CERAMIC TECH CHAT

Episode 19

Title – "Superheroes and open access inspire research: Ricardo Castro (E19)"

INTRO

McDonald: "I'm Lisa McDonald, and this is Ceramic Tech Chat.

> During the past two years, our reliance on the internet grew immensely as people began to work, shop, and hang with friends virtually during pandemic quarantines. Yet as COVID restrictions ease with the availability of vaccines, it is time to remember the many things there are to discover beyond the confines of our homes, things which will require hardware, not just software, to achieve."

Castro: "Coding will create this virtual environment, which is fun, virtual reality is here to stay, it's a fascinating universe. Yes! But if we stop there, coding can only go this far. So, we need more hardware. Either electronic hardware, or materials to explore in the universe, or even materials to make our lives better, more comfortable. And now with the biggest challenge that everything needs to be sustainable."

McDonald: "That's Ricardo Castro, professor of materials science and engineering at the University of California, Davis. Ricardo's research focuses on the processing and properties of nanoceramics, but he is also instrumental in launching several programs to grow student interest in materials science using superheroes.

> What are the benefits and challenges of using superheroes to inspire an interest in materials? Plus, Ricardo discusses the move toward open-access publishing and how it serves to make the materials science field more accessible as well."

> (music)

SECTION 1

McDonald: "Ceramics is not generally the first field people think of when they're like, 'I'm gonna go do science. I'm gonna go do advanced ceramics.' So, what's your story for how did you come to learn about ceramics and get involved with doing nanoceramics?"

Castro: "Well, how I got to that, it's a different story. I was once in a class, and it was an extracurricular class, it was during my undergrad. And when I was there, like this professor—I still have great memories of him, you know, he's a fantastic professor. And he came with this crazy thing in the classroom. And what he did, he actually brought a turbine, an actual turbine, into the classroom. Hey now, that's fine, yeah, he's going to demonstrate a turbine, that's fine. But no, he actually lights it up, like in the classroom, and then you have this fantastic veil of the fires coming out of that. It was basically a piece

of metal, you can imagine that as like a cylinder of metal, like the size of like a soda, two-liter kind of thing, and put inside and made out of metal. And then he basically turned it on, like heats it up, and eventually you start seeing this fantastic flame coming out of the side of that. And then it started making those fantastic noises because it's basically going to Mach 1 and Mach 2, and this is in the classroom. I think, 'This guy's crazy.' But then, that's when I started falling in love with this thing. That's when I said, 'That's what I want to do. I want to be able to design something that actually can do that.' Because then, for some reason, my immediate question is, 'What is this made out of? Like, how can we make one of those?' And then he actually said, 'Well, these, you know, aerospace materials, this is basically, you know, metals in this case.' But, okay, I'll look it up. I started researching how can I build my own. So that is what I wanted to do, build my own turbine.

So, I went back to my university and started knocking the doors of professors in materials engineering, saying, 'I want to do that. What do I need to learn?' And then, one of them told me, 'Oh, okay, this is basically steel, aerospace steel. It's no big deal. The technology's sure now. But there is a lot of new development that you have in ceramics. And there's some coatings that you need for this. So, you're better off if you start your career doing things in ceramics. There's new professor, an assistant professor, that is just starting his lab, maybe you actually learn.' And then I went and talked to him, and then we start talking to him. It's professor Douglas Gouvêa, who became my undergrad supervisor and then later my Ph.D. advisor. He was so passionate about the thing, so passionate about ceramics and everything. And he starts talking to me about like the different kinds of processing, the problems that were in the literature, the opportunities in science. We barely talked about rockets at all. But he was so passionate that he just flooded me with that idea. I was pumped and excited after that. Said, 'Wow, I didn't know that, but actually that's what I want to do.'

