Intro 00:00:01

Inventors and their inventions. Welcome to Radio Cade -- a podcast from the Cade Museum for Creativity and Invention in Gainesville, Florida. The museum is named after James Robert Cade, who invented Gatorade in 1965. My name is Richard Miles. We'll introduce you to inventors and the things that motivate them. We'll learn about their personal stories, how their inventions work, and how their ideas get from the laboratory to the marketplace.

Richard Miles 00:00:39

Using plants to decontaminate water. How does it work and what good will it do? Welcome to Radio Cade, I'm your host Richard Miles. Today, my guest is Dr. Norma Alcantar, the professor of chemical, biomedical and materials engineering at the University of South Florida. And a 2021 inductee into the Florida Inventors Hall of Fame. Welcome to the show Dr. Alcantar and congratulations.

Norma Alcantar 00:01:00

Thank you, Richard. Thank you for having me, and it is a pleasure to be here talking to you.

Richard Miles 00:01:06

And is it okay if I call you Norma? I should ask, is it okay? Good. First of all, we're recording this a few hours before the induction ceremony. So how does it feel? This is like the Academy Award for Florida inventors, and I know you have family and friends in the audience. What are you feeling right now?

Norma Alcantar 00:01:20

Well, I'm feeling like I'm late for everything. It feels very exciting. I never expected to be one of the selected inventors for the Florida Inventors Hall of Fame. When I submitted the application, my nominator kind of pushed me and said, if you don't apply, you will not get it. And I was a little reluctant, but then I said, okay, let's do it. We should do it. And it was because of her that I was able to submit the application, and it was a really nice surprise knowing that I was selected.

Richard Miles 00:01:56

It's very impressive. Also, when you look at the other inductees, you just see like, wow, these are really, it's wonderful to see so many inventive and creative people in the state of Florida, or at least from the state of Florida. And you're not being recognized for just one invention because you, in fact, hold 22 U.S. patents. So, you've been busy inventing a lot of things, but I thought maybe we start with explaining, I guess, one of your core technologies, your core insights, which if I understood it correctly from reading some of the material about it is you use a biomaterial from cactus plants to remove harmful chemicals

from soil and water. So, uh, one, tell me if I got that right. And then tell me, how does this work? And then afterwards, if you could tell sort of the story of the idea where, where did it come from?

Norma Alcantar 00:02:39

Yeah. So that's, 12 of my patents actually relate to the cactus extracts. The cactus plant has a wonderful ecosystem process in which it stores water so they can survive in arid environments. So that mechanism and those cells store the water, kind of like switch back and forth between releasing and obtaining water. And that mechanism is what we were able to harvest. And when you expose these molecules to contaminants, they actually attract them because they are able to go back and forth within the switch that they have internally. So, if you have a contaminant, and it has a charge, then they have part of the molecule that will actually interact with those charges. If you have a molecule that looks like water and then expose those compounds in the molecules that actually attract, like prophylactic, what we call non, like they don't like water. And when you have water, then they have other systems to interact with water easily. So that behavior allows the molecule to wrap around different contaminants of the same way that it kind of like fish them out of the water. If it has that kind of mechanism.

Richard Miles 00:03:58

Does it act like a filter, or is it more like a binding agent or something? Does it transform the molecular structure of the contaminant or is it sort of just removing and separating?

Norma Alcantar 00:04:07

Just remove it. So, you can think about, it is what we call a flock that is capable of bringing things together, forming this big flux. So, when you have sediments, for instance, in the water, what it is going to do is act kind of like a net, like a fishing net. It was going to bring that altogether. Once they have critical mass, they are going to go to the bottom of the solution much, much faster than if you don't have the cactus, the cactus extracts in the water, and then the same with bacteria. So, it's a similar process, kind of like fishing bacteria out of the water. When you have heavy metals, then it has a different interaction because metals are very unique. They have charges, they have groups that have an affiliation for other molecules. And so, it's able to recognize, oh, now it's metal.

