Department of Chemistry
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KEVIN D. WELSHER, PH.D.

CURRENT POSITION

7/15 – Present **Duke University,** Durham, NC
Associate Professor of Chemistry

EDUCATION AND TRAINING

9/10 – 6/15 **Princeton University,** Princeton, NJ
Postdoctoral Researcher
Research Advisor: Prof. Haw Yang
Research Area: Single-molecule biophysics

9/05 – 9/10 **Stanford University,** Stanford, CA
Ph.D. Degree in Chemistry (Chemical Physics)
Research Advisor: Prof. Hongjie Dai
Research Area: Nanoscience
Thesis Title: Single-Walled Carbon Nanotubes as Near Infrared Fluorescent Imaging Agents in Biological Systems

9/01 – 5/05 **Emory University**, Atlanta, GA
B.S. Chemistry, B.A. Physics, Minor in Mathematics

CURRENT SUPPORT

NIH NIGMS MIRA R35GM124868
08/15/2017-05/31/2027

Project Narrative: The study of viral infection has been impeded by lack of spatiotemporal precision in live cell studies. This work aims to develop virus-locked 3D imaging methods to enable continuous observation throughout the viral lifecycle. This work is investigating the interactions of viral particles with the extracellular matrix, the cell membrane and cell surface receptors with unprecedented spatiotemporal resolution.
Role: PI

NSF CAREER 1847899
02/15/2019-01/31/2024

Project Narrative: The objective of this CAREER award is to develop new methods to capture the dynamics of single molecules processes which occur on spatiotemporal scales inaccessible to current imaging methods in two ways. (1) This work will develop target-locked smFRET to follow single cytosolic proteins in real-time to measure the effect of the non-equilibrium cell environment on protein domain motions. (2) This work will develop target-locked superresolution (TL-SR) microscopy to combine single-molecule localization based super-resolution with high-speed 3D tracking.
Role: PI

DOE DE-SC0016467
08/15/2022 – 08/15/2025

Project Narrative: The overall objective of this proposal is to capture the heterogeneity in polymerization reactions and single catalyst turnover using advanced single-molecule and single-particle techniques.
Role: Co-PI

PUBLICATIONS

Complete Publication List: Google Scholar
***Equally Contributing**
****Corresponding Author**

Independent Career

36. A. Niver, **K. Welsher****, Using COBWEBS for 3D active-feedback tracking of freely diffusing particles in tricky environments. *Proc.SPIE* **12386**, 1238605, (2023).

35. C. Johnson*, J. Exell*, Y. Lin, J. Aguilar, **K. Welsher****, Capturing the start point of the virus-cell interaction with high-speed 3D single-virus tracking. *Nat. Methods* **19**, 1642-1652 (2022).
Research Highlight in *Nature*: "High-speed imaging captures viruses as they creep up to cells." https://doi.org/10.1038/d41586-022-03690-9

34. A. Niver, **K. Welsher****, Combined online Bayesian and windowed estimation of background and signal localization facilitates active-feedback particle tracking in complex environments. *J. Chem. Phys.* **157**, 184108 (2022).

33. J. Kim, A. Jozic, Y. Lin, Y. Eygeris, E. Bloom, X. Tan, C. Acosta, K.D. MacDonald, **K. Welsher**, G. Sahay. Engineering Lipid Nanoparticles for Enhanced Intracellular Delivery of mRNA through Inhalation. *ACS Nano.* **16**, 14792-14806 (2022).

32. D. Yu, A. Garcia IV, S. Blum**, **K. Welsher****, Growth Kinetics of Single Polymer Particles in Solution via Active-Feedback 3D Tracking. *J. Am. Chem. Soc.* **144**, 14698-14705 (2022).
Featured on Cover.

31. C. Zhang, **K. Welsher****, Information-Efficient, Off-Center Sampling Results in Improved Precision in 3D Single-Particle Tracking Microscopy. *Entropy (Basel)* **23**, 498 (2021).
Special Issue – "Recent Advances in Single-Particle Tracking: Experiments and Analysis." Featured on Cover.

