A *NUCLEAR NEWS* INTERVIEW

Desrosiers: Irradiation in homeland security

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When anthrax spores turned up inside a letter addressed to two U.S. senators in October 2001, Marc Desrosiers was among the group of people who immediately thought irradiating mail would be a good way to defend against future mail attacks. The completely new concept turned out to be a great idea, so much so that the Postal Service is now looking into constructing its own mail irradiation facility after two years of contracting out the processing.

As Desrosiers relates in the following interview, the development of mail irradiation sprang from one urgent week of government hustle. Seven days after gathering in the White House to figure out a solution, numerous agencies collaborated over a frenzied week to identify, test, and confirm irradiation as the best way to sanitize incoming mail. The tale, as told Desrosiers—a research chemist in the Ionizing Radiation Division of the National Institute of Standards and Technology—is an affirmation of good science at work, with the intrigue of a Hollywood thriller, with its White House gatherings, military experiments, and a team of scientists flying their experiments across the northeastern United States aboard Air Force 3 with a military escort.


Desrosiers: Good science at work

In May, Desrosiers received the Arthur S. Flemming award for outstanding federal employees. He was recognized for his role in responding to the anthrax crisis and for his expertise in providing essential dosimetry measurements that are “crucial to the success of the ongoing homeland security program to protect against this bioterrorism threat,” the citation reads.

He spoke to *NN* associate editor Patrick Sinco about his research specialty in using irradiation in homeland security applications. Desrosiers also went over his and his colleagues’ latest project, to explore the feasibility of using radiation on suspicious luggage at airports to help deactivate any bioterrorism materials.

Desrosiers received a B.S. in chemistry from Boston College and a Ph.D. in chemistry from the University of California, Santa Barbara. He’s been working as a research chemist at NIST since 1989.

What kind of applications for homeland security have you worked on over the last few years in the Ionizing Radiation Division at NIST?

The genesis of this activity was our work with the U.S. Postal Service and some industrial irradiation processors on the project to sanitize mail contaminated with *Bacillus anthracis* spores that caused the anthrax incidents.

This led to research in determining D10 values, the dose needed to reduce a level of a pathogen by an order of magnitude. More data are needed for the reliable application of irradiation technologies, like mail irradiation and luggage irradiation. We need to validate the pathogen inactivation doses for mail irradiation and other applications.

Another project that we worked on involved the irradiation effects on cellulosic materials like paper, to assist the National Archives. They store government documents such as White House mail. They worked with us on studying these effects. They’re the experts; we provided some assistance in the radiation dosimetry and knowledge on radiation effects. Since radiation artificially ages the paper—it’s one of the major net effects of the process—they wanted to study the archivability of these documents with a focus on predicting their lifetime and finding a better way to preserve the irradiated documents.

We also did some work with the Chemical Science and Technology Laboratory here at NIST and their biotechnology division in forensics. There was some concern about the potential destruction of forensic evidence on mail that had been treated with ionizing radiation. It turns out that one of the nation’s experts, John Butler, is at NIST, and we collaborated to demonstrate that the mail irradiation process did not destroy forensic evidence. We were able to establish standard DNA tests on mail that had been treated with ionizing radiation. If you wanted to lift DNA from a fingerprint, the DNA is still useful in the test.

The project you’ve been working on most recently involves studying the possible use *of radiation on luggage in an airport in much the same way it was used on mail: to deactivate any harmful materials or bioterrorism agents. Can you describe the effort in more detail?*

Our latest project is in the area of luggage irradiation, specifically high-risk luggage irradiation; this is being funded through the Technical Support Working Group [TSWG]. We were funded over the past year to do a feasibility study on the irradiation of high-risk luggage.

The idea is not to treat all luggage. Currently there are criteria by which luggage is flagged as high risk. And it would be that luggage that would be routed—if this process were to be in place—through an irradiation facility on site at an airport. The high-risk luggage would go through some extra loop that would carry it through on a conveyor system, passing by an electron beam from an accelerator to treat the luggage before it passes through customs. It's a prophylactic measure to ensure protection at some level of all high-risk luggage.