Of course, before leaving the office, I went back and said, 'Would I be able to actually make a rocket?' And then he looked at me, 'Yeah, sure why not? It's all ceramics.' And, of course, it never happened, he just fooled me totally. But maybe it doesn't matter because he put me in this universe that has such interesting questions and problems to be solved that I was just happy to be in that place. So, later on, I did my own attempts to build the rocket, and I failed miserably. And I say, 'Well, that's one of my frustrations, that I never get to do my own turbine.' But maybe, maybe one grad student will come one day and say, 'Hey, let's do those things.' And I would just say, 'Yeah, yeah.' It's gonna be exciting. I would be happy if this happens."

McDonald: "Even if you haven't gotten to build a turbine, you've definitely got to research a lot of other really interesting things. And so, how did you end up at UC Davis, and what are some of the projects that you've done there?"

Castro: "Yeah, well, I'm originally from Brazil. So, these, all of the story happened there. And I got really excited, and I became a professor at Centro Universitario da FEI in Brazil, and I started digging deeper on this problem of nanoceramics. So nanoceramics is basically two kinds, or maybe three kinds of nanoceramics. You have the powder form, and those

powders, it can do ceramic sensors and can do catalysts with those. And then you have the coatings, nanocoatings, that you can coat metals and coat other ceramics that you need to protect, create these protective layers, which are finding a lot of interesting application in aerospace. But then you have the bulk ceramics, right? The actual parts of nanoceramics, which have nanograins. The grain sizes are very small, and then you have such unique properties. In all of them, there are so many questions to be answered. From the processing of them, trying to get them to be what you want them to be, with the right microstructure, to actually, what are the properties.

From time to time I go to the lab, you know, we do some tests, and honestly, we don't know what we're going to see. We test it and say, 'I have a hypothesis, but I honestly don't know what's going to happen.' And when it happens, you say, 'Oh, what I was thinking was totally wrong. Like, let's sit down and redo our hypothesis.' Because the nano does bring this very unique question.

So, I was back in Brazil, like doing this research with much more limited resources. And then I met this professor at UC Davis—she was in UC Davis, now she's in Arizona State University—Alexandra Navrotsky. And then we started chatting about these, and we created these international collaborations. So, we wrote a project together, and we started collaborating. And when I was in this collaboration, one of those trips like I went to, we were UC Davis, UNAM in Mexico [Universidad Nacional Autónoma de México], and us. So, there are three institutions involved. Then we were in Mexico. I gave my talk, that was nice, and then we went for dinner. We were having a good time over dinner, and then Alex Navrotsky comes to me and says, 'Hey, there's an open position at UC Davis. You should consider it.' And, at this moment, you know, I was very flattered, but I didn't think it was real. I never thought it was actually a thing. And so, 'Yeah, sure, thanks, Alex. I'm sure you're gonna get awesome candidates, and it won't be me.' And then she insisted, 'No. You have to apply for that.' And I said, 'But Alex, I'm doing so great back in Brazil. Things are doing great. I'm gonna get married, I'm going to have a good job, life is good.' And then she said, 'Exactly. That's why we want you. Because your life, because you know how to be successful, and we want you to be here.' I said, 'Okay. So, I'll go through for the experience.'

So, I called my wife-to-be from Mexico because she [Alex] said, 'The position's open, so we have to kind of come up with this thing very quickly.' And okay, I call her, 'What do you think?' And, 'What do you mean? Gonna have to move to U.S.?' And I say, 'Yeah.' 'I've never thought about that.' And I say, 'No, of course, not.' And then, she was super supportive, and says, 'You know what? Let's do that. Let's try.' If I don't get, I don't get an offer, it was an awesome experience. And if I get an offer, then we solve that problem later on. So, it happens that a week before my wedding, I got an offer letter from UC Davis, and I share it with my wife, Luciana, and say, 'Let's go get married and move to U.S.' So, wow, that's a lot of change, but that's what happened. We moved in 2009 here, and it's great now. We have two kids, and we have a blast here in Davis, yeah, for sure."

