CERAMIC TECH CHAT

Episode 07

Title – "Research and Education for Nuclear Waste: Charmayne Lonergan (E07)"

INTRO

De Guire: "I'm Eileen De Guire, and this is Ceramic Tech Chat.

> In recent years, the transition to renewable and green energy sources has evolved rapidly. In fact, last year both the United States and the United Kingdom announced that more electricity was generated from renewable energy sources than from coal, a trend that has continued into this year.
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> Though this transition appears to mark the end of coal's dominance in the energy market, it's less clear what the role of nuclear energy will be in the future. In particular, the question of what to do with nuclear waste drives some of the biggest debates on the use of this energy source.
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> Currently, most nuclear waste from nuclear energy is stored at the site where it's generated in the form of spent fuel, which can be stored safely and securely in dry casks for at least 50 years. This solution is only short-term, though—eventually we will need a long-term solution for storing this waste.
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> At the Pacific Northwest National Laboratory in Richland, Washington, they are looking to answer a similar question—how to handle waste generated from spent fuel that was reprocessed to recover plutonium and uranium for weapons production."

Lonergan: "Richland is home to the Hanford site, where they did a lot of support for the nuclear efforts in World War II and some in the Cold War. And out of those efforts to generate the plutonium, there was a lot of waste that was generated from that. And so, the waste has been stored in tanks out on the Hanford site, which is north of PNNL. And we need to do something with it, we need to get it out of the tanks. One of the ways that we'll do that is by taking the waste and mixing it with glass-forming chemicals to make waste glass."

De Guire: "That's Charmayne Lonergan, materials scientist and STEM Ambassador at PNNL. Charmayne has worked at PNNL since 2016 on waste vitrification, or the process of turning nuclear waste into glass. Not only does she study vitrification, but she also performs outreach to help the general public understand the potential of this technology to solve the challenge of long-term nuclear waste storage.

So how exactly does vitrification work? And how does someone get involved with such a unique application of glass?"

(music)

SECTION 1

De Guire: “Charmayne became interested in glass early in her academic career, but it took her many years and several degrees to realize that she preferred a career in applied sciences rather than the basic sciences.”

Lonergan: “So I was in high school, I really enjoyed chemistry, as I mentioned, and it was like, ‘Oh, well you should do engineering.’ And it’s like, ‘Oh, okay.’ Although now I realize that there are a lot of places that can benefit from chemistry and/or being good at math, not just engineering, although obviously it helps.

And then I went to Clemson for my undergrad. And they have it, or at least they did when I went, where you can’t choose a major in your first year, so as a freshman you have to go and check out the different disciplines.

And, it was the demos, the materials science and engineering department. I mean they just, of course we always have awesome demos, like it’s always the thing. And that is completely what sold me because I think I went to the chemical engineering department and I was like, ‘Oh, okay,’ and then went, well I guess at the time it was ceramic materials and engineering department, and went there for that and they had the silica insulation for the spaceship tiles, and the torch, and melting the penny on that. And it was like, ‘Holy crap, somebody is holding that in their hand and doing that!’ And then, I can’t remember what the other things were. Maybe there was a Rupert drop or something, I can’t remember.”

De Guire: “That’s pretty classic.”

Lonergan: “Yeah, basically classic demos that apparently just continue to work year after year. It was like, ‘Oh my gosh, I need to be doing this with my life.’

And so, I happened to meet, and I think Kathleen Richardson was my advisor at the time, or professor at the time. She’s phenomenal and I think she just went out of her way to try and find people that might be enthusiastic or excited. I’m not sure how she ended up talking to me, but I was doing some metals research, and metals are great, but she was like, ‘No, you should come and join me and do glass.’ And I’m like, ‘Oh, okay.’

And then I got into research with Professor Richardson, and she does materials for infrared, night vision kind of applications and things like that. And I found that very interesting. And by the time I finished my undergrad, I just wanted to know more. Like I wanted to do that deep dive, and I really felt like I just scratched the surface on understanding glasses and how they can be used for whatever applications.

