Travel grant for International Authors. 1420 British Pounds. Grant received in 1999.
14. CC4686, Title: "Investigations into Electronic and Molecular Structure of Unusual Au(II) Complexes". \$37,000. Funded by Research Corporation, Tucson, Arizona. Grant received in 1998.
15. CHE 950033N, Title: "Computational Investigations on Spiroconjugation in Radical Cations Derived from Spiraene". 100.0 SU, Funded by National Center for Supercomputing Applications (NCSA), Located at University of Illinois at Urbana-Champaign. Grant received in 1995

4. Main Research Interests:

- Development of materials for the electrochemical and photo-electrochemical reduction of carbon dioxide into chemicals and fuels. Utilization of spectroscopic (magnetic and optical) techniques for the characterization of materials and elucidation of reaction mechanisms.
- Generation of C₂ and higher order products from CO₂ employing C-C coupling reactions.
- Direct Carboxylation reactions using carbonite ions derived from formate salts.

Patents:

(a) Published patents:

1. "Process for Producing Oxalic acid", by Jerry J. Kaczur, Prasad S. Lakkaraju, and Rishi R. Parajuli, International Patent Publication No: WO 2017/121887 A1. Publication date: **20th July 2017**
2. "Integrated processes for Co-production of Carboxylic Acids and Halogen Products from carbon Dioxide", by Jerry J. Kaczur and Prasad S. Lakkaraju, US Patent Publication No: *20170121831*, Patent Publication date **May 4, 2017**.
3. International patent entitled "Integrated Processes for Co-production of Carboxylic Acids and Halogen Products from Carbon Dioxide" by Jerry J. Kaczur, Prasad Lakkaraju International Publication No: WO 2015/195149/A1 **Dec. 23, 2015**.

(b) Granted patents:

1. "Integrated processes for co-production of carboxylic acids and halogen products from carbon dioxide" by Jerry Kaczur and Prasad Lakkaraju. Date granted: **September 2, 2020**
Patent No: EP 3 157 897 B1
2. "Method and System for Electrochemical Reduction of Carbon Dioxide using a Gas Diffusion Electrode" by Jerry J. Kaczur, Prasad Lakkaraju and Kyle Teamey. Date granted: **June 25, 2019**
Patent No: US 10,329,676 B2
3. Advanced aromatic amine heterocyclic catalysts for carbon dioxide reduction
By: Bocarsly, Andrew B.; Morris, Amanda; Prasad Lakkaraju; Dominey, Raymond
Date Granted: **July 28, 2015**
Patent No.: US 9,090,976
4. "Carbon Dioxide Capture and Conversion to Organic Products" By Prasad S. Lakkaraju and Kyle Teamey
Date granted: **Feb. 25, 2014**
Patent No.: US 8,658,016

5. List of Publication:

1. "Investigating Pervaporation as a Method for Concentrating Formic Acid" by Jerry J. Kaczur, Liam McGlaughlin, and Prasad S. Lakkaraju, published in Carbon, **C 2020**, 6, 42;
doi:10.3390/c6020042
2. "Formate to Oxalate: A Crucial Step for Conversion of CO₂ into Multi-carbon Compounds", by Prasad S. Lakkaraju, Mikhail Askerka, Heidie Beyer, Charles T. Ryan, Tabbetha Dobbins, Christopher Bennett, Jerry J. Kaczur, and Victor S. Batista, *ChemCatChem*, **2016**, 8, 3453-3457.
3. "Substituent Effects in the Pyridinium Catalyzed Reduction of CO₂ to Methanol: Further Mechanistic Insights" by Emily E. Barton Cole, Maor F. Baruch, Robert P. L'Esperance, Michael T. Kelly, Prasad S. Lakkaraju, Elizabeth L. Zeitler, Andrew B. Bocarsly, *Topics in Catalysis*, **2015**, 58(1), 15-22.
4. "A Comparative Study of Imidazole and Pyridine Catalyzed Reduction of Carbon Dioxide at Illuminated Iron Pyrite Electrodes", by Andrew B. Bocarsly, Quinn D. Gibson, Amanda J. Morris, Robert P. L'Esperance, Zachary M. Detweiler, Prasad S. Lakkaraju, Elizabeth L. Zeitler, and Travis W. Shaw. *Catalysis*, **2012**, 2, 1684-1692.
5. "Analysis of the Pyridinium Catalyzed Electrochemical and Photoelectrochemical Reduction of CO₂: Chemistry and Economic Impact" by Kate Keets, Emily Barton Cole, Amanda J. Morris, Narayanappa Sivasankar, Kyle Teamey, Prasad S. Lakkaraju, and Andrew B.