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Our project with TSWG was to examine the feasibility of this approach by identifying which agents are the highest priority, and after assembling data on luggage types and densities, irradiate luggage in an industrial setting. We did test runs at an industrial facility with our dosimetry, both with actual unclaimed luggage or new luggage that we filled with material of uniform densities. Since you can't test every type of luggage in a reasonable amount of time, our plan was to do test runs on specific configurations and luggage types, and then use computational methods to extend our knowledge to the other forms of luggage, in order to build a predictive model for the treatment of a broad range of luggage types. Lastly, we are to assess if this will be feasible in a practical sense—not necessarily just from the cost of an irradiator, but also from the possible inconvenience of how long would it take to treat luggage, what delay would it add to a traveler. That project is ending over the next few months and we'll report all of those findings to TSWG.

You're using ionizing radiation not just as a means of detection, but also to deactivate any malicious agents that may come through.

Yes, because you can't inspect or detect everything. It's easy to seal bioagents in a pouch that would be undetectable.

Like smallpox, say.

Yes. If it's sealed in a plastic pouch in a piece of luggage, you may never detect it. But you could treat it.

So, it is possible to irradiate the smallpox so that it wouldn't be as effective as if it weren't irradiated.

I can't comment on any particular agent. There is an irradiation effect on smallpox. The selection of dose to which you would treat luggage would probably be made on an assumed risk. And, if it were known that in some piece of luggage somewhere there was a vial of smallpox, you would just dial in the dose that you need to do the job. If it were more of a routine, broad treatment of the luggage from many different types of agents, then you might select a different dose. If there was luggage that was coming in from a country where it was known that there was a Foot-and-Mouth disease outbreak, you might select a specific dose. So, an operator would have this table of doses that would be used to inactivate different agents to different safety levels. And the process parameters are adjustable to allow for changing threats.

Whether this is economically feasible and practical is up to those that would implement the technology.

The bottom line is, though, that it actually does look feasible. And, we're just finalizing our report and our work on the project, but I think it'll be a positive report in that sense. By the way, travelers would be notified in advance if this process would treat their luggage.

Is that application new, or has something like that been done before?

It's a completely new idea, as far as I know. It may have been considered before, but I don't think anyone's ever tested the idea.

What are the advantages of using radiation in some of these applications as opposed to more conventional techniques?

One of the advantages is that since you can't physically inspect everything, be it mail or luggage or ship containers, you can use these technologies as support for your inspection services at the airport or the inspection services or technologies that are at the ports. You can target and inspect the ones that are flagged as being the highest risk, and then use this technology to offer some level of protection with the other containers or luggage that come through. Bioterrorism agents and other types of devices can be easily concealed. Inspectors may miss it. And using this technology is an advantage in that sense.

In using the technology, you reduce the risk to inspectors. If the luggage was irradiated prior to the inspector opening it and a harmful agent was in there, it could be deactivated before the inspector may open it.

Also the penetrating ability of ionizing radiation is very important. If these things are hidden in sealed containers, common detection techniques that try to chemically sniff items or other types of detection methods may not work. Since ionizing radiation is highly penetrating, it will provide some level of protection against any type of concealment method. Concealment methods aren't much of a concern because there are also diagnostic techniques that are used at the front end to screen out obvious intended ways of bringing in terrorist agents. For example, if somebody attempted to bring in something in a lead box, you could detect that there was a lead box in a piece of luggage.

So, it might not necessarily turn up the agent itself, but it will find something suspicious.

That's on the diagnostic side. If X rays are used on the front end of an irradiator, one could pre-scan items to see if there is anything suspicious in there, and then, if not, to send it through and treat it.

One more point regarding the high-energy irradiation treatment, one of its most favorable attributes is that it has some effect on pretty much everything. It will kill or sterilize insects and its effect continues as you go down smaller in size from insects to bacteria to viruses. If it's not 100 percent, there's at least some level of protection. And it's over a broad range of potential terrorism agents.

What exactly are these applications designed to protect against?

Well, if you consider ship containers, you are likely looking for bigger objects: someone trying to smuggle in some kind of device—a bomb, be it a conventional one or a radiological type of bomb.

If you're talking about luggage, then the main concern is an attack on the U.S. agricultural industry. It's a daily concern. The Animal and Plant Health Inspection Service of the USDA [Department of Agriculture] is at the airports. They try to protect the U.S. agricultural industry against the accidental or intentional importation of pests—either insects or microorganisms like Foot-and-Mouth disease virus.

It doesn't take much to protect the nation against pests; you actually don't have to kill the insects with radiation. You only have to sterilize them. And the dose required to sterilize insects is relatively low.