Norma Alcantar 00:04:58

And now I'm going to form a complex; by forming that complex that can either change the hydrophobicity of the compound, and can flow to the water air interface, or because they have, the metal is heavy, then it will move it to the bottom and all the solution as well. So, it has this mechanisms, it has this very complex sugars and a combination of them, there is more than 50. All of these sugars can work towards separating the contaminants that you see in the water. The same way that they work in the plant to keep the plant alive by bringing and giving water by storing and giving the water away when it's needed.

Richard Miles 00:05:38

So obviously this is a result of years of research, figuring out exactly how this happens, but it was, um, it was known apparently way to older generations in Mexico. So, tell us about that. How did you hear about that?

Norma Alcantar 00:05:50

There's a very good story. It was years ago when I was in high school, and I came to my grandma's house, and she asked me how's my day. And I had a chemistry lab that we were actually studying what we call sulfations. These are the chemical compounds that we use to remove contaminants from our clothes, and from the hands, and for water, right, and I was explaining to her that we were categorizing these compounds in the water, and how it was separating the different things. And so, she looked at me and said, I know all about that. I was surprised to hear that because my grandma was a very modest person and she really didn't talk much about her upbringing, but it was good to hear that she had a little bit of science, right? Like growing up or she was doing something related to science.

Norma Alcantar 00:06:46

So, I was surprised about that. And I asked her if she could explain, and she said, well, when I was a little kid, I was in charge of bringing the water from the river to the house. Right. And when he was the rainy season, then you have a lot of debris in the water. And when you bring the water, obviously it's dirty. So that day I will have to cook cactus, and the water from the cactus, I will use it, to put it in the dirty water. And the contaminants will just go down to the bottom, out of the pot. And I was very surprised because I don't know if you have ever cooked cactus. But if you do, It's kind of like a greenish. You start with clearwater, but then it turns into a greenish, very viscous, like solution. Yeah, I remember telling her that, how is that possible?

Norma Alcantar 00:07:40

Because you're adding something dirty to clean the water. And she said, oh yeah, it works. It works the same way that you're explaining your chemistry lab today. So, I was like, oh, that's really cool. And kind of like, in the back of my mind, it was always like, how is that working? But I went to school, I went to college, grad school, I did a post-doc, and then I came to USF. And my first year that I arrived, my lab wasn't ready. So, I couldn't really start right away with all the experiments that I wanted to do. And I hired a post-doc and my post-doc came to my office and said, where should we start? And he was ready to go. Right. That's what postdocs do. And I was like, well, let's just start with something that's simple because we don't really have a lot.

Norma Alcantar 00:08:26

We only have like a sink. So he went to the library, he came back and say, why do we look at these lubricants? At that time, I was doing a lot of surface chemistry. So, he came and said, you know, I read this article about oil that snakes have, it could be used as a lubricant and I was like, oh, I don't really like snakes, but that's really good for my memory and what my grandma told me about natural materials. Right. And how the cactus had worked. And I explained to him the whole story. I said, why don't you just go to the lab, make water dirty, boil the cactus, put a little bit of it into the water that is dirty and see what happens. Right. Because I'd never tried before. So, he went to the lab, and it was two days after he came and said, yeah, it works.

Norma Alcantar 00:09:18

I was like, I need more context.

Richard Miles 00:09:19

This was here in Florida? Where in Florida?

Norma Alcantar 00:09:21

In Florida, in Tampa.

Richard Miles 00:09:22

Did you have to go to a plant store to get a cactus?

Norma Alcantar 00:09:23

Yes. We went to a Mexican store to get the pretty pair pads. And, uh, you know, he cut them, just the way that my grandma will cook them for a meal. And then he just a little bit of the water that was from boiling the cactus. And what he said is the solution or pod that has a dirty water shows that the contaminants just go to the bottom of the solution. I mean, it's very visible. Wow. So that was like, why? It doesn't make sense. So, we started looking into it. What is it that the cactus plant has that allows for that to happen? And we did some discoveries. We have some ways to do an extraction, where you can get the molecules that we are using. And then from there we started utilizing everything in the cactus plant because the skin of the cactus can be also, it's a very interesting material.

