Christy Landes, Stephan Link

Perspective on Collaborations

Attending the Bunsen-Tagung 2024 - the Conference of the German Physical Chemistry Society - was an honor for several reasons. First, it was a chance to celebrate our field. In the US, Physical Chemists do not have a special meeting where we learn about cutting-edge research while importantly celebrating our achievements and community. Next, we met with our German collaborators and discussed future research directions on a new team project. Finally, as US and German Physical Chemists and a dual career couple in academia, we reflected on our rewarding partnership that started as graduate students at the Georgia Institute of Technology. We would like to take this opportunity to talk about the unique challenges and benefits of collaborative research in Physical Chemistry and how working and learning together have pushed us to explore exciting new directions and to become better scientists.

How to manage and exploit different working styles? One of the biggest challenges in collaborative research is managing differences in pedagogy, especially when cultural influences play a role. For us, a recurring issue has been reconciling Stephan's thoughtful, methodical approach with Christy's more disruptive and bold ideas. It has taken many years to learn to take advantage of these characteristics in our collaborative work instead of working against each other. We think that the best outcomes of our partnership now clearly reflect both creativity and rigor. It all starts with respect and admiration. Rather than seeing one way as 'right' and seeking to change another's unique traits, team science benefits when members bring their respective strengths to the project, while also leaving room to learn and grow from others. Our first paper on a hybrid plasmonic-polymeric nanomaterial reflects these principles [1]. Based on her expertise in soft matter interfaces, Christy proposed to characterize and exploit these hybrid materials to capitalize on the strong light absorbing properties of plasmonic nanoparticles, in which Stephan is an expert. Demonstrating energy transfer between the nanoparticle core and the polymer shell required combining our strengths. We had to implement a microfluidic electrochemical cell in a hyperspectral dark-field scattering microscope, identify an appropriate electropolymerization medium, and quantify and distinguish charge and energy transfer mechanisms. We established a unique material platform with strong potential for future solution-phase photocatalysis based on energy transfer, while circumventing detrimental photocharging and nanoparticle decomposition (Fig. 1). And our students learned first-hand that there can be multiple correct ways to approach a problem.

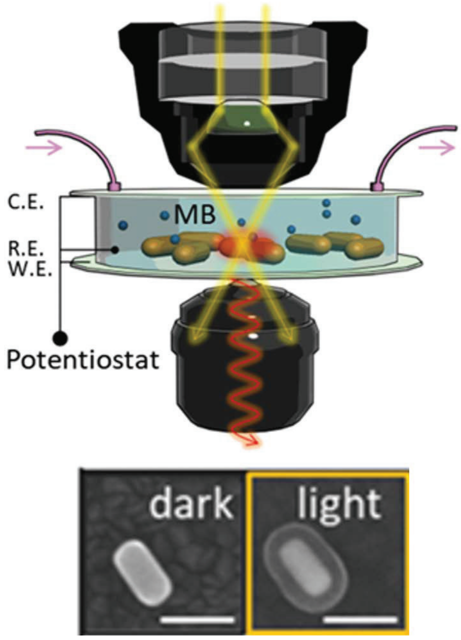

Fig. 1: (top) A microfluidic electrochemical cell on a hyperspectral dark-field scattering microscope allows in operando monitoring of electropolymerization selectively on gold nanorods. (Scale bar 100 nm). (bottom) Example nanorod before and after formation of a polymer shell.

How to choose collaborators? It is time to recruit a new collaborator when a project's direction requires new and unique expertise or talent. We have long been interested in understanding how to use the strong plasmon resonance of metal nanoparticles to sense local changes in protein conformation. To go beyond interfacial binding and gain access to protein conformation, one target in our efforts is plasmon coupled circular dichroism, which leads to a chiroptical signal at the plasmon resonance when chiral biomolecules interact with achiral nanoparticles, a surprising result. Bulk studies suggested that all nanoparticles with bound proteins contribute

Prof. Dr. Christy Landes
Jerry A. Walker Endowed Chair in Chemistry
Department of Chemistry
University of Illinois Urbana-Champaign
Chemical and Life Sciences Laboratory
601 S Goodwin Ave
Urbana, IL 61801, United States
cflandes@illinois.edu
https://landesgroup.illinois.edu/

Prof. Dr. Stephan Link
Charles W. and Genevieve M. Walton Professor of Chemistry
Department of Chemistry
University of Illinois Urbana-Champaign
Chemical and Life Sciences Laboratory
601 S Goodwin Ave
Urbana, IL 61801, United States
slink@illinois.edu
https://link-group.chemistry.illinois.edu/

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to the signal. We demonstrated that plasmon coupled circular dichroism originates instead mostly from proteins adsorbed in the gaps of relatively rare dimers and small aggregates, while protein adsorption can create chiral nanoparticle assemblies [2]. To do so, it was necessary to combine our single-particle circular differential scattering measurements with high resolution transmission electron microscopy, requiring the expertise of a new collaborator, Jennifer Dionne at Stanford University. Together, we showed that plasmon coupled circular dichroism is an exciting means to sense changes in protein secondary structure, but single-particle measurements are crucial to determine which species are responsible for the observed signal. Another important outcome of this project is that our students learned that great science happens when you ask for help, and it is not necessary to do everything yourself.

