Abraham Badu Looks for Affordable Diagnostic Tools

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SPEAKERS

David Staley, Abraham Badu, Eva Dale

E Eva Dale 00:00

From the heart of The Ohio State University on the Oval, this is Voices of Excellence from the College of Arts and Sciences, with your host, David Staley. Voices focuses on the innovative work being done by faculty and staff in the College of Arts and Sciences at The Ohio State University. From departments as wide ranging as art, astronomy, chemistry and biochemistry, physics, emergent materials, mathematics and languages, among many others, the college always has something great happening. Join us to find out what's new, now.

D David Staley 00:32

Abraham Badu is an assistant professor in the Department of Chemistry and Biochemistry at The Ohio State University College of Arts and Sciences. He received his PhD in Chemistry from Purdue University in 2012, where he was awarded three prestigious fellowships. He was a postdoctoral fellow at Harvard University, and joined The Ohio State University in July 2014. Welcome to Voices of Arts and Sciences, Dr. Badu.

A Abraham Badu 00:57

Thank you.

D David Staley 00:59

I understand that one of your areas of research is diagnostic mass spectrometry. Could you tell us a little bit about what that is?

A Abraham Badu 01:06

Sure, I'd be glad to. So, in the early days, doctors were actually called physicians, mainly because they typically based on their diagnosis based on physical changes in our bodies, your temperature, your blood pressure, your color changes. Now, that is kind of changing nowadays. When you go to the doctor's office, they actually have to do some tests before they make a decision on your condition. So while we are trying to do is to make that process, incorporating chemical analysis into the diagnostic process, we want to make it more efficient, we want to simplify the process and make it available to everyone. And the way that the mass spectrometry comes in is to make it more sensitive so that we can diagnose people early enough. I think that is important because many people go undiagnosed and by the time we know it, we have little control of what are their condition is.

D David Staley 02:07

So instead of doing a physical, as you say, what sorts of diagnoses then would a physician be doing? What sorts of things, like blood work? Is that the sort of thing you mean?

A Abraham Badu 02:19

Yes, we do blood work. As the typical, typical day will take several volumes of blood and do the test on it in the traditional level, but we are hoping to do is to take only a drop of blood, a microliter of blood, and not put it on a vessel, put it on a piece of paper, and then do the analysis off from the paper. And we are choosing the paper because it's cheap, and almost any country in the remotest part of the world you can find paper.

D David Staley 02:51

You mean just ordinary paper, you're not talking about sort of specially treated or otherwise, it's just regular paper?

A Abraham Badu 02:57

Certaintly, yep.

D David Staley 02:58

Well then what what sort of analysis could you do with a drop of blood on a piece of paper?

A Abraham Badu 03:01

In fact, we can do from a drop of blood, we can actually test at least four different diseases on the same paper device. The way you do it is, we use the paper, we use a little trick, we print wax onto the paper, and then we stuck the 2D papers and we create a three dimensional microfluidic out of the paper.

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David Staley 03:25

Microfluidic?

A

Abraham Badu 03:26

Microfluidic.

D

David Staley 03:27

Which means what?

A

Abraham Badu 03:28

Means that this device is able to wick or control the movement of fluids from one position to the next. So if you put your drop of blood on to the top of the paper, you would see it move through the 3D paper device and itself is plated into the amount of diseases we want to test. So if you want to test for example, malaria, HIV, syphilis on the same paper, they will make it split into four, and then each zone is designed to look for the specific disease we are interested in, and in the end, it will tell us if you are sick or not sick.

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David Staley 04:11

Does that mean in typical methods, what, these are four separate procedures or four separate blood donations?

A

Abraham Badu 04:18

That's correct. In a typical procedure, there are four separate and also require a lot of volume of blood. So you're probably going to need at least 200 milliliters of blood for each test you do.

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David Staley 04:30

But how much is that, 200 microliters? In terms of, like a, like a shot glass maybe?

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Abraham Badu 04:42

Yes, about.

David Staley 04:43

That's, that's a lot of blood. That's a fair amount of blood, and you're talking about making this procedure such, all four procedures with one drop of blood?

