

## Mark Braiman Publications (as of September 2011):

### Original Research Articles in Refereed Journals:

1. M. Braiman, W. Sailer-Kronlachner, and C. J. Varjas. Bromine-sensitized Solar Photolysis of CO<sub>2</sub>. *J. Phys. Chem. A*, submitted (2011).
2. R.W. Hendler, C. W. Meuse, M. S. Braiman, P. D. Smith, and J. W. Kakareka. Infrared and Visible Absolute and Difference Spectra of Bacteriorhodopsin Photocycle Intermediates". *Appl. Spectrosc.* 65, 1029-1045 (2011).
3. P. Gourdon, A. Alfredsson, A. Pedersen, E. Malmerberg, M. Nyblom, M. Widell, R. Berntsson, J. Pinhassi, M. Braiman, O. Hansson, N. Bonander G. Karlsson, and Neutze R. "Optimized in vitro and in vivo expression of proteorhodopsin: a seven-transmembrane proton pump." *Protein Expr Purif.* 58, 103-113 (2008). doi:[10.1016/j.pep.2007.10.017](https://doi.org/10.1016/j.pep.2007.10.017)
4. Y. Xiao, R. Partha, R. Krebs, and M. Braiman. "Time-resolved FTIR spectroscopy of the photointermediates involved in fast transient H<sup>+</sup> release by proteorhodopsin." *J Phys Chem B.* 109, 634-641 (2005). DOI: [10.1021/jp046314g](https://doi.org/10.1021/jp046314g)
5. Y. Xiao and M. S. Braiman. Modeling amino acid side chains in proteins: <sup>15</sup>N NMR spectra of guanidino groups in nonpolar environments. *J. Phys. Chem. B*, 109:16953-16958. (2005). DOI: [10.1021/jp051279e](https://doi.org/10.1021/jp051279e)
6. R. Partha, R. Krebs, T. L. Caterino, and M. S. Braiman. Weakened coupling of conserved arginine to the proteorhodopsin chromophore and its counterion implies structural differences from bacteriorhodopsin. *BBA Bioenergetics* 1708, 6-12. (2005). DOI: [10.1016/j.bbabi.2004.12.009](https://doi.org/10.1016/j.bbabi.2004.12.009)
7. Y. Xiao, M. S. Hutson, M. Belenky, J. Herzfeld, and M. S. Braiman. Role of Arginine-82 in Fast Proton Release during the Bacteriorhodopsin Photocycle: A Time-Resolved FT-IR Study of Purple Membranes Containing <sup>15</sup>N-Labeled Arginine. *Biochemistry* 43: 12809-12818 (2004). DOI: [10.1021/bi049238g](https://doi.org/10.1021/bi049238g)
8. Vongsvivut, J.; Fernandez, J.; Ekgasit, S.; Braiman, M. S. Characterization of supported cylinder-planar germanium waveguide sensors with synchrotron infrared radiation. *Appl. Spectrosc.*, 58: 143-151 (2004).
9. R. A. Krebs, D. Dunmire, R. Partha, and M. S. Braiman. Resonance Raman Characterization of Proteorhodopsin's Chromophore Environment. *J. Phys. Chem. B*, 107: 7877-7883 (2003).
10. J. Vongsvivut, S. V. Shilov, S. Ekgasit, and M.S. Braiman. Symmetrically-Tapered <30-μm-thick Quasi Planar Ge Waveguides as Chemical Sensors for Microanalysis. *Appl. Spectrosc.*, 56: 1580-87 (2002).
11. R. A. Krebs, U. Alexiev, R. Partha, A. M. DeVita, and M. S. Braiman. Detection of fast light-activated H<sup>+</sup> release and M intermediate formation from proteorhodopsin. *BMC Physio.* 2, 5 (2002). <http://www.biomedcentral.com/1472-6793/2/5>
12. M. S. Hutson, R. Krebs, S. V. Shilov, and M. S. Braiman. Halide Dependence of the Halorhodopsin Photocycle As Measured By Time-resolved Infrared Spectra. *Biophys. J.* 80:1452-1465. (2001).
13. M. S. Hutson, U. Alexiev, S. V. Shilov, K. J. Wise, and Mark S. Braiman. Evidence for a Perturbation of Arginine-82 in the Bacteriorhodopsin Photocycle from Time-Resolved Infrared Spectra. *Biochemistry* 39: 13189-13200. (2000)

