FACES OF MASS SPECTROMETRY / Veronica Pinnick

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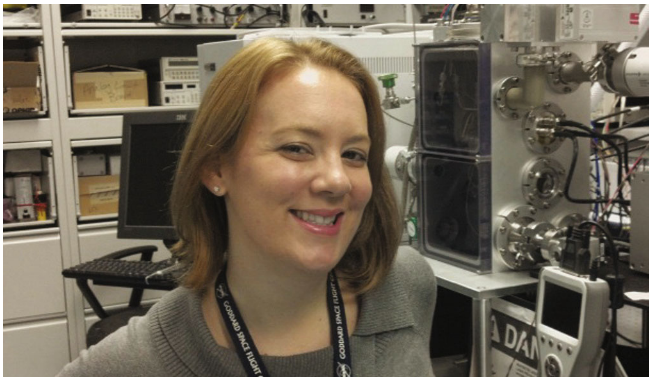


A Narrow Window of Opportunity for Chemistry on Mars

Even though an unexpected meeting forced a last minute delay to our conversation, Veronica Pinnick only took a few minutes before returning the call to chat about her research. "No, no… this is perfect timing," she laughs. "I had enough of that!"

Keeping on schedule is key to Pinnick's work at NASA Goddard Space Flight Center where, as part of the Mars Organic Molecule Analyzer (MOMA) project, she has spent the last nine years engineering a tiny, super-robust mass spectrometer that can withstand the temperature extremes, shaking, and violent collision needed to survive a mission to the Red Planet. Missing the deadline for this project would delay research for several years.

"Payloads are launched when Earth and Mars are at their closest, so we design, build, and test mass spectrometers based on schedules that literally depend on the alignment of planets," she says. "Working at NASA is both rewarding and incredibly stressful."

Pinnick was introduced to instrumentation design early, and she has made it the focus of her career. As an undergraduate at Minot State University in North Dakota, she salvaged parts and helped remake an X-ray diffraction machine. She chose Texas A&M for graduate school, working under the direction of Emile Schweikert, so that she could explore building new and better instruments, and by 2009 she was working in Bob Cotter's lab at the John Hopkins Medical School of Medicine on his "side project," MOMA.

Set to launch from Kazakhstan in July 2020, MOMA is the key analytical tool of the next Mars Rover's payload. The new vehicle will probe and scrutinize the surface of Mars with a drill capable of collecting dirt more than 1.5 meters deeper than the Curiosity rover was able to. It will perform both gas chromatography and laser desorption mass spectrometry, and the hope is that the new samples will be collected deep enough from within the planet that the harsh, oxidizing substances known to be on the surface don't interfere with detection of organic compounds indicating signs of life, the "Holy Grail" of the Mars mission.

"Mars' atmosphere is mostly carbon dioxide, and there are a lot of perchlorate molecules on the surface that make gas chromatography difficult," says Pinnick. "It is a hard place to keep organic molecules intact because, when you bake organics with perchlorate, especially in a mostly CO_2 atmosphere, combustion occurs."

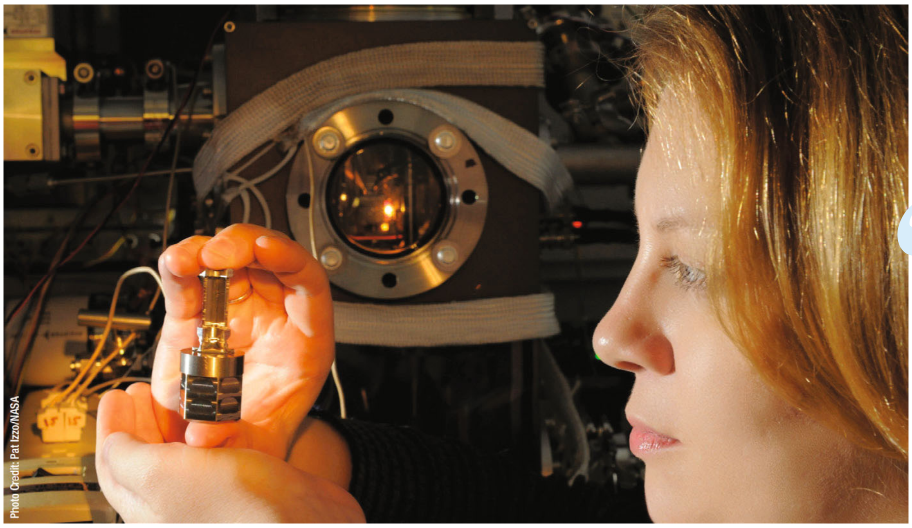
How did you end up engineering at NASA?

