TECHNIQUES FOR THE DETECTION OF EXPLOSIVES

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Mister Chairman

Esteemed Colleagues

Ladies and Gentlemen

Truly I feel privileged to have been asked to deliver the keynote address to this conference. I thank you.

I personally hope that the tone of this conference will be the exchange of information, ideas, and techniques of analysis and detection. I tell you that this conference is significant for many reasons, but for me one of the greatest reasons is that I do not have to try to explain concepts, numbers, properties and actions of molecules to governmental people who do not understand, and explain these in such a way that they think that they do understand. Do you have that problem also? Take my word--it is a treat to talk to people who understand the problem.

The title of this address, "Techniques for the Detection of Explosives," brings to my mind an automatic separation into Bulk Detection and Vapor Detection. There has been much research in the USA in both fields in the last few years. Since my area of interest is vapor detection, we will first consider the research in the bulk detection and then get to the interesting stuff.

In the area of X-ray the main developments have been in the computer enhancement of the images. Many of the regular instruments use color enhancement to assist the operators in detecting suspicious articles in baggage. However, some of the newer X-ray units work differently. One unit works by differentiating the compton scattering of organic materials from the photoelectric attenuation of inorganic materials as well as the transmitted view on the video screen. This particular unit colors the different effects with different colors. Another unit uses backscattering to give additional information about the organic materials in bags and cases. One of the problems with this technique is the thickness of bags and possible shielding material attenuating the backscattered signal. One choice for a fix of this problem is to put in a forward scattered detector along with the backscattered detector which they have done.

A new technique for checked luggage is the Thermal Neutron Analysis (TNA) device. Although TNA itself is not new the use of the technique as a check for nitrogen in a bag at an airport

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is quite a departure from what has been acceptable in the near past. Extensive testing of this device has been carried out in airports in our state of California, which is our state with the most stringent safety standards, and the test results are impressive.

The technique of Nuclear Magnetic Resonance (NMR) has been studied for detecting explosives in baggage for a number of years. The obvious problem is when metal is introduced into the magnetic field. You know you have a problem when a bag passes through the magnetic field and the identification tag stands straight up at the end of its metal chain. Although there are problems using the technique there is still interest in NMR applications.

There is a possibility of developing a low power microwave detector as an explosives detector. Using the correct frequency to get the right 1/4 wave length one can measure the conductance and determine the dielectric constant of materials through other materials such as cloth, wall board, thin steel, etc. This could allow explosives and other materials of concern to be detected without dismantling the vehicle or disrobing the individual. One example of the operation of this device is to monitor bodily functions such as watching a heart move within a chest cavity in real time without operating. A few years ago the Lovelace Foundation in Albuquerque, New Mexico, did some work on monitoring heart functions through a wall without the patient knowing and being disturbed by the monitoring.

Now let us look at the interesting science! Let's look at vapor detection of explosives. The techniques that we discussed before were just application of known technology. Now we are entering an unknown space where everything is not cut and dried but we must learn new material. At this time let me apologize to any "dog" people who might be here because I have not addressed their problem at all.

Although we have made great strides in vapor detection in the past few years we still have many problems. One main problem is the pressure that is being applied by the recent incidents in the airline industry. Since most of us got here by airplane, no one has to explain the urgency of developing an explosives detector that detects all the explosives of interest.

Since we cannot actively probe people with neutrons, X-rays, or whatever, we must concentrate on "sniffing" the vapors. As one looks at the complete field of vapor detection it is evident that there is a logical division of the field. The array divides into those situations that require "hand-held" sampling and those that require "portal" sampling. For example, searching a building for a bomb would at this time be a hand-

held job where searching passengers entering an airport would be a portal scenario. In effect both the hand-held and the portal scenarios have identical requirements, i.e., getting the sample or sampling, separating the explosives molecules from air and interfering compounds or preconcentration, and having a detector that is sensitive enough to detect the molecules.

Any investigation obviously starts with the detector. If the detector is not sensitive enough to detect what is collected the enhancement of the other factors will not help. I feel there are currently four detectors to choose from depending on the scenario for use. The four are an Electron Capture Detector with a Gas Chromatographic separator (GC-ECD), a Mass Spec/Mass Spec (MS/MS), an Ion Mobility Spectrometer (IMS), and a Chemiluminescence Detector. The GC-ECD and the IMS detectors are logical choices for hand-held devices with possible applications in other scenarios. The Chemiluminescence and MS/MS detectors are for larger installations. Let us say something about each of the detectors individually.

All of us who have GC with ECD detectors in our labs know that the commercial explosives detectors are not using the potential of the combination. The main problem is that since these molecules are sticky, the sample never reaches the detector and therefore cannot be detected. Look for a new GC-ECD detector in less than a year which under ideal conditions will detect all the molecules of interest.

In a paper that will be given at this conference we will describe an evaluation of the Oak Ridge MS/MS which was built for sampling mail. This unit was very easy to use and had a Limit Of Detection (LOD) of 3 ppt (30 femtograms/cc air in 6.4 cc air/sec) using the quartz sample tube as a preconcentrator.