30. X. Tan, **K. Welsher****, Particle-by-particle in situ characterization of the protein corona via real-time 3D single-particle tracking spectroscopy. *Angew. Chem.-Int. Edit.* **60**, 22359-22367 (2021).
Selected as a "Hot Paper." Featured on the Back Inside Cover.

29. S. Patel, N. Ashwanikumar, E. Robinson, Y. Xia, C. Mihai, J. P. Griffith, 3rd, S. Hou, A. A. Esposito, T. Ketova, **K. Welsher**, J. L. Joyal, O. Almarsson, G. Sahay**, Naturally-occurring cholesterol analogues in lipid nanoparticles induce polymorphic shape and enhance intracellular delivery of mRNA. *Nat. Commun.* **11**, 983 (2020).

28. X. Lang, **K. Welsher****, Mapping solvation heterogeneity in live cells by hyperspectral stimulated Raman scattering microscopy. *J. Chem. Phys.* **152**, 174201 (2020).
2020 JCP Emerging Investigators Special Collection.

27. S. Hou, J. Exell, **K. Welsher****, Real-time 3D single molecule tracking. *Nat. Commun.* **11**, 3607 (2020).

26. C. Johnson, J. Exell, J. Kuo, **K. Welsher****, Continuous focal translation enhances rate of point-scan volumetric microscopy. *Opt. Express* **27**, 36241-36258 (2019).

25. S. Hou, **K. Welsher****, An Adaptive Real-Time 3D Single Particle Tracking Method for Monitoring Viral First Contacts. *Small* **15**, e1903039 (2019).

24. S. Hou, C. Johnson, **K. Welsher****, Real-Time 3D Single Particle Tracking: Towards Active Feedback Single Molecule Spectroscopy in Live Cells. *Molecules* **24**, 2826 (2019).
Special Issue – "Single Molecule Fluorescence."

23. S. Hou, **K. Welsher****, A Protocol for Real-time 3D Single Particle Tracking. *JoVE*, e56711 (2018).

22. S. Hou, X. Lang, **K. Welsher****, Robust real-time 3D single-particle tracking using a dynamically moving laser spot. *Opt. Lett.* **42**, 2390-2393 (2017).

Graduate and Postdoctoral Publications

21. W.-Y. Li, S. Yin, S.-W. Huang, M.-H. Yang, P. MT. Chen,S.-R. Wu, **K. Welsher**, H. Yang, H.; A. Y.-M. Chen. The Trajectory Patterns of Single HIV-1 Virus-like Particle in Live CD4 Cells: A Real Time Three-dimensional Multi-resolution Microscopy Study Using Encapsulated Nonblinking Giant Quantum Dot. *J. Microbiol. Immunol. Infect.* (2022).
20. **K. Welsher**, H. Yang**, Imaging the behavior of molecules in biological systems: breaking the 3D speed barrier with 3D multi-resolution microscopy. *Faraday Discussions* **184**, 359-379 (2015).
19. **K. Welsher**, S. A. McManus, C.-H. Hsia, S. Yin, H. Yang**, Discovery of Protein- and DNA-Imperceptible Nanoparticle Hard Coating Using Gel-Based Reaction Tuning. *J. Am. Chem. Soc.* **137**, 580-583 (2015).
18. **K. Welsher**, H. Yang**, Multi-resolution 3D visualization of the early stages of cellular uptake of peptide-coated nanoparticles. *Nat. Nanotechnol* **9**, 198-203 (2014).
17. **K. Welsher**, H. Yang**, Model-Free Analysis of Time-Dependent Single-Molecule Spectroscopy Dynamics of Biological Macromolecules. *2012 9th IEEE International Symposium on Biomedical Imaging (ISBI)*, 921-923 (2012).
16. Z. Chen, G. Hong, H. Wang, **K. Welsher**, S. M. Tabakman, S. P. Sherlock, J. T. Robinson, Y. Liang, H. Dai**, Graphite-Coated Magnetic Nanoparticle Microarray for Few-Cells Enrichment and Detection. *ACS Nano* **6**, 1094-1101 (2012).
15. **K. Welsher***, S. P. Sherlock*, H. J. Dai**, Deep-tissue anatomical imaging of mice using carbon nanotube fluorophores in the second near-infrared window. *Proceedings of the National Academy of Sciences* **108**, 8943-8948 (2011).