Abraham Badu 04:51

A drop of blood.

David Staley 04:52

Amazing.

Abraham Badu 04:52

Amazing. And we are interested because, actually babies, if you're taking such a volume of blood from babies, that becomes a problem. In this case, no problem. In fact, we're actually more interested in making it less invasive, which means instead of blood, instead of blood, we want to use saliva or urine.

David Staley 05:13

Oh, that's a possibility?

Abraham Badu 05:15

That is a possibility.

David Staley 05:16

Using the same sort of procedures or different?

Abraham Badu 05:18

The same procedure, but when you use urine or saliva, the amount of the chemical that you want to detect is reduced. The concentration in, of the chemical in the blood is higher than in the urine or the saliva. That's, that's how the spectrometer comes in; it's sensitive enough to tell even the smallest amount in there.

David Staley 05:45

And so tell me what a spectrometer is, just a quick definition.

And so tell me what a spectrometer is, just a quick definition.

A Abraham Badu 05:49

Yes. So the spectrometer, a typical way that people have gone around doing this test is use your eyes for detection. So the color will change and that will tell you yes or no. That procedure requires a lot of the biomarker before you can see it. With a spectrometer, it's almost like a little instrument or machine that detects chemical species based on their mass. And because every compound or every chemical has a unique mass, if we can measure that mark, it tells us if that is there or not. And it's very sensitive, we only need, we are literally counting the particles. That counting process is efficient than to use your naked eyes for detection.

D David Staley 06:40

So one of the things you said earlier in this discussion was that the, the data that are produced through this sort of process would be available to everyone. Who is everyone? Who would, who would, that medical data be available to?

A Abraham Badu 06:55

That's a great point and it's part of our program. It's both the data and also the device. Yes. So let me start with the device first. So, in the U.S., it's easy to go around collecting blood onto a vial, but in other places like in Africa or Southeast Asia, people live very far away and typically there's nothing there. So how do we reach these people, and test them to see how they are doing? And cancer today is killing a lot of people, and the way that we test it is not efficient enough to diagnose early, particularly because where they live, we are not able to reach them. The way that we are proposing to everyone means the rich and the poor, the people that live in the cities, people that live far away. It literally doesn't matter who you are, and what you are, we will be able to do the test and get some results and tell you how you are doing. The results is also for everyone because you don't need extensive training to understand what if that, the data is already encoded from the beginning, they will know what we are looking for. So when you go in, you're looking for that specific thing, is it there, or is it not there.

D David Staley 08:16

As opposed to looking at with my naked eye, that requires a level of training, maybe.

A Abraham Badu 08:20

Yes. Especially in... that's a very good point. If you view with the naked eye, typically, it's aided with some microscope that helps you to, to look at what is there. And in that process, there's a training, because it's very subjective. Who looks or what you get depends on who's doing the work.

D David Staley 08:42

And so you're taking away some of that subjectivity.

A Abraham Badu 08:44

Out, yes.

D David Staley 08:45

You also do research in what's called accelerated droplet reactions. Tell us, tell us what that means.

A Abraham Badu 08:52

I'm glad to bring this up. Actually, this is the most successful project in my lab because this also is for everyone, but the way we are doing it is unique. So in simple terms, chemical reactions typically is done in a bulk solution. So you take the cup, you mix some stuff in and you wait a day, you go home, you come back and see what are the things change or didn't change. And if you want to use that process to find new ways that two species can react, that is too slow. For example, we are all interested in harvesting the sun energy.

D David Staley 09:36

Sure.

A Abraham Badu 09:37

For, for all kinds of purposes, but not every chemical can absorb the sun energy. They're only specific ones, two cycles, a photo complex. So to look for a compound that can absorb that sun energy, and transfer that energy to another compound, so that chemical reaction can okay, it's not trivial. And if you will not sit down and just do the thing in a bulk, go home, come back, go home, come back,go home, come back, that prolongs the process. What we are doing is to do the process in a micro droplets, and micro droplets, the volume is shrink down to a smaller, much, much smaller size.

D David Staley 10:17

That sounds like even smaller than a drop of blood.