(music)

SECTION 2

McDonald: “When students start out in materials science, everything is often foreign to them, and they don’t really have any personal connections to the material. But one way that Ricardo is helping students become more interested in understanding the larger picture of ceramics is to connect the topic to things that are personal to them, in this case being superheroes.”

Castro: “The superheroes project is an amazing, yeah, it’s amazing to talk about. So, the Engineering Superheroes project was an initiative that we have just to really engage the students with challenging concepts, right? So, talking about ceramics or metals or calculus or whatever you do that is hard core or difficult to understand will automatically create some barriers. And then you start reading the literature about education and then you see those guys saying that it’s very challenging to have classrooms and classes that are longer than one hour because the students lose attention, the attention span of a human being, it’s not so long. And then I say, ‘Wait a minute. I just came from the theater, and I was sitting for three hours watching Infinity War or End Game, and nobody was distracted. Like, people were really, really focused.’ And I can ask a week later, ‘What are the key aspects of the movie? Who are the key characters? Who is the evil guy? What were his powers?’ And they would know everything. So, I don’t think there is a problem with the time on attention spans of students. I think the challenge or the problem is actually now we need, we have been designing ourselves to need to be entertained.

And, a combination of entertainment and education can be the key to actually engage students at young age into solving complex problems. Just for them to start seeing those in an interesting way. Seeing these as a cool thing to do. Like, it’s very similar to the moment I got into my advisor’s room, and he just sold ceramics to me. He was passionate, he had the right example, he was super excited about that. And I said, ‘Yeah, this is what I want to do. I want this excitement. I will buy the excitement, and I will do the hard work because I am excited.’ And with the superhero world is you basically bring those things together and it’s an easy one, it’s an easy thing to bring the students to attention. And there is a risk. It’s a fine line, though, that you have to walk not to become just entertaining. And then actually when I started this, I had some students, I like those students who are, you know, those are my favorite students that question you, even in your education. And then they come say, ‘Are you seriously talking about superheroes in college? Is this what my dad is paying for?’ And I say, ‘Yes. By the end of this course, I will ask you this question again, and I want you to tell me if that worked for you or not.’

So then, we started with the course as an undergrad course that we have that’s called Materials Marvels. So that’s for the freshman students, and basically, we started with a little bit of history of materials in the civilization, and then we start getting to how are you going to develop newer materials, new things, and what if we actually start exercising the creative part of our brain and started bringing superheroes to the problem. And then when we start talking about superheroes, they realized that if I bring the Arc Reactor [a fictional fusion-type power source] as a piece of engineering, we can dissect that thing from an engineering perspective and trying to understand metals, ceramics, plasma, lasers, and,

you bet, even nuclear reactions. It's really such a rich element. And then I can bring the actual concepts and they can learn. And what happens, more often than not, is that students get interested in specific points of that. And every student will be interested in a different thing. Like one student will be interested and say, 'Oh, I love this laser part.' And then I tell them, 'You know what? You should talk to this professor. You know, that's his job, to build ceramics for lasers.' And then go be there and do their research and enjoy. I'm just happy that I inspire that student to become a researcher. Like they just, yeah, I don't know what is going to be the future, but at least I inspire them to go next step.

So, we started with the undergrad course, Materials Marvels, and that was a hit. I started surveying the students, and they were just, 'Yeah, this is amazing.' And I started asking questions, 'If you were in high school, would that be something that you would be interested in?' And they said, 'Well, yeah, absolutely. You know, I've been watching these movies since I was in middle school.' And so okay, that's great. So, that's what I needed. And then we came up with this concept well, let's bring this in little more simplified manner to the schools, and, you know, help the teachers, we provide lesson plans for the teachers. So, let's do this outreach. And thanks to NSF Ceramics, Lynette Madsen program manager, and basically that was an amazing opportunity. But then we got COVID pandemic."

McDonald: "It threw a little wrench in everyone's plans."