14. G. S. Hong, S. M. Tabakman, **K. Welsher**, Z. Chen, J. T. Robinson, H. L. Wang, B. Zhang, H. J. Dai**, Near-Infrared-Fluorescence-Enhanced Molecular Imaging of Live Cells on Gold Substrates. *Angew. Chem.-Int. Edit.* **50**, 4644-4648 (2011).
13. S. M. Tabakman*, **K. Welsher***, G. S. Hong, H. J. Dai**, Optical Properties of Single-Walled Carbon Nanotubes Separated in a Density Gradient: Length, Bundling, and Aromatic Stacking Effects. *J. Phys. Chem. C* **114**, 19569-19575 (2010).
12. J. T. Robinson, **K. Welsher**, S. M. Tabakman, S. P. Sherlock, H. L. Wang, R. Luong, H. J. Dai**, High Performance In Vivo Near-IR (> 1 μm) Imaging and Photothermal Cancer Therapy with Carbon Nanotubes. *Nano Res.* **3**, 779-793 (2010).
11. G. S. Hong, S. M. Tabakman, **K. Welsher**, H. L. Wang, X. R. Wang, H. J. Dai**, Metal-Enhanced Fluorescence of Carbon Nanotubes. *J. Am. Chem. Soc.* **132**, 15920-15923 (2010).
10. L. Zhang, X. M. Tu, **K. Welsher**, X. R. Wang, M. Zheng, H. J. Dai**, Optical Characterizations and Electronic Devices of Nearly Pure (10,5) Single-Walled Carbon Nanotubes. *J. Am. Chem. Soc.* **131**, 2454-2455 (2009).
9. **K. Welsher**, Z. Liu, S. P. Sherlock, J. T. Robinson, Z. Chen, D. Daranciang, H. Dai**, A route to brightly fluorescent carbon nanotubes for near-infrared imaging in mice. *Nat. Nanotechnol* **4**, 773-780 (2009).
8. G. Prencipe, S. M. Tabakman, **K. Welsher**, Z. Liu, A. P. Goodwin, L. Zhang, J. Henry, H. Dai**, PEG Branched Polymer for Functionalization of Nanomaterials with Ultralong Blood Circulation. *J. Am. Chem. Soc.* **131**, 4783-4787 (2009).
7. Z. Liu, S. M. Tabakman, **K. Welsher**, H. Dai**, Carbon nanotubes in biology and medicine: In vitro and in vivo detection, imaging and drug delivery. *Nano Res.* **2**, 85-120 (2009).
6. **K. Welsher***, Z. Liu*, D. Daranciang, H. Dai**, Selective Probing and Imaging of Cells with Single Walled Carbon Nanotubes as Near-Infrared Fluorescent Molecules. *Nano Lett.* **8**, 586-590 (2008).
5. X. Sun, S. Zaric, D. Daranciang, **K. Welsher**, Y. Lu, X. Li, H. Dai**, Optical properties of ultrashort semiconducting single-walled carbon nanotube capsules down to sub-10 nm. *J. Am. Chem. Soc.* **130**, 6551-6555 (2008).
4. X. Sun, Z. Liu, **K. Welsher**, J. Robinson, A. Goodwin, S. Zaric, H. Dai**, Nano-graphene oxide for cellular imaging and drug delivery. *Nano Res.* **1**, 203-212 (2008).
3. A. P. Goodwin, S. M. Tabakman, **K. Welsher**, S. P. Sherlock, G. Prencipe, H. Dai**, Phospholipid-Dextran with a Single Coupling Point: A Useful Amphiphile for Functionalization of Nanomaterials. *J. Am. Chem. Soc.* **131**, 289-296 (2008).
2. N. Nakayama-Ratchford, S. Bangsaruntip, X. Sun, **K. Welsher**, H. Dai**, Noncovalent Functionalization of Carbon Nanotubes by Fluorescein-Polyethylene Glycol: Supramolecular Conjugates with pH-Dependent Absorbance and Fluorescence. *J. Am. Chem. Soc.* **129**, 2448-2449 (2007).
1. X. L. Li, X. M. Tu, S. Zaric, **K. Welsher**, W. S. Seo, W. Zhao, H. J. Dai**, Selective synthesis combined with chemical separation of single-walled carbon nanotubes for chirality selection. *J. Am. Chem. Soc.* **129**, 15770-15771 (2007).