I actually was at a conference in Italy and happened to meet/run into Dr. Brow. And he was like, ‘Oh, well you should apply for a fellowship.’ It was a GAANN fellowship.

Graduate Assistance in Areas of National Need. So, it was a fellowship designed to engage minorities and women in STEM fields to try and get into STEM at advanced degree level and at one point hopefully become a professor.

So, I applied for that and visited Missouri University of Science and Technology, loved the department there. And, yeah, and the rest was history. I went straight to the Ph.D. from undergrad, and yeah, loved it."

De Guire: "So tell me a little bit about what turns you on about glass."

Lonergan: "It's just, I just love it. You know, there's so many things you can do with it. You know, there's so many applications. My group mainly focuses on waste form development, but of course you probably know there are so many other things you can do with it, right? But I think I really, truly enjoy it because the community is kind of smaller. Like I look at the metals community and it's really big, for example, and the glass community is just awesome.

I mean, I feel like after I finished my Ph.D., I felt like I knew a decent number of people, and so even though I moved jobs, or went to a post-doc or something, when I went back to the Glass & Optical Materials Division meeting, it's like seeing old friends, like you, right? Eileen, I see you all the time and I love it. And so that, I never would have guessed as an undergrad, you know, looking forward, what things would be impactful, and I feel like that's one of them.

But off of that, I like glass because I think you can do a lot of things with it, and I just found it very interesting for some reason. When I was an undergrad, I wasn't sure what I wanted to do, I thought I wanted to do chemical engineering because I really liked chemistry, and then I realized that chemical engineering doesn't do a lot of chemistry, they do a lot of fluids and things like that. And so then I got into materials science, or I guess, ceramic materials engineering, and yeah, I just loved it. You know, the design of materials, understanding why we have the certain properties or behaviors that we do, and really how that impacts everything, you know. A lot of times people in other disciplines don't realize what they really have is a material problem. So whether it's glass, ceramics, metals, polymers, you need to have people that can kind of dive into that and help, you know, whether it's make a better material, or figure out a new material for the problem that you need to solve, and I just really, really loved doing that with glass."

De Guire: "Yeah, and sometimes it's how those materials interact with each other, like a glass on a metal substrate. So, you need to understand all that stuff. And then in service too you've got things under load, or in hot environments, or cold environments, or caustic environments. So yeah, lots going on there."

Lonergan: "And I'm sure this is similar for other things, but with ceramics and glass, I just love that you have access to such a wide range of technology readiness levels, or like applications, right? You know you can do the basic fundamental science, that's super interesting and gets you mechanisms and things like that. Or, on the maybe other end of

the spectrum but definitely still related, is the more applied, right? Like, okay, I have a problem to solve, and I really know what that is, and I know what I need to do to try and get this done. Which is kind of what I appreciate about the work that I'm doing now. Knowing that my work is going to a specific problem that impacts and helps society is really important to me."

De Guire: "So it sounds like you always knew you were heading in a technical direction. Or at least by the time you got to college you knew you were heading in a technical direction."

Lonergan: "Yes, definitely. I didn't know what exactly that looked like. And I think it actually took me doing my Ph.D. I think when I finished my Ph.D., I still wasn't quite satisfied and one of my committee members was like, 'I mean, you did a great job,' and I'm like, 'Well yeah, but I didn't solve a problem.' And he's like, 'Well, it sounds like you should definitely make sure that you do more applied work/maybe on the engineering side of things,' and I was like, 'Oh yeah, I guess I never thought about it like that.' But definitely technical, but yeah and also definitely way more maybe on the applied side, or at least within arms' reach of the problem that actually needs to be solved."

De Guire: "That makes sense. And that was actually a pretty useful insight it sounds like from your committee member."