14. M. Shim, S. V. Shilov, M. S. Braiman, and P. Guyot-Sionnest. Long-lived Delocalized Electron States in Quantum Dots: A Step-scan FTIR Study. *J. Phys. Chem. B* 104, 1494-1496 (2000).
15. C. Trindle, M.S. Braiman, and A.B. Prager. Modeling Arginine-Halide Interactions in Proteins. II. Effects of Chloride and Bromide Counterions on Ethylguanidinium Vibrational Frequencies. *Int. J. Quant. Chem.* 74, 291-297 (1999).
16. M. S. Braiman, D. M. Briercheck, and K. M. Kriger. Modeling Vibrational Spectra of Amino Acids in Proteins. III. Effects of Protonation State, Counterion, and Solvent on Arginine C-N Stretch Frequencies. *J. Phys. Chem. B* 103, 4744-4750 (1999).
17. M. S. Hutson and M. S. Braiman. Application of Doubled-Angle Phase Correction Method to Time-Resolved Step-Scan FT-IR Spectra. *Vib. Spectrosc.* 19, 379-383(1999).
18. C. A. Baer, E. E. Van Niel, J. W. Cronk, M. T. Kinter, N. E. Sherman, M. S. Braiman, and F. Gonzalez-Fernandez. Arginine to Glutamine Substitutions in the Fourth Module of *Xenopus* Interphotoreceptor Retinoid-Binding Protein. *Mol. Vis.* 4, 30 (1998) <<http://www.molvis.org/molvis/v4/p30>>.
19. F. Gonzalez-Fernandez, C. Baer, E. Baker, T.-L. Okajima, B. Wiggert, M. Braiman, and D. R. Pepperberg. Fourth Module of *Xenopus* Interphotoreceptor Retinoid Binding Protein: Activity in Retinoid Transfer Between the Retinal Pigment Epithelium and Rod Photoreceptors. *Current Eye Res.* 17: 1150-1157 (1998).
20. M. S. Hutson and M. S. Braiman. Direct Phase Correction of Differential FT-IR Spectra. *Appl. Spectrosc.* 52: 974-984 (1998).
21. C. A. Baer, J. D. Retief, E. E. Van Niel, M. S. Braiman, and F. Gonzalez-Fernandez. Soluble Expression in *E. coli* of a Functional Interphotoreceptor Retinoid-Binding Protein Module Fused to Thioredoxin: Correlation of Vitamin A Binding Regions with Conserved Domains of C-terminal Processing Proteases. *Exp. Eye Res.*, 66: 249-262 (1998).
22. A. K. Dioumaev and M. S. Braiman. Nano- and Microsecond Time-Resolved FTIR Spectroscopy of the Halorhodopsin Photocycle. *Photochem. Photobiol.* 66: 755-763 (1997).
23. S. E. Plunkett, R. E. Jonas, and M. S. Braiman. Vibrational Spectra of Individual Millimeter-Size Membrane Patches Using Miniature Infrared Waveguides. *Biophys. J.* 73: 2235-2240 (1997).
24. S. E. Plunkett, S. Propst, and M. S. Braiman. Supported Planar Germanium Waveguides for Infrared Evanescent-Wave Sensing. *Appl. Optics* 36: 4055-4061 (1997).
25. M. S. Braiman and S. E. Plunkett. Design for Supported Planar Waveguides for Obtaining Mid-IR Evanescent-Wave Absorption Spectra from Biomembranes of Individual Cells. *Appl. Spectrosc.* 51: 592-597 (1997).
26. A. K. Dioumaev and M. S. Braiman. Two Bathointermediates of the Bacteriorhodopsin Photocycle, Distinguished by Nanosecond Time-Resolved FTIR Spectroscopy at Room Temperature. *J. Phys. Chem. B* 101: 1655-1662 (1997)
27. M. S. Braiman, A. Dioumaev, and J. R. Lewis. A Large Photolysis-Induced pK<sub>a</sub> Increase of the Chromophore Counterion in Bacteriorhodopsin: Implications for Ion Transport Mechanisms of Retinal Proteins. *Biophys. J.*, 70:939-947 (1996).
28. K. Jørgensen, A. Klinger, M. Braiman, and R. Biltonen. Slow Non-equilibrium Dynamical Rearrangement of the Lateral Structure of a Lipid Membrane. *J. Phys. Chem.* 100: 2766-2769 (1996).