Bocarsly. Publication for the special issue on "Carbon Dioxide Capture, Separation and Utilization" for the *Indian Journal of Chemistry A*, **2012**, *51*, 1284-1297.

6. "Catalytic conversion of carbon dioxide to methanol and higher order alcohols at a photoelectrochemical interface" Author(s): Kate Keets; Amanda Morris; Elizabeth Zeitler; Prasad Lakkaraju; Andrew Bocarsly, published in *Solar Hydrogen and Nanotechnology V* (Proceedings of SPIE Volume: **7770** Editor(s): **Hicham Idriss**; **Heli Wang**, **2010**. ISBN: **9780819482662**).

7. "Using a One-Electron Shuttle for the Multi-electron Reduction of CO₂ to methanol: Kinetic, mechanistic and Structural Insights Formation of methanol" by Emily E. Barton, Prasad S. Lakkaraju, David Rampulla, Amanda Morris, Esta Abelev, Andrew Bocarsly, *J. Am. Chem. Soc.*, **2010**, *132*, 11539-11551.

8. "Incorporation of 2-Arylhexas-1,5-diene into Pentasil Zeolite: A Distorted 1-Arylcyclohexane-1,4-diyl Radical Cation at Room Temperature" by H. Ikeda, T. Minegishi, T. Miyashi, P. S. Lakkaraju, R. R. Sauers, and H. D. Roth, *J. Phys. Chem. B*, **2005**, *109*, 2504-2511.

9. "Oxidation of Aryl- and Diarylcyclopropanes in a Pentasil Zeolite: Ring Opening with Deprotonation or Net Hydrogen Migration" by T. Herbertz, P. S. Lakkaraju, F. Blume, M. Blume and H. D. Roth, *Eur. J. Org. Chem.* **2000**, 467-472.

10 "Extended Diaryl Diselenide Radical Cations in Pentasil Zeolite Studied by EPR and DR" by Lakkaraju, P. S.; Shen K.; Roth, H. D.; Garcia H., *J. Phys. Chem. A*, **1999**, *103*.

11. "Oxidation of Aryl Cyclopropanes in Solution and in a Zeolite: Structure and Rearrangement of Phenylcyclopropane Radical Cation" by Roth, H. D.; Herbertz T.; Lakkaraju, P. S.; Sluggett, G.; Turro, N. J., *J. Phys. Chem. A*, **1999**, *103*, 11350.

12. "Oxidative Ring Contraction of 2-Phenyl-1, 3-dithiane in ZSM-5. Restricted Mobility of 1,2-Dithiolane Radical Cation in Zeolite Channels" by Roth, H. D.; Shen, K.; Lakkaraju, P. S.; Fernandez, L., *Chemical Communications*, 1998, 2447.

13. "Oxidative Cyclization of Diphenyl Disulfide in a Pentasil Zeolite: An EPR Study" by Lakkaraju, P. S.; Zhou, D.; Roth, H. D., *J. Chem. Soc. Perkin Trans 2*, **1998**, 1119. 14" "Medium- and Sensitizer- Dependent Radical Cation Reactions: Deprotonation in Fluid Solution and Solid Matrices" by Roth, H. D.; Weng, H.; Zhou, D.; Lakkaraju, P. S., *Acta Chemica Scandinavica*, **1997**, *51*, 626.

15. "The structure of streptonigrin semiquinone in solution." Soedjak, H.; Hajdu, J.; Raffetto, J. D.; Cano, R.; Bales, B. L.; Prasad, Lakkaraju. S.; Kispert, L. D. *Biochim. Biophys. Acta, Gen. Subj.* **1335**, 73-90 (1997).

16. "Oxidation and Dehydrogenation of a Phenol Ether in a Pentasil Zeolite (NaZSM-5): An EPR Study" by Lakkaraju, P. S.; Zhou, D.; Roth, H. D. *Chem. Comm.* **1996**, 2605.

17. "Generation and EPR of Hexamethyl(Dewar)benzene Radical Cation at Room Temperature" by Roth, H. D.; Lakkaraju, P. S.; Zhang, J. *J. Chem. Soc. Chem. Commun.*, **1994**, 1969.

18. "Homoconjugation in Radical Cations of 7-Substituted Quadricyclane and Norbornadiene" by Roth, H. D.; Du, X.-M.; Weng, H.; Lakkaraju, P. S.; Abelt, C. J. *J. Am. Chem. Soc.* **1994**, *116*, 7744.

19. "EPR of Iminoxyl radicals In Restricted Media: Direct Evidence for the Assignment of Z- and E- Isomers" by Lakkaraju, P. S.; Zhang, J.; Roth, H. D. *J. Phys. Chem.* **1994**, *98*, 2722.