Can you tell the story of the decision in the fall of 2001, in the wake of the discovery of anthrax in letters addressed to several prominent Americans, to irradiate mail?

The mail irradiation story was a really fine example of how government agencies can come together to get a job done effectively in a very short time. There was a large group of us. My division chief, Bert Coursey, was one of the key people in all of this activity.

When these letters were delivered, there was a big scramble to find the most effective way of sanitizing all of this contaminated mail so that it could be delivered. It was quickly identified that ionizing radiation was the most effective way of doing this. Medical products have been sterilized with radiation for decades in the United States. Fifty percent of all medical products are sterilized with ionizing radiation. It's known that bacteria and other harmful organisms can be killed with ionizing radiation. So, it was a question of how do we do this—mail had never been irradiated before—and what dose to use.

Very early on we gave lectures on this technology and identified companies that could do this, as well as consultants that would be useful to the Postal Service and to the other government agencies to provide advice on the best ways to treat the mail.

In late October 2001, we were asked by the U.S. Postal Service and other government agencies to give an overview of the technology. This industry sector is one that we work with on a daily basis. The NIST Ionizing Radiation Division maintains the national standards in ionizing radiation and disseminates these standards to industry through measurement services. We work very closely with them and know them personally.

That daily interaction, that firsthand close working relationship with industry was, it turned out to be, a very key reason we were able to effectively treat the mail so quickly—because it wasn't a question of our having to go out and calibrate these facilities, train personnel, and build the process from the ground up. Industry processes medical products, et cetera, on a daily basis. And they're calibrated periodically throughout the year through our services. Not only do we know the operators for these facilities are capable of doing the job, but we had established measurement traceability between their facility and our standards through our certification process. They have measurement certificates in place that document that they can deliver a prescribed dose with a certain level of accuracy and precision.

So, on the 29th of October, we were asked to attend a White House Office of Science and Technology Policy meeting. Dr. John Marburger, as the recently appointed head of OSTP, was faced with this problem. The Postal Service and other government agencies were looking to OSTP to give this process their blessing. And basically OSTP asked out to the group of agencies that were there, "How can we assure that this process works? I know that you say that these facilities are calibrated and these people are very capable people that operate the facilities, but it's never been done before." Mail has never been treated before and we've never tried to kill anthrax-causing spores in an industrial process, and with a large volume of material.

In response, I suggested that we test boxes of dummy mail with NIST dosimetry contained in the boxes of letters along with spores. This led to a collaboration with the Armed Forces Radiobiology Research Institute [AFRRI], in Bethesda. They had the spore technology and knew how to assay and determine the spore kill. We used surrogate spores in these tests.

At that meeting on Monday the 29th, task force composed of NIST, USDA, AFRRI, and FDA [Food and Drug Administration] representatives was formed. As it turned out, the two key agencies in this exercise were AFRRI and NIST.

The next day, Tuesday, we met early that morning at AFRRI to design the experiment. We laid out how we would do this and then we went back to our respective labs to assemble the items that we needed to do the job—the dosimetry detectors from NIST, and spores from AFRRI—so that 24 hours later on Wednesday afternoon we met at AFRRI to assemble boxes of mail. We made dummy mail and placed them in letter trays that we obtained from a local post office.

Next we had to get them out to Ohio to the irradiation facility. Titan Corporation owned the first facility that was being used.

But it was quickly realized that commercial transport was impossible, because in order to properly test mail irradiation, we had to exactly duplicate the conditions. To do this, these dummy mail trays were going to have to be packaged exactly like contaminated mail. So we had to take them to Brentwood [mail facility in Washington, D.C., now called the Curseen-Morris Mail Processing and Distribution Center, named for the two employees who died after coming into contact with anthrax-laced mail at the facility] and have them put them in biohazard sleeves. And sometime between Tuesday and Wednesday, we realized that we weren't going to be able to get on an airplane with biohazard boxes [laughs]. So we called down to OSTP, and they called the White House, and shortly thereafter we received White House permission to use Air Force 3 to fly the task force to Lima, Ohio, with the test boxes. So, we had Air Force 3 with a military escort flying our experiment out to Ohio on Thursday morning.

They were irradiated during the day on Thursday, and they arrived back Thursday night. The boxes were disassembled. The spore tests began that night or early the next morning. The dosimetry measurements were complete by Friday afternoon. And the spores, because it's a biological system, needed several days to complete.