29. A. Dioumaev and M. S. Braiman. Modeling Vibrational Spectra of Amino Acid Side Chains in Proteins: The Carbonyl Stretch Frequency of Buried Carboxylic Acid Residues. *J. Am. Chem. Soc.* 117: 10572-10574 (1995).
30. Q.M. Mitrovich and M.S. Braiman. Differences Between the Halide Transport Mechanisms of Halorhodopsin and the Acid Purple Form of Bacteriorhodopsin Analyzed with Millisecond Time-Resolved FTIR Spectroscopy. *Biophys. Chem.* 56: 121-127 (1995).
31. C.A. Baer, K.L. Kittredge, A.L. Klinger, D.M. Briercheck, M.S. Braiman, and F. Gonzalez-Fernandez. Expression and Characterization of the Fourth Repeat of *Xenopus* Interphotoreceptor Retinoid-Binding Protein in *E. Coli*. *Current Eye Research* 13: 391-394 (1994).
32. S.O. Smith, G. Metz, R. Jonas, M. Braiman, B.J. Bormann. Secondary Structure and Orientation of the Transmembrane Domain of Glycophorin in Lipid Bilayers. *Biochemistry* 33: 6334--6341 (1994).
33. M.S. Braiman, T.J. Walter, and D.M. Briercheck. Infrared Spectroscopic Detection of Light-Induced Change in Chloride-Arginine Interaction in Halorhodopsin. *Biochemistry* 33: 1629-1635 (1994).
34. T.J. Walter and M.S. Braiman. Anion-Protein Interactions During Halorhodopsin Pumping: Halide Binding at the Protonated Schiff Base. *Biochemistry* 33: 1724-1733 (1994).
35. R.E. Jonas and M.S. Braiman. An Efficient Source-to-Fiber Coupling Method Using a Diamond Rod: Theory and Application to Multimode Evanescent-Wave IR Absorption Spectroscopy. *Appl. Spectrosc.* 47: 1751-759 (1993).
36. Y. Cao, G. Váró, A.L. Klinger, D.M. Czajkowsky, M.S. Braiman, R. Needleman, and J.K. Lanyi. Proton Transfer from Asp-96 to the Bacteriorhodopsin Schiff Base Is Caused by a Decrease of the  $pK_a$  of Asp-96 Which Follows a Protein Backbone Conformational Change. *Biochemistry* 32: 1981-1990 (1993).
37. A. L. Klinger and M. S. Braiman. Structural Comparison of Metarhodopsin II, Metarhodopsin III, and Opsin Based on Kinetic Analysis of Fourier Transform Infrared Difference Spectra. *Biophys. J.* 63: 1244-1255 (1992).
38. M.S. Braiman, A.L. Klinger, and R. Doebler. Fourier Transform Infrared Spectroscopic Analysis of Altered Reaction Pathways in Site-Directed Mutants: The D212N Mutant of Bacteriorhodopsin Expressed in *Halobacterium halobium*. *Biophys. J.* 62: 56-58 (1992)
39. O. Bousché, M.S. Braiman, Y.-W. He, T. Marti, H.G. Khorana, and K.J. Rothschild. Vibrational Spectroscopy of Bacteriorhodopsin Mutants. Evidence That Asp-96 Deprotonates During the M→N Transition. *J. Biol. Chem.* 266: 11063--11067 (1991).
40. M.S. Braiman, O. Bousché, and K.J. Rothschild. Protein Dynamics in the Bacteriorhodopsin Photocycle: Submillisecond Fourier Transform Infrared Spectra of the L, M, and N Photointermediates. *Proc. Natl. Acad. Sci. USA* 88: 2388-2392 (1991).
41. W.-G. Chen and M. S. Braiman. Kinetic Analysis of Time-resolved Infrared Difference Spectra of the L and M Intermediates of Bacteriorhodopsin. *Photochem. Photobiol.* 53, 905-910 (1991).
42. K. J. Rothschild, M. S. Braiman, Y.-W. He, T. Marti, and H. G. Khorana. Vibrational Spectroscopy of Bacteriorhodopsin Mutants: Evidence for the Interaction of Aspartic Acid 212 with Tyrosine 185 and Possible Role in the Proton Pump Mechanism. *J. Biol. Chem.* 265: 16985 -16991 (1990).