20. "Generation and EPR of Iminoxyl Radicals in a Pentasil Zeolite" by Lakkaraju P. S.; Zhang, J.; Roth, H. D. *J. Chem. Soc. Perkin Trans*, **1993**, 2319.

21. "Ab-initio Studies of Radical Cations derived from Hexa-1, 5-diene Systems - Semibullvalene" by Roth, H. D.; Lakkaraju, P. S. *J. Phys. Chem.* **1993**, 13403.

22. "Studies on Gold(II) Complexes with Hard and Soft Donor Ligands. IV. A Reactivity Study in Solution Using EPR Spectroscopy" by Koley, A. P.; Lakkaraju S. Prasad; Manoharan P. T.; Ghosh, S. *Inorg. Chim. Acta* **1992**, *194*, 219.
23. "Studies on Gold(II) Complexes with Hard and Soft Donor Ligands. III. Complexes with N-(2-Pyridylmethyl)-2-mercaptoaniline" by Koley, A. P.; Nirmala, R.; Lakkaraju S. Prasad; Ghosh, S.; Manoharan, P. T. *Inorg. Chem.* **1992**, *31*, 1764.
24. "Studies on Gold(II) Complexes with Hard and Soft Donor Ligands. II. Complexes o-(Methylthio)aniline and 1,2-bis((aminophenyl)thio)ethane" by Koley, A. P.; Purohit, S.; Lakkaraju S. Prasad; Ghosh, S.; Manoharan, P. T. *Inorg. Chem.* **1992**, *31*, 305.
25. "Chemistry of Molybdenum with Hard and Soft Donor Ligands 2. Complexes with Molybdenum (VI), - (V), and (IV) Oxo Complexes with Tridentate Schiff Base Ligands" by Purohit, S.; Koley, A. P.; Lakkaraju S. Prasad; Manoharan, P. T. *Inorg. Chem.* **1989**, *28*, 3875.
26. "Studies on Gold(II) Complexes with Hard and Soft Donor Ligands. I. Complexes with o-Aminobenzenethiol" by Koley, A. P.; Purohit, S.; Ghosh, S.; Lakkaraju S. Prasad; Manoharan, P. T. *J. Chem. Soc. Dalton Trans.* **1988**, 2607. Corrections to this manuscript were published *ibid*, **1989**, 555.
27. "EPR study of Radical Cations of Short Chain Polyenes" by Lakkaraju S. Prasad; Ding, R.-S.; Bradford, E. G.; Kispert, L. D.; Wang, H.-Q. *Isr. J. Chem.* **1989**, *29*, 33.
28. "An EPR Study of Monomeric and Dimeric Radical Cations of 2,5-Dimethyl-2,4-hexadiene and 2,7-Dimethyl-2,4,6-octatriene" by Lakkaraju S. Prasad; Ding, R.-S.; Wang, H.-Q.; Bradford, E. G.; Kispert, L. D. *Chem. Phys. Lett.* **1988**, *151*, 443.
209. "Zero field Tensor for Ni(II) in Zn(ethylenediamine)₃(NO₃)₂: EPR Study" by Lakkaraju S. Prasad; Subramanian, S. *J. Chem. Phys.* **1988**, *88*, 43.
30. "EPR of VO²⁺ in Zn(antipyrene)₂(NO₃)₂: On the Orientation of Vanadyl Doped in a Low Symmetry Crystal Field" by Lakkaraju S. Prasad; Subramanian, S. *J. Chem. Phys.* **1987**, *86*, 629.
31. "EPR of Ni(I) Radiolytically Produced in Ni(II) Doped Cd(imidazole)₃SO₄.H₂O" by Lakkaraju S. Prasad; Subramanian, S., *Molec. Phys.* **1986**, *57*, 543.
32. "On the Charge Compensation Effects in Mn(II) Doped (NH₄)₂SbF₅: EPR Study" by Lakkaraju S. Prasad; Subramanian, S. *J. Chem. Phys.* **1985**, *83*, 1485.
33. "EPR Study of Pseudo-V_k Center [CrO₃Cl-CrO₃Cl]⁻ in Irradiated KCrO₃Cl" by Lakkaraju S. Prasad; Subramanian, S. *Molec. Phys.* **1983**, *48*, 645.

6. Recent Poster presentations at National Conferences:

1. High Temperature Raman Spectroscopy Study of the Conversion of Formate into Oxalate: Search for the Elusive CO₂²⁻ Intermediate, By Charles Ryan, Anna Mead, Prasad Lakkaraju, Jerry Kaczur, Christopher Bennett, and Tabbetha Dobbins. APS March Meeting 2016, Abstract ID: BAPS.2016. MAR. T1.50, presented on March 17, 2016.