Who is in charge? Although consensus is important, it is crucial that each project has a single director whose expertise most closely aligns with the big picture. Depending on the project's primary conclusions, one or the other of us will make the ultimate decisions about crucial milestones such as determining when experiments and theory are finished, approving the final figure outline, deciding on a potential journal, and coordinating the response to reviewers. All students, postdocs, and research scientists collaborate as ONE team, with us both serving as mentors to everyone. However, each team member at the end has only one official advisor. This arrangement again requires 'respect and admiration' and is favored over formal co-advising for the benefit of the trainee. Scientific disagreement is therefore resolved by us with each other and not through the student or postdoc.

How to choose collaborative projects? The best collaborative projects offer a chance at convergence research, in which Physical Chemists can both broaden our expertise and work on complex problems with societal relevance. In our quest to use hybrid nanomaterials to achieve sustainable chemistry, we had the chance to collaborate with Professor Andreas Fery, who heads the Leibniz Institut für Polymerforschung Dresden. With Andreas, we expanded the range of materials shown to undergo energy transfer between a plasmonic nanoparticle donor and a polymer acceptor [3]. Even better, working with Andreas opened up a new way to approach, understand, and control mass, charge, and energy transfer at soft-hard material interfaces. Our collaboration with Andreas has been funded by an interagency program between the US National Science Foundation (NSF) and the Deutsche Forschungsgemeinschaft (DFG) called Measurements of Interfacial Systems at Scale with In-situ and Operando aNalysis (MISSION), which also includes Professor Franziska Lissel of the Hamburg University of Technology as an expert in materials synthesis. The project, "NSF-DFG MISSION: Imaging interfacial mass, charge, and energy transfer in nanoparticle/conductive polymer hybrids", will provide an *in operando* means to probe and control dynamics at nanoscale interfaces using coupled plasmonic-polymeric materials. Student exchanges between US and German institutions will benefit from the complementary nature of our respective research cultures.

We have grown as physical chemists and as individuals because of our long collaboration. Although our scientific and personal relationship does not reflect everyone's experience or interest, our story might help anyone who is worried that a dual career in physical chemistry is a barrier to success or happiness.

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Prof. Dr. Stephan Link

Professor Stephan Link received a Diploma of Chemistry in 1996 from the Technical University of Braunschweig in Germany, followed by graduate work at the Georgia Institute of Technology under the supervision of Professor Mostafa El-Sayed. Starting in 2001, Stephan gained postdoctoral research experiences at the Georgia Institute of Technology under Professors Mostafa El-Sayed and Rick Trebino, and then the University of Texas at Austin, where he worked with Professor Paul Barbara.

In 2006, Stephan started his independent academic career in the Chemistry Department at Rice University. He was promoted to associate professor in 2013, full professor in 2017, and the Charles W. Duncan, Jr.-Welch Chair in Chemistry in 2021. In 2024, he moved to the University of Illinois Urbana-Champaign, where he is Charles W. and Genevieve M. Walton Professor of Chemistry. Stephan also currently serves as a Senior Editor for The Journal of Physical Chemistry.

Stephan's research is focused on understanding the effects of heterogeneity on the collective opto-electronic properties of complex nanophotonic nanostructures consisting of metallic nanoparticles coupled to each other as well as to soft molecular or inorganic interfaces. Stephan has published over 200 papers receiving >40,000 citations.

Prof. Dr. Christy Landes

Professor Christy Landes earned her BS from George Mason University in 1998 and completed a Ph.D. in Physical Chemistry at the Georgia Institute of Technology in 2003 under the direction of Mostafa El-Sayed. She was a postdoctoral researcher at the University of Oregon and an NIH postdoctoral fellow at the University of Texas at Austin under the direction of Geraldine Richmond and Paul Barbara, respectively.

Christy started her independent career in 2006 as an assistant professor at the University of Houston. She moved to Rice University in 2009 where she was promoted to associate professor in 2014, full professor in 2017, and to the Kenneth S. Pitzer – Schlumberger Chair of Chemistry in 2021. Since 2023 she is the Jerry A. Walker Endowed Chair in Chemistry at the University of Illinois at Urbana-Champaign, with courtesy appointments in Electrical & Computer Engineering and Chemical & Biomolecular Engineering.

Christy is the Director of the NSF Phase I Center for Adopting Flaws as Features. She is the 2024 Past-Chair of the Physical Chemistry Division of the American Chemical Society. She is a senior editor of the *Journal of Physical Chemistry Letters* and serves on the Editorial Advisory Boards of *ACS Nano* and *Accounts of Chemical Research.* She is a Fellow of the Kavli Foundation, the American Chemical Society, and the American Association for the Advancement of Science. Her awards include the ACS Early-Career Award in Experimental Physical Chemistry, the Langmuir Lectureship, and the Kinosita Award in Single-Molecule Biophysics.

The Landes Group is comprised of chemists, applied physicists, and engineers who develop next generation tools to image dynamics at soft interfaces at the limit of a single event. They devise new methods and models for understanding macroscale processes such as protein separations and photocatalysis using this super-resolved chemical knowledge.

That‘s yPC

Simon Sprengel, MSc
young Physical Chemists (yPC)
simon.sprengel@uol.de

„Moin, my name is Simon! As part of the yPC core team, I help with the yPC digital infrastructure and act as yPC Representative in the Communication Team of the European Young Chemists' Network EYCN."

Simon Sprengel is currently a PhD candidate in the field of electrochemical nanotechnologies at the University of Oldenburg. He develops micro- and nanoscale 3D-printing approaches utilizing electrochemical confinement for precise metal ion reduction on a conductive substrate via electroplating to create solid metal structures.

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