43. K. J. Rothschild, D. Gray, T. Mogi, T. Marti, M.S. Braiman, L.J. Stern, and H.G. Khorana. Vibrational Spectroscopy of Bacteriorhodopsin Mutants: Chromophore Isomerization Perturbs Tryptophan-86. *Biochemistry* 28: 7052--7059 (1989).
44. K.J. Rothschild, M.S. Braiman, T. Mogi, L.J. Stern, and H.G. Khorana. Conserved Amino Acids in F-helix of Bacteriorhodopsin Form Part of a Retinal Binding Pocket. *FEBS Lett.* 250: 448-452 (1989).
45. M.S. Braiman, T. Mogi, Th. Marti, L.J. Stern, H.G. Khorana, and K.J. Rothschild. Vibrational Spectroscopy of Bacteriorhodopsin Mutants. Light-driven Proton Transport Involves Protonation Changes of Aspartic Acid Residues 85, 96, and 212. *Biochemistry* 27: 8516-8520 (1988).
46. M.S. Braiman, T. Mogi, L.J. Stern, N.R. Hackett, B.H. Chao, H.G. Khorana, and K.J. Rothschild. Vibrational Spectroscopy of Bacteriorhodopsin Mutants: I. Tyrosine-185 Protonates and Deprotonates During the Photocycle. *Proteins: Structure, Function and Genetics* 3: 219-229 (1988).
47. K.J. Rothschild, O. Bousché, M.S. Braiman, C.A. Hasselbacher, and J.L. Spudich. Fourier Transform Infrared Study of the Halorhodopsin Chloride Pump. *Biochemistry* 27: 2420-2424 (1988).
48. M.S. Braiman, P.L. Ahl, and K.J. Rothschild. Millisecond Fourier Transform Infrared Difference Spectra of Bacteriorhodopsin's M<sub>412</sub> Photoproduct. *Proc. Natl. Acad. Sci. USA* 84: 5221-5225 (1987).
49. M.S. Braiman, L.J. Stern, B.H. Chao, and H.G. Khorana. Structure/Function Studies on Bacteriorhodopsin: IV. Purification and Renaturation of Bacterio-opsin Polypeptide Expressed in *E. coli*. *J. Biol. Chem.* 262: 9271-9276 (1987).
50. S.O. Smith, M.S. Braiman, A.B. Myers, J.A. Pardo, P.P.J. Mulder, C. Winkel, J. Lugtenburg, and R.A. Mathies. Vibrational Structure of the Retinal Chromophore in Light-adapted Bacteriorhodopsin. *J. Am. Chem. Soc.* 109: 3108-3125 (1987).
51. S.O. Smith, I. Hornung, R. van den Steen, J.A. Pardo, M.S. Braiman, J. Lugtenburg, and R.A. Mathies. Are C<sub>14</sub>-C<sub>15</sub> Single Bond Isomerizations Involved in the Proton-Pumping Mechanism of Bacteriorhodopsin? *Proc. Natl. Acad. Sci. USA* 83: 967-971 (1986).
52. T.N. Earnest, P. Roepe, M.S. Braiman, J. Gillespie, and K.J. Rothschild. Orientation of the Bacteriorhodopsin Chromophore Probed By Polarized FTIR-Difference Spectroscopy. *Biochemistry* 25: 7793-7798 (1986).
53. K.J. Rothschild, H. Marrero, M. Braiman, and R. Mathies. Primary Photochemistry of Bacteriorhodopsin: Comparison of Fourier Transform Infrared Difference Spectra with Resonance Raman Spectra. *Photochem. Photobiol.* 40: 675-679 (1984).
54. M. Braiman and R. Mathies. Resonance Raman Spectra of Bacteriorhodopsin's Primary Photoproduct: Evidence for a Distorted 13-Cis Retinal Chromophore. *Proc. Natl. Acad. Sci. USA* 79: 403-407 (1982).
55. M. Braiman and R. Mathies. Resonance Raman Evidence for an All-Trans to 13-Cis Isomerization in the Proton-Pumping Photocycle of Bacteriorhodopsin. *Biochemistry* 19: 5421-5428 (1980).