Lonergan: "Yeah it was, because it hadn't clicked like that. I just kind of felt like, 'Oh, well, I didn't do a very good job.' You know, it's just like, then I finished this and, did you guys just pass me? And they're like, 'What? No, you're being ridiculous, you did a great job.' And I'm like, 'Well, I just feel like something was missing.' And it's like well you can't, it's not, you know the Ph.D. isn't necessarily about solving all the problems, right? It's about deep diving and showing that you can understand a problem, think of a plan of attack, you know, use the literature, problem solve, all those other things. You solve a problem, then great, but it's not necessarily a requirement. He's like, 'But keep that in mind as you go forward, understand that that's maybe something that you need to fill to feel fulfilled.' And I'm like, 'Yeah, that's a good point.' And he's been spot on."

(music)

SECTION 2

De Guire: "Charmayne's research on waste vitrification at PNNL is definitely an applied field of work, as waste vitrification is a technology that has been used for decades at nuclear power plants around the world. However, when talking to the public about her research, Charmayne says the biggest challenge is helping people realize this technology even exists."

Lonergan: "I think where the big impact is, is letting people know that this is a way that we can handle waste. I know that it seems like there's a lot of maybe pushback on moving to nuclear, whether it's the typical like light-water reactors, where you have water in the rods, or, you know, even molten salt. Molten salt reactors are something that they're

trying to explore now. But the question still comes up that, 'We have all this nuclear waste, what are we going to do with it? We have no solutions for it.'

And I guess that's the biggest thing that when I try and talk to people, I try and let them know that we do have a solution for it. You know, we can do this, this is a proven technology. As we improve the research that we're doing, maybe instead of making a hundred cans of glass, you can get that down to 50 or 20, right? Like if we could start doing that then we start having a more manageable response for, 'Well, what are you going to do if we fill up a repository?' or like 'What do we do if we can't have something like Yucca Mountain?' or 'Where do we put the glass?' I feel like those are the big questions that we have, not what do we do with but it where does it go."

De Guire: "You mentioned that the lab occasionally opens for tours and welcomes people in, and I know you've been very engaged in STEM outreach programs at PNNL. Can you talk to us a little bit about the STEM outreach going on an PNNL?"

Lonergan: "Sure, yeah. So we have so many tours, and it's actually really nice because we get people in whether it's interns, high school students, college students, again kids for Take-Your-Kid-to-Work day, so even younger, maybe middle school. And of course this is all before COVID, but we would have a variety of people coming in, and we could talk about the work that we do, and how it's impactful, and how we try and tackle this big problem of dealing with nuclear waste.

And what we do kind of varies depending on the audience, but we have done Rupert drops, but typically the bread-and-butter is you go in and you have a furnace at 1,150 degrees Celsius, and you pour out a simulated waste glass. So my group, the building that we're in, we don't do rad materials [radioactive], although some of the people in my group do kind of have access to radiological areas and they can do radioactive waste glass. But the majority of what we do is on simulants because really what we care about, the radioactive parts are a minor component, really what's going to dictate the properties of the glass will be the borosilicate part of it, right? The soda, the iron oxide, those types of things are in larger quantities depending on what the waste looks like.

So with regards to the STEM outreach, it's actually really awesome. So PNNL started a program, I think maybe a year and a half or two years ago, called STEM Ambassadors. And this was an effort to try and help scientists and engineers develop the skills to be able to convey what they do, their science, their impact, to a general audience. So we're all usually pretty familiar with presenting at conferences and things like that where we have a technical audience, but really trying to reach nontechnical audiences is where some of us have some sort of skills that need to be developed.

So they developed the STEM Ambassadors program, and I think I was actually one of the first ambassadors that went through the program. But basically we took our projects, and so myself and my partner, it was Jaime George, she also was at Missouri S&T with me under Dr. Brow, and we basically, 'What is a glass, why is it useful for trapping nuclear waste, what are the things that we kind of care about.' And those were more designed to

be able to go to a classroom or, what we often do, which was setup somewhere on campus and have a display.