Norma Alcantar 00:10:21

It is exposed to extreme changes of temperature, right? So, the cactus grows in the desert, in the mornings it’s cold, at night it’s cold, but during the days are hot. And if you put any other material in

those conditions, it will crack. But the cactus pads survived, they are able to resist these changes. So, we started also looking into that. That's another of our patents, you know, figuring out what has that behavior. When the oil spill happened, that was in 2010. I also have another of my students that had already been working on separating arsenic from water. I told her, you know, we'll just try with, uh, oil and see what happens. So again, she comes back three days later, and she say, yeah, it works, again, right? Like what is it that you're seeing? So, she puts oil in salty water. She puts the cactus inside and then you can see the oil disappear. So why is it happening? So, the interesting part of my job is trying to figure out why. And every time we think that we know this is the property they had, then we tried doing something else and boom, we try it with the amyloid beta peptide, the form, the Alzheimer's plaques. My research originally was going to be all in Alzheimer's right. If you give me an out there...

Richard Miles 00:11:42

So that's what you would have done? If you'd had a lab set up? Right?

Norma Alcantar 00:11:47

Yes! And I did, I had a student and she looked at how the plaques disrupt, they disrupt. And that's also another story, because I remember her telling me at the center and, you know, we were doing cactus research and her research with Alzheimer's and she said, should we try the cactus in here? And I was like no, it's not going to work. Yes. Later another of my students tried and it worked. So, oh my goodness. I wasted 10 years of my life, right, but it's you never know. So that's probably one of the messages, listen to your students, try to look like all the little fibers out of the big mess.

Richard Miles 00:12:26

Right? You started this idea or at least the research, because at that moment you had nothing better to do, right? So, in a way, it exposes how creativity can work, often creativity works best when you hit a wall, right? Because if you had, like you said, had your lab completely ready to go. You probably never would have done that. Okay. We're off to the races. And we're going to research something that doesn't involve cactus.

Norma Alcantar 00:12:47

That's right. We would have done probably a total different thing and never, I would have never figure out what happened.

Richard Miles 00:12:53

But you were limited in what you can do. So I have to ask, was your grandmother still alive? Is she still alive now?

Norma Alcantar 00:12:57

She's not alive now. She passed away in 2008, but I did get my first grant from the National Science Foundation in 2004.

Richard Miles 00:13:06

So, she saw you starting this research.

Norma Alcantar 00:13:07

So, I call her; I got the grant. That was my first grant too. And I called her, and I explained to her that they have given me money to study all the properties that the cactus has to separate these contaminants from water. And I explained it, it was really hard to get a grab on and open the fine. And she said, but I told you it was going to work. Like, why do you think you would not believe me? I said, no, I did believe you grandma, I just wanted to know why. And I don't think we know why, we are trying to figure out why that is. That's where they give me money for it. But she was like, well, it works.

Richard Miles 00:13:45

Well number one, the moral of the story is always listen to your grandparents. So, I'm a grandfather now. So, this is what I'll tell my granddaughter one day, you listen to me, but it must've been exciting as you establish that it worked, but then figuring out how it worked, right? Because like you said, until you understand precisely how it works, you can't really go out and use it for any significant applications because otherwise people say, well, why am I doing this?

Norma Alcantar 00:14:07

That was my example for the oil, right? Because we knew that it worked with the oil, and the crude oil has this huge molecules are really messy, and it's capable of dispersing them the same way that another commercial dispersant can do. Right? And when you have a spill, you want to disperse the oil. If there's a one way to get rid of it and bacteria will be able to eat it, if it's dispersed, because then it only has the small bubbles so that they can access to it. So, when that happened, I remember thinking if we can work with the oil, probably can do something to the amyloid beta because the peptides form the plaques and once they formed the plaques could not dissolve them. Right. They're really hard. It' in, in a fiber like formation and they form blobs of it, and they go on top of the neurons and then you lost the neuron. So, I thought we can add something to disrupt that formation, if we can do it with the oil, maybe you could do it with it.

