

Smart Sand

Introduction

Detection of unrecovered land mines is a growing international problem. Unrecovered land mines are a legacy that continues to harm people long after the hostilities cease. The most widely used tool for land mine detection today is the hand-held metal detector. Other methods for landmine detection are limited due to their high false alarm rate.

Chemical sensors have been investigated for mine detection. For chemical species having favorable spectral properties, remote sensing can be achieved by fluorescence light detection and ranging LIDAR. Nitroaromatic explosives exhibit strong ultraviolet absorption but low fluorescence, thus direct detection of TNT is not practical. Indirect detection of TNT in soil can be obtained using a synthetic chemical polymer that exhibits a change in fluorescence in the presence of an explosive compound.

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Preconcentrating of explosives (nitroaromatic compounds)

The sensor particle is composed of a highly fluorescent chemical polymer (C14) [2] that is deposited into a commercially available polymer carrier particle. The carrier polymer particle is chosen on the basis of its ability to absorb nitroaromatics from aqueous soil environments. The result is a preconcentration of nitroaromatics in the presence of water onto the carrier particle.

Fluorescence measurements

The C14 polymer exhibits an absorption maximum approximately at 430nm and an emission maximum at approximately 460nm. The C14 polymer material exhibits a diminished fluorescence response to nitroaromatic explosives due to the quenching of the highly delocalized electronic state. (See Fig.1) The change in the 460nm emission intensity of the C14 polymer due to the TNT-quenching would present a dark signal on a bright background.

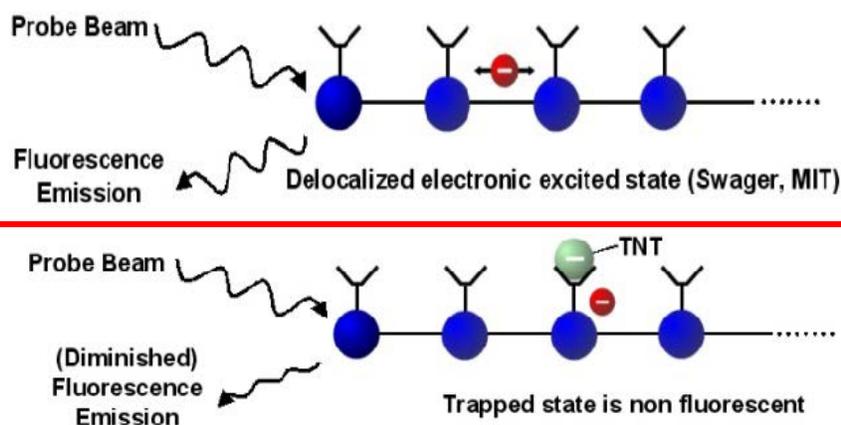


Figure 1. Chemical sensor particle.

The fluorescence measurement would come after the C14 chemical polymer and the carrier particle were distributed over a suspected minefield area. Due to the possibility of non-uniform deposition of the sensor particles over the suspected area or other experimental variables, the use of a second fluorescent material in the sensor particle that is insensitive to nitroaromatics is necessary. The second fluorescent material acts as an internal standard and as an energy transfer reagent. The internal standard fluorescent material has an emission maximum approximately at 430nm.

The spectra are normalized to the internal standard by taking the ratio of the two emissions. Figure 2 illustrates the fluorescence image with no interference filter and Figure 3 is a constructed image of a pixel-by-pixel ratio of two video frames captured with the same camera. One frame was captured using a 420nm interference filter, while the other frame was captured using a 450nm filter. The 450/420 ratio image clearly shows the difference in relative emission for the particles plus TNT and the particles and without TNT.

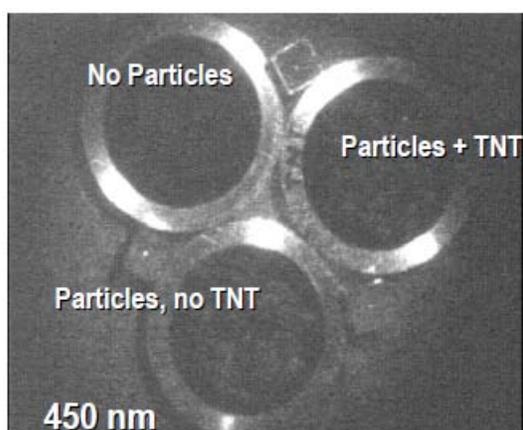


Figure 2. Unfiltered image (450nm) shows no difference in soil samples with or without particles and TNT.

Field measurements will use a long-range fluorescence LIDAR system to excite the sensor particle system and measure the fluorescence response. This keeps military and civilian personnel out of the minefields.

References

1. Remote Detection of Nitroaromatic Explosives in Soil using Distributed Sensor Particles," Sandia Report, SAND2001-0907C, Sandia National Laboratories, Albuquerque, NM, Printed July 2001
2. The fluorescent polymer was originally synthesized by Professor Timothy Swager's group at M.I.T. and has been licensed by Nomadics, Inc. (Stillwater, OK).

For additional information or questions, please email us at MGA@sandia.gov.

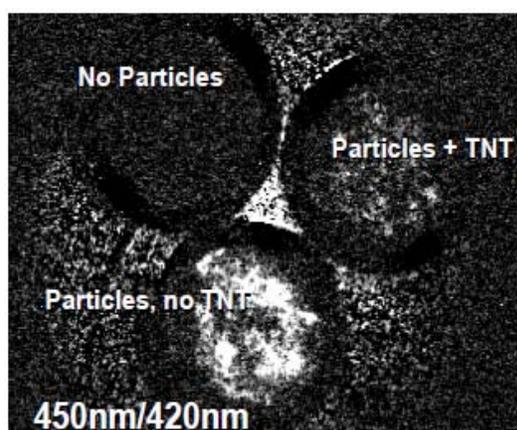


Figure 2. Filtered (ratio of 450 nm/420nm) Fluorescence image shows quenching of particles due to TNT.