And unfortunately, we couldn't take a furnace with us anywhere, so we just poured some glass pieces in the lab and then showed them, and I think we had varying levels of chromium oxide in the glass, for example, and so the depth of the color varied. So that was one of the things like, 'Okay, well, if chromium oxide gives it its color, which one, which glass piece do you think has more, which one do you think has less.' And kind of tying that back to, the things that we care about, we're trying to get as much in as possible, and we happen to be showing color here, but that can impact the properties, and we need to understand what that means and what impacts that has on things like viscosity, or how fluid a liquid is, or the resistance of flow, and the conductivity, the electrical conductivity, because how melters operate, you kind of need your electrical conductivity of your melt in a certain range, and what crystals form depending on what the components are in the glass, things like that.

So we try to set up a display that we could convey that type of information in an accessible way to people in the community because, and especially for this community, I mean, we're in the Tri-Cities, so it's Richland, which is where the lab is, but there's also Kennewick and Pasco. But you know, they have the Hanford site right in the backyard, and for a lot of them it's just kind of a place that they've heard about it and they've heard that nuclear waste is there, but that's maybe all that they've heard, or maybe it hasn't been spun in such a great light. And obviously having nuclear waste isn't great, but maybe they don't know that we have a path forward. And so that's kind of what we've tried to do.

And also the biggest thing that I've realized people didn't know that our outreach has done, which is when we talk about waste vitrification, or you know, trapping waste in glass, containing waste in glass, immobilizing, whatever you'd like to call it, a lot of people think that we are, it's like, the waste is a soda and we're pouring it into a bottle and then capping it. And what actually is happening is the waste is the color of the bottle, right? You know you're mixing the waste with the chemicals of the frit and you're turning it into the glass. So, it's not something being poured into a vessel and trapped, it's becoming part of the vessel, and it's one solid piece. And hence why that's so robust, and we can feel confident that we won't have appreciable amounts of radioactive or harmful things released into the environment over hundreds of thousands of years.

And so I think that that's probably the biggest thing that, from the glass science side, it's maybe fairly clear that that's what we're doing. But for people unfamiliar, we were able to kind of be like, 'Oh, no no no, this is what actually is happening. When we say that we're trapping waste in the glass, we're actually, the waste turns into the glass and it's a part of it, and to get it out, you need to break that glass up into the individual atoms.' Not just like, 'Oh, if it cracks, it's just going to spew out,' like, you know, a broken soda bottle."

De Guire: "Right, it's definitely a different way of thinking about waste. We're used to thinking about dumping waste into something, not making it the thing."

Lonergan: “Yes, exactly.”

(music)

SECTION 3

De Guire: “So as you think about the future and your future STEM outreaches, what kind of goals do you have for becoming an ambassador or maybe more of a mentor or role model? You’re a young, African American woman, do you feel that that gives you maybe a different approach? Or different audience that you’d like to reach?”

Lonergan: “Yeah, great question. I think going forward, and especially with kind of the times that we’re in now, I’ve been really reflecting on my sphere of influence and what can I do. And, you know, you had greats like Martin Luther King Jr. and things like that, and I was really struggling with like, ‘Why can I never be like Martin Luther King Jr.?’, like ‘What am I doing with my life? I’m not doing anything.’”

De Guire: “Oh, you and millions of people.”

Lonergan: “I realized that, okay, first of all, calm down. Second, you know, we all have our ways that we can be impactful. Of course, MLK was on another level, and we have people like that even today, but not everyone’s going to be like that, and that’s okay, right? You know, we have diversity for a reason, and we have different ways that we can make a difference. And you know, just acknowledging that okay, maybe mine is more on an individual level, right? You know, my sphere. And I think it really hit me when I, well I guess, included in my reflections during this time, before I’ve had interns that I’ve met who had other mentors or whatever, but I’m always happy to be there to help and to chat. And one of them was Black and he was like, ‘You know, it was really nice seeing someone else like me.’ And I think that maybe I take for granted that that’s a thing.