Richard Miles 00:15:08

And so, Norma, just so I'm clear, amyloids were something you already had worked on. Are you familiar with that structure before doing work on the cactus?

Norma Alcantar 00:15:16

Yes. So that was the Alzheimer's research that I was going to do, right from the beginning. So, I still started my group with the Alzheimer's research, because I wanted to be able to figure out how these plaques form, because once you know that, then you can dissolve them, then you can do something about it. So, my research has started by looking at how these plaques will form the amyloid beta. We know that that is the compound that exists in the brain and there is something that triggers the mechanism for that to form larger fibers, these fibers then interact with the neurons and then form a block on top of the surface. And so, I wanted to figure out the molecular forces that make plaque formation possible so that we can reverse the mechanism. Years later, I am like 10 years later, I started trying it and we find out that it works, that also gave us an insight of why it can work with the oil, right. Because how it's interacting with these hydrocarbon molecules, it don't like to interact with anything that likes water, right? And the cactus likes water. Right.

Richard Miles 00:16:25

That's really amazing. So, I imagine that the cactus-based solution is not the only thing that can treat oil spills or even amyloids, but is it better in some way, is it cheaper to produce or is it environmentally safer?

Norma Alcantar 00:16:38

Well, so we also study the toxicity, right? That's very important. We realize that any extract from the cactus plant is environmentally friendly. We use very, very large concentrations and it wasn't until we used 10 times the allowed doses. That we saw an effect on toxicity. And if you use a tiny little amount of any other dispersion, it will actually affect some marine organisms. So, the fact that the cactus doesn't really do that much, then that opened up the research that we did of the fish and agriculture, because the fish farm. Well, we were approached by marines and they wanted to have a way to establish using fresh water for natural culture. If you think about any, any foreign fish, it smells fishy, right, because you are growing a lot of fish in a small tanks, and they eat and poop at the same time.

Norma Alcantar 00:17:39

So, you have waste, waste, produces bacteria, bacteria produces compounds that give that smell to a fish. So, when you producing fish, you actually use a little fresh water to try to dilute all these compounds away, also from the skin of the fish and the water that they have been into. And it is a large amount every day. So, they wanted to have something that will remove these compounds without using

your water. Right? So, we did some research, and we were able to use some of the cactus extracts to separate these compounds that give the water the fishy smell. And as the research for the agriculture started...

Richard Miles 00:18:16

This is like a miracle plant, right? It's what they say about coffee and red wine. Is there anything it can't do? So, is it also true that you're also working on certain types of cancers, brain and ovarian cancer?

Norma Alcantar 00:18:28

Yes. So that's a different technology. It's also not all materials.

Richard Miles 00:18:31

Okay. So, it has nothing to do with cactus then?

Norma Alcantar 00:18:33

It doesn't have to do with it. It has to do with a technology that you can encapsulate chemotherapy drugs, kind of like balloons. Right? You can actually put some of that on the shell and some of the core, depending on their chemistry. And then you can have a cocktail of chemotherapy drugs within that encapsulation. You use a gel to capsulate those balloons, and then you can put it near the tumor site. And it will attract the shape of the cavity that is left after. After a brain tumor has been removed, allows for this gel to actually expand and take every single part of that cavity. So, when the drug is released, you can release it, right? Any cancer cells, still alive after they remove it. That technology works. And I have a lot of ideas well doing by biomedic systems, that use natural materials and how can we apply those to serve our needs? And we have a problem then let's see the solution.

Richard Miles 00:19:35

One final question Norma, and then I'll let you go, looking back now on your career all these years in the lab, it sounds like it was easy, right? You just say, hey, what was grandma told me about the cactus and boil it up. And it solves all these problems, but I'm guessing it wasn't that easy that there are days in the lab where you may have been discouraged and had setbacks or detours and so on. So, if you were giving a young researcher advice, I'm sure you probably have matured young researchers that may have a great idea, but they may not see the full fruition of that idea for 10 years or more, something like that. What sort of advice do you give those people?