By Monday morning, exactly one week after we were first introduced to one another, we were back at OSTP and we were able to report that all areas of the letter tray were treated to at least the minimum dose specified and that all the spores were killed.

It was an impressive exercise. Again, irradiation had never been tested on mail, and we proved it could be effective. We had a high degree of confidence that it would happen because of the measurement infrastructure that NIST maintains across the United States.

When mail was first being irradiated, people were using eBay to sell pieces of mail that had been processed. Many of them said that the letters had turned slightly brown by the irradiation process.

Yes, they were. Most of that was due to a combined effect of heat and electron beam irradiation, and that this mail was sealed in thick biohazard bags. Paper has moisture in it, and there's a large amount of energy that's deposited into the letter trays. So, a lot of heat is generated producing steam, along with ozone that's created from the ionization of the air and the radiation effects. All of these contributed to the poor quality of the mail early on. If you were to slit these bags open you would have to stand back because steam would evolve from the cut. Actually, that was one of the recommendations early on that helped: that immediately after the process, the bags were slit and vented so that it reduced the combined effect of the heat and the ozone. After that the quality improved because it was no longer required that they be packed in biohazard bags. They were placed into trays that were more ventilated.

A lot of the negative information that you've heard on irradiated mail comes from those early days. They knew it was contaminated and knew they had to hit it with a high dose, but the process wasn't optimized at the time. Mail handlers at the time were not told how to pack the boxes. When you process materials, say for medical products, they are packed in particular configurations, with a uniform density. Mail is random in size and its packing was random in that the boxes weren't always full, etc.

Why did you do the testing all the way out in Ohio?

Continued

The closest irradiation facility is a cobalt gamma-ray facility in Maryland. But it doesn't offer the throughput that the accelerators offered. They were looking for an accelerator facility.

In both of these cases, the Titan case and the IBA [Ion Beam Applications, which operates an electron beam facility in Bridgeport, N.J., where early work on sanitizing mail was performed in late 2001 and still continues today] case, these facilities just happened to be not in use at the moment. The Titan facility was recently purchased. A company turned it over to Titan, and Titan hadn't started any of its commercial activities in that facility. And the IBA facility was the same thing. It was a brand new facility. And it just happened that they hadn't started processing anything in there yet. And, as you can imagine, from a safety point of view, it doesn't make sense to treat spore-contaminated mail at the same facility that you're irradiating medical products. Ideally, you'd want a dedicated facility. It turned out that these two facilities were available. There just was a little bit of luck there.

How does activity in this area of homeland security applications compare before and after September 11? Was it a big jump or has this work been going on all along?

It was like night and day [laughs]. The good old days, before 9/11, we were doing our job and maintaining standards and providing services to industry. And then, all of a sudden, there was a new application. Again, it started with mail and then moved to this luggage work.

Is there much going on in the way of international collaboration in this work?

Not that I am aware of. I suspect that there are some university researchers that are working on homeland security topics, possibly working with foreign colleagues. From my view at the government level, it's mostly government agencies working with other government agencies or contracting with industry.

I should mention that I have been invited to speak in Budapest next March at a NATO workshop on bioterrorism. In that sense, there is some level of cooperation. But, obviously, this international interaction is through a secure military alliance.

What will you be working on after the luggage study is wrapped up?

If it were decided to move forward with luggage irradiation, then we would advance to other phases of the project where we would identify what type of accelerator would be the best for this purpose, and then to build the processing parameters of that accelerator around the type of luggage that you would be irradiating.

So, the current work is a feasibility study in a general sense: Are the numbers reasonable? Can we get reasonable throughput numbers and effective dose values? If the answers are yes and the funding agencies want to move forward with a test facility, then we need to take the specifics of that particular facility and fine-tune the process.

We will continue to provide measurement support for AFRRI. They continue to do research on irradiation and inactivation of a variety of agents. Since they're in Bethesda, very close to us, we have a very close working relationship. And, so we provide some support for them in their work.

And then there are other activities that I'm not directly involved in. There's a lot of work being done in radioactivity, on detection and on screening of cargo containers and portal screeners, and also on the neutron end, mostly having to do with trying to detect radiological devices. This work on different aspects of homeland security applications is spread among the staff of the Ionizing Radiation Division.

We continually strive to be the best in the world in radiation metrology. Industry and government agencies look to us for measurement quality for their daily operations, as well as to determine whether these irradiation technologies should be implemented. NN