Castro: "Exactly. So, okay, I have to change this somehow. And, well, everybody's in front of the computer now, so let's start thinking can we do this online. Can we actually do a class, or at least something that is entertaining and educational at both times. So that's when we came up with the Engineering Superheroes series. And I call it a series because I'm just optimistic because it just has one episode. But hopefully we have more episodes to show soon. But the idea is exactly that. Let's combine superhero science with materials science, and basically trying to get student, attract more students who go for these particular majors. And then create an episode that has hands-on activities, you know, we can do some mechanical tasks and basically show what do you need to do to actually have Captain America's shield to be, perform as a material. So, is that something real, is that just fictional. We talked about Spider-Man's webs and what kind of polymer you should be using in that. So, it's a little broader than ceramics, but it creates a whole new universe for conversations. And, yeah, it's been successful, but I'd love to continue that, and it's looking good, it's looking good, that's what I was going to say."

McDonald: "Well, do you have a favorite superhero that you like?"

Castro: "Well, I like them all. I'm a big fan of the superheroes and the supervillains. I love supervillains equally. Like the Green Goblin is just this amazing character. Like, you think about the technology he created, it is just equivalent to Iron Man, right? So, you start thinking maybe in a fight, who's going to win? I don't know. But I like them both. But my favorite is Iron Man just because it's such an obvious character to like if you're an engineer, right?"

McDonald: “Of course.”

Castro: “You’re there, in a cave, and you got nothing, and then eventually you just build an arc reactor and a whole armor, and this is the symbol of ingenuity. Like, just creating something useful from whatever you have around you. And so, it’s a great character. Yeah, that’s my favorite.”

(music)

BREAK

McDonald: “Communicating science to nonspecialist audiences is something scientists do almost every day. Yet knowing how to communicate science effectively to different groups is a skill not always taught in school. ACerS’ ‘Communicating science’ webpage offers some useful resources to learn how to communicate science effectively. Visit the webpage at www.ceramics.org/communicating-science.”

SECTION 3

McDonald: “We love having you here at The American Ceramic Society. So, what’s your story of how you became a member with ACerS?”

Castro: “So, when I was back in Brazil, the Ceramic Society was already for me the gold standard, and it still is the gold standard of societies. I was thinking, always saw that as, ‘Wow, the people that really matter in this field are all there.’ That was always my perspective. And then I thought, ‘That’s what I need to be. And if I really want to understand what are the challenges of society, to grow in my career.’ And then, you know, I became a member, even when I was professor back in Brazil.

And I was, I honestly, I had to face some challenges because when you are a domestic student and you are part of The American Ceramic Society since you’re a grad student, you naturally become like part of that Society when you are professional or professors in time, and basically you know people, right? You already know, you’ve seen, they’re all familiar faces. At least you’re going to find one or two familiar faces to contact. Your professors will be here. So, we always have some familiar faces. So, here I am coming from Brazil, and getting in here and looking at the core of The American Ceramic Society and say, ‘How am I gonna get in this Society?’ So, I’m very shameless. I’m just going to show my face in every meeting, and I’m gonna start organizing symposia, and I’m going to go to all the award ceremonies, I’m going to sit at table with random people and then start conversations, and let’s see how that goes. And what I realized is that everybody was so friendly and so welcoming. They’re all thinking about ceramics and talking about ceramics, and they have similar questions as I do, and then it just became an important part of my career.”

McDonald: "You've contributed so much to the Society too. You've helped with our short courses, and probably one of the biggest things is you helped with the foundation of the new open-access journal, right? *The international Journal of Ceramic Engineering & Science*."

Castro: "Yes, yes, yeah. *IJCES*, it was a great challenge that ACerS put on my plate. And I was really excited. I think the concept is very, it's very unique. It brings everything we need in science in general, right? We need things that are open for everyone. Like, open access, I know there's still, it's a cursed name still. Everybody think about open access, you think about things that are not of great quality, you know, it's just being approved because you're friends with the editors and whatever, or it's a money machine, like some of those predatory journals. And of course, those are around there, but it's a shame because it taints the whole novel concept of an open-access principle.

