FACES OF MASS SPECTROMETRY / Abraham Badu-Tawiah

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Using What's Available for New Discovery

***Abraham Badu-Tawiah** was compiling documents for his fourth year review—he is on the faculty at Ohio State University in Columbus—when he was asked if it was a good time to talk about mass spectrometry. His response exuded infectious energy: "No problem, let's go!"*

Badu-Tawiah is an innovative scientist who holds a number of patents for rapid and early diagnosis of disease using mass spectrometry combined with hydrophobic paper spray ionization. He has spent more than a decade in the U.S., working through graduate school and post-doctoral research before starting his own lab in Ohio State's Department of Chemistry and Biochemistry. Last year, he received both an Eli Lily Young Investigator Award and one of two American Society for Mass Spectrometry Research Awards; this year, recognition continues with the Arthur F. Findeis Award for Achievements by a Young Analytical Scientist from the ACS Division of Analytical Chemistry.

His ability to take advantage of opportunities as they present themselves has shaped his path and the intensity of his drive to explore and combine new fields in chemistry. Growing up in rural Ghana, he was one of three graduates from a high school of 500 that went on to attend a university, and he knows how important it is to his children to have the educational opportunities available in the U.S.

When he is not at work, he is "just with family."

How did you work with mass spectrometry begin?

When I got to Purdue in 2007, I worked with Graham Cooks who had been working on this idea: because reactions in mass spectrometer are so efficient, maybe we could use it as a scientific tool to create new chemical species. My task was to work in ambient conditions, so, as a naïve scientist, I started with my basic knowledge, not understanding why mass spec had been essentially done in a vacuum for a century. We did find a way to do an assay-related microdroplet reaction using our new ambient soft-landing device [Badu-Tawiah, A.K., Wu, C., Cooks, R.G. *Anal. Chem.,* **2011**, *83*, 2648–2654.]. Other people in the lab were using reactive desorption electrospray ionization (DESI) to enhance chemical detection, but my work involved performing chemical reaction outside of the vacuum where the product could easily be collected and quantified. This opened a new field [Badu-Tawiah, A.K., Campbell, D.I., Cooks, R.G. *J. Am. Soc. Mass Spectrom.*, **2012**, 23, 1077-1084.].

What excites you most about your research?

I enjoy pure discovery, learning what I never expected. This is the most successful area in my lab right now because the whole cycle of discovery is very efficient with droplet chemistry. For example, we can buy a very cheap off-the-shelf chemical that absorbs light and, within seconds, screen it to test if the catalyst can perform in new ways [Chen, S., Wan, Q., Badu-Tawiah, A K. *Angew. Chem. Int. Ed.* **2016**, *55*, 9345-9349.]. We have also made hydrogen gas using a different photocatalyst that has potential importance for the energy industry if it can be cheaply stored for later use, and we recently applied for a patent for our general reaction screening that is integral to all of these studies.

What led you to chemistry in the first place?

I am sure that you can hear from my accent that I didn't grow up here [chuckles]. When you grow up in Africa, you don't choose what you want to do. To cut a long story short, I was categorized as a math, chemistry and physics person. I remember saying that I wanted to do biology, and the teachers said, "no, you can't do it" [chuckles]. It


Photo by: Pam Frost Gorder, courtesy of The Ohio State University

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took me years to accept this until reality came to me: this is what you have, so make use of it. The biggest lesson that I've learned is that you might not get what you set out to do, but you can always make use of what is available.

How did your research in disease diagnosis start?

After graduate school, I wanted to implement the droplet reactions in a traditional macrofluidic platform so that I could work in real time and collect the products with ease. Luckily, George Whitesides gave me a chance to come to his lab. But when I got there, he told me he was not interested in reactions in droplets [chuckles]. I learned how to put together a macrofluidic platform, printing wax and to do enzymatic reactions on paper that, when urine or blood containing a biomarker for a specific disease is added, produces a quick, inexpensive diagnosis. A problem was that the enzymes used are not stable and need special storage. By the time I finished my post doc, it was clear to me that I could create a field using mass spec as a detector for diseases because antibodies are stable.

How did you develop inexpensive disease detection with a mass spectrometer?

The first problem was coupling antibody reactions on paper to a charged particle so that mass spec could detect it. I synthesized cleavable ionic probes that could be attached to any antibody, and we then made a simple paper platform that could screen people efficiently and without refrigeration [Chen, S.,Wan, Q., Badu-Tawiah, A.K. *J. Am. Chem. Soc.* **2016**, *138*, 6356-6359.]. We started with malaria. Malaria is difficult to diagnose in Africa—clinics count parasites with optical microscopes which is subjective, takes a long time, and requires a high level of experience—so fever is over-treated with anti-malarials. We must eliminate this through early detection. We propose taking advantage of how communities are organized: farmers and children regularly travel to towns and could bring paper cards (prepared at home) to a generator or a battery-powered mass spectrometer.

So far, our cards detect the biomarker in blood, and our focus now is to increase the sensitivity to detect the parasite in saliva or urine. Using the same approach but changing the antibodies, I am also working on early colorectal cancer detection and zika diagnosis in people who are asymptomatic. We can change things in the developing world and even for the developed world; this really motivates me.

What has been your biggest challenge?

Having not grown up in the Western world—I came here when I was 25 for graduate school—the big challenge is culture. In Africa, you don't put yourself out there and we usually work in the background — the system encourages one to remove oneself from the show. I struggled with this, particularly at Harvard. At the end of my first two years there, the lab manager called me to his office and told me "don't be afraid to be who you are." That was the best advice. I am still reserved. But now I am very proud to say that I grew up in Africa.