Norma Alcantar 00:20:08

You know, when you come to the lab, you had to come without biases and misconceptions, and you really had to really be an open-minded, and see how the material or the structure or sign that you're working on, where it is that it's going to lead you and how can that be applied for a solution. So, I think about it, like you had to be determined and what is it that you're trying to solve? And then it's what you were producing. Would they solve it? But if it doesn't, then maybe it can be applied to something else. And it's not a failure. It's just that it may be something that doesn't work for that specific problem. But you may have another problem that can be applied to, so be patient and everyday there's going to be good days and bad days. I know my job is fun. And I can say that a hundred percent because they are much better, good days than bad days, good days take you through the bad days. Well, you just had to learn, and you just had to go through it, but I have a lot more good days than bad days.

Richard Miles 00:21:18

So, to that that point. Let me just ask one follow-up question. When you got this first results back, uh, you know, in the lab that wasn't supposed to be ready yet. And the cactus appeared to work, did you know right away that you had stumbled upon something big, and you just weren't sure how it would be used, or did it take you a little while longer before you realized this is actually a very important discovery?

Norma Alcantar 00:21:36

Thinking back, I thought this was a good plan B for my research.

Richard Miles 00:21:42

So it was a good plan B at that point?

Norma Alcantar 00:21:44

At that point, I was like, well, I'm glad I thought about it. So, we started applying it to different systems and looking at the different properties, looking at the data at some point, I was like, wow, this is actually funding 50% of my research. And then I have other projects that are the other 50%, but that they are much less in terms of how much funding I have. And a lot of students, wanting to work on that, they see the value, the students that had worked on the cactus, research with them thinking that we had to find more things good for the environment, and whatever they're doing right now, they are applying that knowledge. You know, so one of my students is working at Tico, and he is the director of sustainability. I, and my other student that is a teacher, she's teaching science for sustainability and design for sustainability. So, I think they learn that there is a way for us to live in a more sustainable world. I think there's a good message that I learned from my students. Yeah.

Richard Miles 00:22:48

If I got to say, a lot of researchers would love to have your plan B, they're probably asking me, do you have any other plan B? And that's a great story. And I think a testament to your patience, and your diligence to following up this idea that had so much promise, but obviously needed somebody to sort of develop it and figure out exactly what's going on, in chemistry.

Norma Alcantar 00:23:06

And I was really lucky to have my grandmother telling me one day why she did when she was little. And there were many other things that I learned from my mother and my grandmother, very valuable. And so, I think also transferring knowledge from one generation, of our parents and our grandparents to our children. I think that's, that's very valuable. We should not lose that ever. The technology that we have now, we should always try to advance it as well already.

Richard Miles 00:23:35

I think that's a great point. I think there's a lot of embedded wisdom in things that previous generations did. And now we have the tools to find out exactly how they work. So, it was before it would have been just folklore handed down, or you do this. We don't know why it works, but it does. Now we have the tools to actually investigate and see, oh so this is how it works. So, grandma was right, but now, wwe know why she was right. She knew it was going to work. Norma, thank you very much for coming on Radio Cade, again, congratulations on your being inducted into the Hall of Fame and hope we can have you back on the show at some point.

Norma Alcantar 00:24:06

Thank you. Thank you for having me. And see you at the induction ceremony.

Richard Miles 00:24:09

Great.

Outro 00:24:12

Radio Cade is produced by the Cade Museum for Creativity and Invention, located in Gainesville, Florida. Richard Miles is the podcast host and Ellie Thom coordinates inventor interviews. Podcasts are recorded at Hardwood Soundstage and edited and mixed by Bob McPeek. The Radio Cade theme song was produced and performed by Tracy Collins and features violinist Jacob Lawson.