I really wanted to be an instrument builder, which is kind of a rare thing now-a-days. Coming out of grad school, I was offered a post doc position with Bob Cotter. He loved building instruments and had a side project focused on building a mass spectrometer to go to Mars on a European Rover [Cotter, R., *et al., Eur. J. Mass Spec*., **16**, 331-340 (2010)]. I was like, well, that's cool, and I eventually transitioned to being a staff scientist at NASA on the same project.

What does it take to build a mass spectrometer for another planet?

When you design a mass spectrometer for spaceflight, it needs to be robust and, at the same time, very low weight, low energy, and miniaturized. You also have to "extra" design them to be shaken up during a rocket launch and able to take the shock loads of landing.

Our group publishes a lot of instrumentation papers to show that MOMA can effectively analyze organics on Mars, despite the challenges [Goesmann, F., *et al., Astrobiology*, **17**, 655-685 (2017)]. One group does campaigns in the field by going to geologic places that in some way reflect conditions on Mars, like the Atacama Desert in Chile, to understand the signatures that come out of the instruments. Other scientists work on analog samples from the Curiosity Rover to build libraries of soils into which we dump different kinds of organics with different amounts of perchlorate to see what we might expect to see if we were



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on Mars. It's complicated looking at dirt: some minerals act as a matrix to enhance ionization, and some make a lot of peaks on the chromatograph that you have to disentangle [Li, X., *et al., Astrobiology*, **15**, 104-110 (2015)].

What are you expecting to see on Mars?

What are we looking for? Boy, isn't that the billion-dollar question. It's hard to know. Do we look for organic molecules that indicate biology on Earth? Or should we look for repeating patterns or signs of complex chemical organization that *could* be an indicator of life elsewhere in our universe?

Because MOMA can do things that previous expeditions couldn't, it is probably our best chance for finding big, complex organics. This is the first mission that will drill deep below the surface to bring up samples from under the topsoil and chemically analyze them. If we find a juicy biologically-derived organic molecule, that will be the most amazing news of all time, right? But even if we don't see that, just learning about how the chemicals vary as a function of the depth that you drill is really important stuff that we just don't know [Goetz, W., *et al., Int. J. Astrobiology*, **15**, 239-250 (2016)].

How did you end up in science?

I'm a nerd. I cannot deny [laughs] it. I still remember my first experiment in second grade—a chromatography lab where a paper towel picks up water from a cup through capillary action. My second grade mind was blown seeing the ink smeared on the towel turn into reds, purples, and blues.

I can say that I wouldn't be where I am without incredible, incredible mentors: that second grade teacher, or my high school physics teacher who busted me every time I didn't do my homework. My college professor who took apart an X-ray diffraction machine to see how it worked. Emile Schweikert, who was an excellent, excellent grad school advisor. Bob Cotter, who was an amazing mentor and helped transition me to NASA. Mentors are huge to the success of many people. It is important work, and I always try to pay it forward.

What was your first research in mass spectrometry?

I ended up going to Texas A&M for my Ph.D. where we were building and maintaining these custom time-of-flight mass spectrometers. It was very alluring and fun to be an instrument builder in grad school. I also chemically analyzed coated nanoparticles [Pinnick, V., *et al., Anal. Chem*., **80**, 9052-9057 (2008)], and we also started calculating the physics of how the energy is dissipated during nanoparticle: nanoparticle collisions [Pinnick, V., *et. al., Anal Chem*., **81**, 7527-7531 (2009)].

Do you have a favorite research project?

Right now, we are designing the spacecraft for a mission that will look at ocean health, called Plankton, Aerosol, Cloud ocean Ecosystem (PACE). But for me, it is also awesome to look forward at proposals that are super imaginative. One of the things that we are proposing is the Dragonfly mass spectrometer (DraMS) that would fly on Saturn's moon Titan. It is like a drone octocopter flying around on this ocean world [laughs]. I like proposing these creative, big ideas and doing the engineering and science to prove that it is totally possible to accomplish.

What do you do outside of the lab?

Outside of work, I do normal things. I like to go out with friends, play guitar, travel, and learn foreign languages. I now have a six-year old, and we do the same thing I did as a kid—we play games like, "Hey let's rip open your toy and see how it works." Usually, I clip the sound cables; it's a very clever experiment [laughs].

But it's all tied to science. I live and breathe the stuff.