A Abraham Badu 10:20

Yes.

D David Staley 10:20

So how small, can you give us a sense of scale here? Do I need a microscope to see micro droplets?

A Abraham Badu 10:28

No. Probably because they...

D David Staley 10:35

A pinprick maybe?

A Abraham Badu 10:36

Yes.

D David Staley 10:36

Like a pinprick. Wow, that is , that is small.

A Abraham Badu 10:38

Yes. That, that will probably be, our own is maybe smaller than that.

D David Staley 10:43

Maybe even smaller.

A Abraham Badu 10:44

Smaller than that. We are generating several of these at the same time. So if you can concentrate these reactants into such a tiny little volume, they have no choice but to react. So now we are shrinking down that time, 24 hours, into milliseconds.

D David Staley 11:03

So it's not just scale, it's also a time scale?

A Abraham Badu 11:07

Time. Yes. So both space and time, and the space comes, becomes important, when it equals the amount of chemical you need. So if you are doing in the bulk, you need milligram quantities, to do this. In that tiny volume, we need only pico, that is ten to negative 12 of, of the same compound. And the day, I mean the time for the reaction is also reduced many orders of magnitude. And plus, we are able to also watch what is happening in the droplet in real time. So, you don't have to go home and come back, we can detect and tell you what has happened with your catalyst immediately. If we can tell you that, you have a better chance of making changes in the same day.

D David Staley 12:00

Like diagnosies or treatments of some kind?

A Abraham Badu 12:03

Of something, all been changing the conditions. And all of that, the cycle process is, we've escalated the process, so the discovery is increased also.

D David Staley 12:17

It sounds like you do a lot of work, or at least a lot of collaboration with medical doctors. Is that, is that a fair statement?

A Abraham Badu 12:24

That is true.

D David Staley 12:24

So your research lab is called, appropriately, The Badu Research Group. Are doctors a part of your research lab?

A Abraham Badu 12:32

I have collaborators that are doctors, in fact, my work on malaria, I have a collaborator in the medical school, who's actually a trained medical doctor. I have other collaborators who are also trained to actually deal with insects. And I'm particularly proud, aside from doctors and other people that are specialized in their work, the work that we do is so simple that even the untrained people can do it, and so I also have undergraduates in my lab.

D David Staley 13:07

D David Staley 13:07

Undergraduates?

A Abraham Badu 13:08

Even high school students.

D David Staley 13:09

High school students?

A Abraham Badu 13:10

This summer, I'm getting two high school students.

D David Staley 13:13

So what will you have high school students do in your lab this summer?

A Abraham Badu 13:16

So the process starts from thinking about how we make the paper to become a device. So there's a printing going on, there is a computer modeling that we use to create how the fluid should move. A high school student can sit down and do this tunneling, or they can even come in and put the paper device together. That paper device is actually made from ordinary paper, and also from double sided adhesive tapes. So we are bonding the paper together, hand by hand. By the way, I'm working with another company that's helping us to make this automated, but for now, even a high school student is able to put together such a device and make it useful. And so, of course, I have a postdoc who's highly advanced, I have graduate students who's also over there, undergraduates, and even high school students. And the way that I'm planning this is a kind of a Hara Kiko training, where the postdoc is able to easily transfer the knowledge to the graduate student, graduate student easily able to train undergraduate, undergraduates able to train high school students. And even sometimes in the summer, we bring in middle school students to see what we are doing. In there to, I try to bring the high school students to also show the middle school students, to them what have done.

D David Staley 14:41

Are these high school students that have already expressed an interest in chemistry? How do you, how do you sort of select the high school students that will be in your lab?

A Abraham Badu 14:48

That's a good question. When I started, it was difficult finding the high school students. I had interest, interest in doing this, but I've also been looking for money to bring more people. But the way I find it is through schools. So some schools, they know that some faculty are interested in allowing high school students to work in the lab, so the teachers reach out to us based on our research, and then they bring the students based on their interest to us. What I found is that most of these schools that are doing this, actually programs, are all in the suburban parts of the city, good schools. Within Columbus City Schools, I haven't had anybody. That's because of the kind of schools they have, they don't have this good system. One part of my goal is actually to find a way to reach out to these schools also. And when I started, I wanted to use my life experience as an example, for people who would otherwise shy away from medical field.