PATENTS

Yang, H. & **Welsher, K.** Multiscale spectral nanoscopy. PCT/US2013/051062 (2013).

AWARDS & HONORS

Sloan Research Fellow, Alfred P. Sloan Foundation, 2023-2025
Emory University 40 Under 40, Emory Alumni Association, 2021
Robert B Cox Distinguished Teaching Award, Duke University, 2019
NSF CAREER Award, 2019
Top 5% in Student Evaluations in Natural Sciences, Duke University, 2018, 2019, 2021 & 2022
Best Poster Award, Single Molecule Approaches to Biology GRC, 2018
Nominated for **Walter J. Gores Award for Excellence in Teaching**, Stanford University, 2009
Sigma Pi Sigma Physics Honor Society, Emory University, 2005
Summer Undergraduate Research at Emory (S.U.R.E.) Fellowship, Emory University, 2004

TEACHING

Lecturer, Chemistry 301: Principles of Physical Chemistry
Fall 2016-2022
Top 5% in Student Evaluations in Natural Sciences: 2018, 2019, & 2021

Lecturer, Chemistry 590: Physical Chemistry Tools for Spectroscopy and Microscopy in Living Systems
Fall 2015 & Spring 2017, 18, 19, 21

INVITED SEMINARS

27. **Truman State University, March 2023**
    Department of Chemistry
26. **North Carolina A&T State University and UNC Greensboro, February 2023**
    Joint School of Nanoscience and Nanoengineering
25. **University of Virginia, November 2022**
    Department of Chemistry
24. **North Carolina State University, July 2022**
    BioLunch Seminar
23. **University of Chicago, January 2022 (Virtual)**
    Institute of Biophysical Dynamics
22. **Nankai University / LMU Munich, November 2021 (Virtual)**
    Sino-German Symposium on Virus Tracing
21. **University of Washington, October 2021 (Virtual)**
    Department of Chemistry
20. **Princeton University, October 2021**
    Department of Chemistry
19. **University of Wisconsin-Madison, October 2021 (Virtual)**
    Department of Chemistry
18. **MRC London Institute of Medical Sciences LMS/Imperial College London, August 2021 (Virtual)**
    LMS Seminar Series

17. **High Point University, July 2021**
    HPU Summer Research Program
16. **University of Illinois at Urbana-Champaign, April 2021 (Virtual)**
    Guest Lecture, Cancer Nanotechnology
15. **Massachusetts Institute of Technology, April 2021 (Virtual)**
    Modern Optics and Spectroscopy Seminar Series
14. **Emory University, March 2021 (Virtual)**
    Department of Chemistry
13. **University of California at Irvine, March 2021 (Virtual)**
    Department of Chemistry
12. **Temple University, February 2021 (Virtual)**
    Department of Chemistry
11. **Oregon Health Sciences University/Oregon State University, January 2021 (Virtual)**
    School of Pharmacy
10. **Rice University, November 2020 (Virtual)**
    Department of Chemistry
9. **University of Michigan, November 2020 (Virtual)**
    Department of Chemistry
8. **Yale University, Department of Chemistry, November 2020 (Virtual)**
    Department of Chemistry
7. **California State Polytechnic University, Pomona, January 2019**
    Department of Chemistry
6. **Florida Gulf Coast University, November 2017 (Virtual)**
5. **Virology Works in Progress, Duke University, October 2017**
4. **Structural Biology and Biophysics Seminar, Duke University, May 2017**
3. **Fitzpatrick Institute of Photonics Seminar Series, Duke University, September 2016**
2. **Massachusetts Institute of Technology, Department of Chemistry, Langer Group, August 2014**
1. **University of Pennsylvania, Center for Targeted Therapeutics, June 2014**

SYMPOSIA ORGANIZED

Upcoming: Vice-Chair Elect for the 2024 Single Molecule Approaches to Biology GRC