#### **Issued Patents and Published Patent Applications**

1. M. Braiman. Bromine-sensitized solar photolysis of liquid CO<sub>2</sub>. US Provisional patent application application 61/313,740 , published 15 September 2011
2. R. Partha and M. S. Braiman.. Rapid and inexpensive method for the purification of proteorhodopsin. *US Patent # 7517968* (April 14, 2009)M. S. Braiman, S. E.

- Plunkett, and J. J. Stone. Supported planar and tapered quasi-planar germanium waveguides for infrared evanescent-wave sensing *US Patent # 6,496,636* (Dec. 17, 2002).
3. M. S. Braiman, S. E. Plunkett, and J. J. Stone. Supported Planar Germanium Waveguides for Infrared Evanescent-Wave Sensing. *US Patent #5,980,831* (Nov. 9, 1999).
  4. M. S. Braiman. Treatment of psoriasis with 11-cis-retinoic acid. *US Patent # 5,719,195* (Feb. 17, 1998).
  5. M. S. Braiman and R. E. Jonas. Light coupling device for optical fibers. *US Patent # 5,355,425* (Oct. 11, 1994).

### Conference Proceedings and Other Book Chapters

1. M.S. Braiman and Y. Xiao. "Step-scan time-resolved FTIR spectroscopy of biopolymers," in *Vibrational Spectroscopy of Biological and Polymeric Materials*, eds. V. Gregoriou and M.S. Braiman, CRC Press, Taylor and Francis group (ISBN 1-57444-539-1), pp. 353-418 (2007).
2. S. V. Shilov, M. S. Braiman, and L.-Z. Mi. Mid-IR Evanescent-wave Sensors for Tiny Biological Samples. *Proc. SPIE 3918*, 202-207 (2000).
3. M. S. Braiman and L.-Z. Mi. Tapered Quasi-Planar Germanium Waveguides for Mid-IR Chemical and Biochemical Sensing. *Proc. SPIE 3540*, 146-152 (1998).
4. M. S. Braiman, S. E. Plunkett, and J. J. Stone. Surface-Sensitive FTIR Spectral Measurements of Nanogram Samples Using 30-100- $\mu\text{m}$ -Thick Planar Ge Waveguides. In *Fourier Transform Spectroscopy (AIP Conference Proceedings 430)*, Ed. J. A. deHaseth, pp. 577-580 (1998).
5. J. J. Stone, M. S. Braiman, and S. E. Plunkett. Mid-IR Evanescent-Wave Absorption Spectra of Thin Films and Coatings Measured with  $\sim 50\text{-}\mu\text{m}$ -Thick Planar Ge Waveguide Sensors. *Proc. SPIE 3105*, 371-377 (1997).
6. R.E. Jonas and M.S. Braiman. Compact Source-to-Fiber Diamond Optical Coupler Enhances Absorbances from Optical Fiber Evanescent-Wave IR Spectroscopy Using a Simple Design. In *Fiber Optic Sensors in Medical Diagnostics, Proc. SPIE 1886*, 9 -14 (1993).
7. T.J. Walter and M.S. Braiman. FT-IR Difference Spectroscopy of Halorhodopsin in the Presence of Different Anions. In *Structures and Functions of Retinal Proteins* (J.-L. Rigaud, ed.) pp. 233-236. John Libbey, Paris (1992).
8. M. S. Braiman and R. E. Jonas. Evanescent-wave IR Spectroscopy of Single-Bilayer Membranes Coated on Chalcogenide Fibers: Sensitivity Improvements Using a Diamond Rod Coupler between Fiber and Source. In Chemical, Biochemical, and Environmental Fiber Sensors IV, *Proc. SPIE 1796*, 402-410 (1992).
9. M.S. Braiman and K.J. Wilson. New FTIR Techniques for Studying Biological Membranes, in *Proceedings of the Seventh International Conference on Fourier Transform and Computerized Infrared Spectroscopy*, (D. G. Cameron, ed.), *Proc. SPIE 1145*: 397- 399 (1989).
10. M. S. Braiman and K. J. Rothschild. Fourier Transform Infrared Techniques for Probing Membrane Protein Structure. *Annual Reviews of Biophysics and Biophysical Chemistry 17*: 541-570 (1988).
11. M. Braiman, J. Bubis, T. Doi, H.-B. Chen, S. L. Flitsch, R. R. Franke, M. A. Gilles-Gonzalez, R. M. Graham, S. S. Karnik, H.G. Khorana, B. E. Knox, M. P. Krebs, T. Marti, T. Mogi, T. Nakayama, D. D. Oprian, K. L. Puckett, T.P. Sakmar, L. J.