And as I have more conversations about diversity and I try and engage more, whether it’s talking at the different colleges in the area or doing things like this, you know, just showing that it doesn’t matter what you look like or what your background is, you can do it, right? Like it’s not reserved for a certain type of person, you can do STEM if you’d like. And we have, you know, a lot of our outreach is, we also, kind of there are Native American tribes in the area, like they try and engage with them, and also we have a lot of people that do like a lot of field work and things like that, and so then you have first-generation students here that may be the first in their family to go to college and things like that.

And just, I guess, maybe providing them with a diverse set of people that they have access to, and showing that not only do we have programs that are there to like reach out, like ‘Oh, well if you want to come do an internship here,’ but also having programs where you can be a mentor, and I try and do those as frequently as I can, but also just if we have people on campus, then if we have interns on campus, we also do things. Like I just hosted a webinar on presentation skills and things like that, and just offering different resources

to them, whether it's either my time or just me chatting with them being a mentor, or it's other types of things that can just support their experience here or any other place.

I think all of that kind of comes together, and I'm realizing is very critical, and just trying to increase diversity, right? I mean I feel like there's a lot of effort to recruit at the advanced degree level or college level, but I'm realizing that a lot of it starts earlier than that. You know, it starts in middle school or maybe even elementary.

And so, circling back to the STEM Ambassadors, that's one of the things that we have a target audience of. And maybe English isn't their first language, right? Like can you do something that's accessible to people, so hands-on, maybe bilingual displays or handouts or pamphlets when you can, but to show them that, yeah, it doesn't look like, well one, it's not just crazy mad scientists that do science, right? And you know, kind of maybe changing that stigma maybe, just that it's craziness that happens or they're all the bad guys in the movies. Like why do all these bad guys have advanced degrees in these Marvel movies?

And so that but also it doesn't matter what you look like, it doesn't matter what your background is. If you're first generation, you can still do it. You have people that are here to support you, but we know that you are capable of doing it, it's just trying to provide resources and showing them that they are and that they can do it.

I'm repeating myself, but it's been a big thing that I've been thinking about recently. And that's one of the things that I appreciate about PNNL. I mean, it's the first place that I've actually worked outside of a post-doc, so I'm sure that there are other places and I know that other national labs have these types of programs too, but it's just something that I really appreciate about this because it's at all levels, it's not just recruitment. You have to increase the diversity of the pool to then be able to pull good candidates from a given pool.

And so, yeah, I've been really trying to dive into the STEM outreach and making sure that I try and give back in some sort of way, and I try and do all that I can in my sphere of influence while learning if I can do more. There's always more to do. And so, yeah, you know, it's a great question because it's been a real struggle for me these past couple months."

De Guire: "I can easily imagine."

Lonergan: "And not just me, right? You know I say that from my house where I still have a job and my family is all healthy, we're fine, right? You know, like 'I'm struggling,' you know. I know that there are people out there that are actually struggling, and so I get that it's all relative, but for me it definitely was kind of an existential crisis. Like, if you're not part of the solution, you're part of the problem, like what can I do."

De Guire: “Right. And I think you’re doing it by putting yourself out there, and making yourself available, you’re being the change that you want to see and you’re showing others this is the direction we can go, let’s do this.”

Lonergan: “I’m at least trying. I’m still grappling with that one, but I definitely, definitely like okay. It’s always part of the path forward, and I feel much better.”

De Guire: “Yeah, well, and right now there’s no roadmap for how to handle a pandemic.”

Lonergan: “Yeah, that’s so true.”

(music)

CONCLUSION

De Guire: “Regardless of the times, it’s important to reflect on the impact we can make in our roles as responsible engineers, scientists, and citizens. And as Charmayne says, your personal sphere does not need to be large for your impact to be meaningful.

I’m Eileen De Guire, and this is Ceramic Tech Chat.”

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“Visit our website at ceramics.org for this episode’s show notes to learn more about Charmayne’s work at PNNL. Ceramic Tech Chat is produced by Lisa McDonald and

Until next time, I’m Eileen De Guire, and thank you for joining us.”