So, open access means that everyone around the globe would have access to that. And why is this important? Well, if you are in U.S., if you are in a university in U.S., maybe it won't make any difference to you. But if you are back in Brazil and your institution doesn't have access to ACerS just because it was too expensive this year to renew the contract, how are you supposed to read the material? How are you supposed to catch up with literature? You're not. So, you're behind, you're automatically behind. I'm not saying that all institutions in Brazil don't have access. Most of them have, the government does a great job trying to give access to that. But it is expensive. And so, you're pressing those countries that are known not to have a lot of money already to actually pay for these accesses and subscriptions and so forth, and then these creates a problem for me of, basically, the democracy of the data. So, to dream of this, 'Oh, if I produce the science, they produce the data, it belongs to everyone.' Well, as a scientist, I think that's a given. You know, if you're producing science, for what? Just for you to get better and to get awards and a pat on the back. I think it's beyond that. You create science to evolve and develop the society. And if I do this, lock it in between dollar amounts and say, 'You can have access to this only if you pay $35 a paper.' For me, it doesn't feel right. So, the model has evolved to this, it is what it is. You know, it's not bad, people generally have access, but it is time to change, it's time for us to go beyond that concept.

And *IJCES* is helping that. It's really helping changing this publication model to something that is, well, let's make it open. Papers that are published in there already see the difference. There are more downloads, people read it more, it is really, like, it is gonna have more impact. Of course, it takes time, right? Because I just created a journal. Anyone that creates a journal, the journal will take a few years for the people to recognize and see the value in that. So, we are taking our time to be indexed and have impact factors. But when we analyze the data, we start seeing, 'Hey, some of our papers are more downloaded than the papers in the *Journal of the American Ceramic Society*, which is an awesome journal.' And so that's where we see the power of the open access."

McDonald: "And I also know *IJCES*, unlike some of the more traditional journals, it's also been a great platform for people who have case studies, like in industry. I know a lot of people in industry have been expressing interest because they don't always have an outlet to talk

about the results that they have. And again it feeds into what you said about, you know, the more viewpoints you have, the more diversity, the more ways you can look at a problem. And *IJCES* is one way that we can get more of that industry perspective."

Castro: "You bet. We already have some very, very good papers from an industry perspective in the field. Because it's not that, I know some industries that do have this complex that, 'I don't want to publish because it's gonna be telling my secrets,' and so forth. But if you think about it, there's a lot of things that you can publish. And I'll tell the industry, 'Do tell us what your problems are, because then the academia can actually help you solve those problems.' So, if you're just super quiet about that and just say, 'I don't want to tell anyone about this, this is my secret,' it won't help you much. But if you start sharing these challenges and problems, even if, you know, we do accept things like negative data, things that you tried several times and it never worked. We are open for this in *IJCES* because I believe that negative data is as important as a positive data because basically we'll save a lot of time for a lot of people. Because if you already tried and it didn't work, I want to know. But not a lot of journals would accept those because they're going to say, 'Ah, there's nothing new here, it's not going to be impactful.' I disagree. It's going to be equally impactful because it first, maybe in a not so obvious way because, you know, I'm not going to try that because that company already with failed that, when at the same time, we'll actually feed some new perspective, and I want to look at that problem from industry and say, 'Hey, I know how to solve this,' or I will write a project to NSF, or I will contact the company and write a project with them, like these GOALI proposals to NSF, and maybe I will get some money and we can work together on this problem to solve that. So, this is indeed a fantastic place for industry to put their work, yeah."

(music)

CONCLUSION

McDonald: "While research can be hard work, it can also be a lot of fun, especially when you can share your research freely and in a relatable manner.

I'm Lisa McDonald, and this is Ceramic Tech Chat."

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"Visit our website at ceramics.org for this episode's show notes and to learn more about Ricardo's work at UC Davis. Ceramic Tech Chat is produced by Lisa McDonald and copyrighted by The American Ceramic Society.

Until next time, I'm Lisa McDonald, and thank you for joining us."