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David Staley 15:58

What do you mean your life experience? What in your life experience is...?

A

Abraham Badu 16:02

Well, yeah, I grew up in Africa. And in Africa, you don't have much choice. You literally make that, take advantage of what is available. Me realizing that very early on in my life has helped me almost every step of the way, and I have many friends that gave up to the process, they just gave up. They said, this is not for me, and I know, at least I live in the U.S. about 10 years, that many people, even in the US, that even face that problem. They think this is for a certain class of people, or this is not for me, but I'm, I'm sure that if they see other people that look like them, that have done it, that should motivate them too.

D

David Staley 16:49

This is why it's important to have middle school students come to your lab, get them interested in chemistry at that age, early. So when did you, at what stage did you realize you wanted to be a chemist? What got you into chemistry?

A

Abraham Badu 17:04

Good question. I'm laughing because one way, I think it's a serendipity.

D

David Staley 17:09

Serendipity?

A

Abraham Badu 17:10

Yes.

D David Staley 17:12

The best things in life come through serendipity.

A Abraham Badu 17:14

And, as I said, realizing that sometimes you might not get to where you want to be, but by taking advantage of what you have now, will always benefit you. So, in fact, in Ghana, where I grew up, at high school, you don't get a chance to decide on what you want to do. Based on your grades and based what the teachers perceive you to be, they categorize you. So I got categorized as math, physics, chemistry person. Other people would categorizes biology, physics, other stuff. And so I remember telling my teacher I wanted to do biology. He said, there's no room! You're good at math, do maths, you know. And so from there, that's what I did. And the school that I went to was not that good, so my grades also were not that good, but I made a good grade to qualify me to, to college. And at the college level, the same thing happens. Based on your grades, they put you in. So although chemistry was not what I wanted to do, that was what was available. And it took me a while to realize it, but I realized this is what I have, I have to do. It wasn't until I came to U.S. and I realized actually how useful chemistry can be. But I am doing this medical research because that's what I actually wanted to do in the early beginning. I thought if I do chemistry I'm lost, but it's still not like that, because now even though I'm not a medical doctor, what I'm doing could actually, someday will be involved in the hands of the doctor itself to the diagnosis.

D David Staley 18:53

It certainly sounds like that. So what's next for you in your research, in your research group? What's the, what's the next frontier, your next research?

A Abraham Badu 19:02

My research is just to continue to bring in new levels of simplicity and practicality. Combine that with cost performance to cost ratios, and I'm saying this because, what are two things I'm saying, that I want to make detection simple and practical, and then I also want to make it affordable, and yet we don't have to lose their performance. So performance to cost ratio, I'm trying to keep it low, or maybe high, depends, but simple enough that most people can afford it. So that is where I want to go. How do you do it? I'm taking advantage of what is already available: paper. I even begin to use thread.

D David Staley 19:55

Thread?

A Abraham Badu 19:56

Thread. In forensics, DNA or something, they, they will maybe take from your clothes, they'll

Thread. In forensics, DNA or something, they, they will maybe take from your clothes, they'll take the whole thing and try to extract it from your clothes. But we are saying, from a single thread from your clothes, all we need is that thread pulled out from your clothes.

D David Staley 20:14

From my shirt?

A Abraham Badu 20:15

And we can tell you if your DNA is in that thread or not, we can use that thread for chemical detection. If you modify the thread to make it almost as if you are fishing, put a thread in any solution, remove the thread, something is stuck to the thread, that is specifically what you're looking for.

D David Staley 20:33

It sounds like you're talking about forensic science.

A Abraham Badu 20:36

That's also part of my work.

D David Staley 20:39

Abraham Badu, thank you.

A Abraham Badu 20:41

Thank you very much.

E Eva Dale 20:42

Voices is produced and recorded at The Ohio State University College of Arts and Sciences Technology Services studio. Sound engineering by Paul Kotheimer, produced by Doug Dangler, I'm Eva Dale.