Southeastern Regional Meeting of the American Chemical Society, November 2021
Title: "Single-Molecule Approaches to Chemistry and Biology"
Co-organizers: None

Microscopy and Microanalysis (M&M) 2021, August 2021
Title: "Frontiers in Fluorescence Lifetime and Super-resolution Imaging of Biological Structures and Dynamics"
Co-organizers: Prof. Michelle Digman, Prof. Matthew Lew, Prof. Andreas Gahlmann

CONFERENCE PRESENTATIONS

37. **ACS National Meeting, August 2023 (Invited Talk)**
    Optical Spectroscopy and Microscopy Across Biological Scales
36. **Microbiology Society (UK) Annual Conference, April 2023 (Invited Talk)**

35. **Annual Meeting of the Fitzpatrick Institute of Photonics, Duke University, March 2023 (Invited Talk)**
34. **Physical Virology GRC, January 2023 (Poster)**
33. **FACSS SciX, October 2022 (Talk)**
    Analytical Imaging - NSF Chemical Measurements and Imaging Program II
32. **Single Molecule Approaches to Biology GRC, July 2022 (Talk and Poster)**
31. **Single-Molecule Biophysics (SMB), Les Houches, February 2022 (Talk)**
30. **66th Annual Meeting of the Biophysical Society, February 2022 (Invited Talk)**
    Workshop: "Probes for Live Cell Imaging including RNA"
29. **66th Annual Meeting of the Biophysical Society, February 2022 (Invited Talk)**
    MadCity Labs Exhibitor Presentation: Novel Single Molecule Methods for Tracking, Transport, and Protein Complex Analyses
28. **66th Annual Meeting of the Biophysical Society, February 2022 (Poster)**
27. **Probing Chemical Reactions by Single-Molecule Spectroscopy 2021, June 2021 (Talk, Virtual)**
26. **SPIE Photonics West, March 2021 (Talk, Virtual)**
    Single Molecule Spectroscopy and Superresolution Imaging XIV
25. **SPIE Photonics West, March 2021 (Talk, Virtual)**
    Advanced Chemical Microscopy for Life Science and Translational Medicine 2021
24. **65th Annual Meeting of the Biophysical Society, February 2021 (Poster, Virtual)**
23. **260th ACS National Meeting, August 2020 (Invited Talk, Virtual)**
    ACS Symposium on Single-Molecule Microscopy
22. **260th ACS National Meeting, August 2020 (Invited Talk, Virtual)**
    ACS Symposium Nonlinear Optical Microscopy
21. **ALIS Kickoff and Southeast Ultrafast Laser Conference, October 2019 (Invited Talk)**
20. **Triangle Soft Matter Workshop, May 2019 (Invited Talk)**
19. **63rd Annual Meeting of the Biophysical Society, March 2019 (Talk)**
18. **257th ACS National Meeting, March 2019 (Talk)**
17. **Physical Virology GRC, January 2019 (Poster)**
16. **Single Molecule Biophysics (SMB), January 2019 (Poster)**
15. **NanoDDS 2018, September 2018 (Talk)**
14. **Single Molecule Approaches to Biology GRC, July 2018 (Poster)**
13. **Southeastern Regional Meeting of the American Chemical Society, November 2017 (Talk)**
12. **Annual Meeting of the Fitzpatrick Institute of Photonics, Duke University, March 2017 (Invited Talk)**
11. **Annual Meeting of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE), November 2016 (Talk)**
10. **252nd ACS National Meeting, August 2016 (Talk)**
9. **248th ACS National Meeting, August 2014 (Talk)**
8. **248th ACS National Meeting, August 2014 (Poster)**
7. **58th Annual Meeting of the Biophysical Society, February 2014 (Poster)**
6. **Frontiers in Optics and Laser Science, October 2013 (Talk)**
5. **246th ACS National Meeting, September 2013 (Talk)**
4. **8th Annual Keller Center Innovation Forum, Princeton University, March 2013 (Talk)**
3. **Stanford University, Cancer Nanotechnology Excellence Review Meeting, February 2010 (Talk)**
2. **238th ACS National Meeting, August 2009 (Talk)**
1. **Stanford University, Cancer Nanotechnology Excellence Review Meeting, February 2008 (Talk)**