- Stern, S. Subramanian, and D. A. Thompson. Studies on Light Transduction by Bacteriorhodopsin and Rhodopsin. *Cold Spring Harbor Symposia on Quantitative Biology* 53: 355-364 (1988).
12. H. G. Khorana, M. S. Braiman, B. H. Chao, T. Doi, S. Flitsch, M. A. Gilles-Gonzalez, N. R. Hackett, S. S. Karnik, T. Mogi, M. M. Nassal, and L. J. Stern. Site-Specific Mutagenesis in Structure-Function Studies of Bacteriorhodopsin. *Chemica Scripta* 27b: 137 -147 (1987).
  13. S. S. Karnik, M. S. Braiman, B. H. Chao, R. Dunn, M. A. Gilles-Gonzalez, N. R. Hackett, E. Jay, K. A. Kronis, M. Nassal, and H. G. Khorana. Expression and Site-Specific Mutagenesis of an Integral Membrane Protein, Bacterio-Opsin. In *Protein Engineering* (M. Inouye and R. Sarma, eds.) pp. 217-232. Academic Press, New York (1986).
  14. M. S. Braiman. Resonance Raman Methods for Proton Translocation in Bacteriorhodopsin, in *Biomembranes -- Protons and Water: Structure and Translocation* (L. Packer, ed.) *Methods in Enzymology* 127: 587-597. Academic Press, New York (1986).
  15. M. Braiman, P. Ahl, and K.J. Rothschild. Fourier Transform Infrared Spectroscopy on the Millisecond Time Scale: Bacteriorhodopsin's M412 Intermediate, in *Spectroscopy of Biological Molecules*, (A.J. Alix, L. Bernard, and M. Manfait, eds.), pp. 57-59. Wiley-Interscience (1985).
  16. S.O. Smith, M. Braiman, and R. Mathies. Time-resolved Resonance Raman Spectroscopy of the K<sub>610</sub> and O<sub>640</sub> Photointermediates of Bacteriorhodopsin, in *Time-resolved Vibrational Spectroscopy*, (G. Atkinson, ed.), pp. 219 -229. Academic Press, New York (1983).
  17. M. Braiman and R. Mathies. Spinning Sample Raman Spectroscopy at 77K: Bacteriorhodopsin's Primary Photoproduct. Chapter 77 in *Biomembranes: Visual Pigments and Purple Membranes* (L. Packer, ed.) *Methods in Enzymology* 88: 648--659. Academic Press, New York (1982).