The IMS detector as represented by the PC-100 sold by PCP Inc., West Palm Beach, Florida, has increased in sensitivity tremendously over the last few years. We mention the name only because this unit is the only IMS unit that we have numbers on. Recently we repeated the Limit Of Detection (LOD) determination on this unit and found it to be 0.3 ppt RDX (3 femtograms/cc in 3 cc/sec flow) in air. The LOD for the unit with a quartz tube preconcentrator and background subtraction is a factor of 10 lower than the above figure.

The chemilumimescence detector is a sensitive detector. Upon the addition of a GC column the detection unit becomes also specific and selective. I do not have the exact numbers for the sensitivity of the most recent unit. I can say there has been a tremendous amount of work done with the technique in the last two years and there are people here who can give more information on the technique.

Next let us discuss sampling of an explosives vapor from a person in a portal configuration. A study was done at Sandia on this subject. The conclusion was that the best way to take a sample from an individual was with an air flow down across the head of the individual to the feet and to pick up the sample below the floor through a widely spaced grid. It seems the body is a reasonably good airfoil and the air flow follows the contours of the body (some contours easier than others) and picks up these molecules. These molecules are large and are greatly affected by air flows. In these tests they showed a strong preference to flow in a downward direction and with the flow of the air. Recent studies in Canada confirm the propensity of these molecules to follow the air flow. After the molecules pass through the grid they can be trapped on a preconcentrator or transferred in the air flow through the largest tube possible to the preconcentrator. We have already alluded to the "stickiness" of these molecules and their action can be simply stated that if they touch anything they stick to it. However, if they do not touch they can be transported to the preconcentrator. We do not propose to tell you that our way is the only way to sample because we see that most portal units sample from the side. We wonder how much of that decision was from science and how much from politics. One purveyor of commercial equipment admitted that his loss going to the side flow was only a factor of 5 or 6. I happen to think that we need every factor we can get our hands on. When we get to where we have extra factors of sensitivity, then we can afford to throw them away, but not now. To summarize this section it is sufficient to say that there remains much to be done in portal sampling of explosives vapors.

Now let us discuss a preconcentrator. A simple definition of an explosives preconcentrator is a selective filter that picks explosives molecules from a large air flow and holds them while dumping almost everything else overboard. These trapped molecules are then released into a smaller flow resulting in a compression of the sample and therefore enhanced sensitivity. From studies at the University of Texas at Austin it was learned that silicon dioxide is a neutral oxide and is the most favorable material of all the materials studied for a preconcentrator. We have used quartz extensively as a preconcentrating material. We have just completed a study that evaluated a 6 mm O.D. quartz tube with a 6.4 mm quartz wool plug as a preconcentrator. It is an amazing device at low flows. Previous work had proven that 3.2 cm O.D. glass tube 7.6 cm long filled with glass melting point capillary tubing works well as a preconcentrator at flows of 1000 L/min. with a retention factor of approximately 30 percent.

Most of the other preconcentrators in use benefit from Sandia's experience in preconcentrators in that they use some form of silicon dioxide coating even if the units are covered with a GC coating.

We have discussed a number of problems that we have with these explosives molecules. However, there are a couple of additional characteristics of these molecules that should be discussed in this presentation and the first one is their adsorption from solutions. We had noticed previously when standard solutions were added to different glasses we obtained different concentrations when the resulting solutions were analyzed. Very simply stated we do not have standard solutions of these molecules because some of the molecules adsorb onto the walls of the volumetric containers. After studying this problem at Sandia, it was found that different glasses adsorb different quantities of explosives molecules from various solvents. In each case where the molecules were in solution in a solvent the coverage on the glass was limited to one monolayer as compared to multilayer coverage on glass surfaces when the molecules were adsorbed from vapor. When the glass surfaces were silylized there was no adsorption from the solutions studied. We find, however, that silylization of glass surfaces has little or no effect when capturing explosives vapors in a preconcentrator.

The second chacteristic that should be discussed is the diffusion of these molecules from boxes and bags. We will not spend much time on this subject because Professor Thomas Griffy will give us the theoretical equations for the diffusion of these molecules. The tests that we have done indicate that the diffusion times calculated by the professor for these molecules are reasonable. However, if one expects to detect explosives vapors from bags or boxes by sampling the outsides of the containers near cracks and holes, the times will be inordinately long.

In closing, I must say, "let us not be complacent and think the job has been done". Actually, we have almost succeeded in defining the problems. I think we can all agree on several points, the first being that explosive molecules are difficult to work with, when you can find them. The physical problems of sampling have had to be deciphered and solved. Yet there still remains some questions, particularly in the area of personnel sampling in booths. Secondly, preconcentration is a virtual necessity for vapor detection of explosives. Again, a great deal of effort by many groups has focused on this problem and although the problems may seem to have been solved for the most part there is additional work to do. We still must strive toward the impossible goal of 100% collection efficiency. Lastly, perhaps the most difficult problems have been encountered in the techniques for explosives detection because of the very low vapor pressure of most explosives. Again, technology has been developed which can detect most explosives under controlled conditions. However, there remains much to be done in this area because the limit of detection of these systems simply are not good enough yet to meet the demands of detecting devices prepared by technically competent terrorists.

Thank you.