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January 31, 1966

To: Distribution

From: R. M. Elrick, 5234, and R. E. Smith, 9311

Re: Report of Trip to Naval Ordnance Test Station (NOTS), January 18, 1966, to Investigate the Feasibility of Using a Special Chemiluminescent Material (TMAE) They Have Developed

Persons Visited: Carl Morley, Dr. Aaron Fletcher, Mel Bens, and Mel Gerka

Background

On April 2, 1964, during a visit to Rome AFB, N.Y., R. E. Smith learned of a chemiluminescent material developed by NOTS that at that time appeared to have possible applications in our flight test studies such as Low Altitude Burnup (LAB) and High Altitude Particulate Sampling (HAPS) that were under investigation at that time. A subsequent trip to NOTS by S. L. Jeffers and R. E. Smith provided much information about the material, but also disclosed that the material was not suitable for LAB or HAPS flight tests (see trip report dated June 3, 1964, to A. J. Clark, from S. L. Jeffers).

Recently it appeared that the material could have a very useful application in our atmospheric particulate dispersion studies (see Memo of Record dated December 21, 1965, Re: Meeting on December 13, 1965, Bldg. 832, subject, Review of TRC Work with Dr. K. D. Hage). Because of the current ANS interest in conducting a number of atmospheric dispersion studies to check the model TRC is developing, R. M. Elrick and R. E. Smith visited NOTS to investigate the possibilities of using this oxygen excited, chemiluminescent material. One sobriquet for the substance is TMAE (pronounced Tammey) which represents its chemical name tetrakis (dimethylamino) - ethylene; it is known to its creators, Dupont, as PR155 and is being studied by NOTS under Project TIARA. This substance is not to be confused with another tracer TMA, an acronym for trimethyl aluminum. From this trip much useful information was obtained, and is discussed in this report under the following categories:

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A. What Is Known About TMAE
B. What Is Not Known About TMAE
C. A Recommended Program to Delineate the Possibilities of TMAE as an Atmospheric Tracer

Material Investigation and Program Recommendation Report

A. What Is Known About TMAE

Some General Properties:

1. An empirical equation has been developed for the intensity of luminescence of TMAE as a function of the molecular oxygen present, the concentration of TMAE, and the concentration of activator or catalyst used - so far an alcohol. Recently, the intensity was found to be strongly dependent on the temperature. For example, lowering the temperature from 30° to 0°C increases the intensity by a factor of 20 because of a combination of increased efficiency of light production and an increased reaction rate.

2. The luminous energy is independent of the partial pressure of oxygen above 100 mm of Hg but decreases about linearly for lesser amounts.

3. The spectral distribution of the light peaks at 5,000 angstroms with a half-width of about 1,000 angstroms and is a lime green in color.

4. "Very little" heat is evolved in the oxidation reaction.

5. TMAE's properties are not destroyed by freezing although it does cease to luminesce below its freezing temperature - minus 5°C (23°F), but low temperature formulations do exist. Other known physical and chemical properties are listed in a TMAE handbook (Conf.) written by the NOTS group. We requested a copy, and also a reprint of all the published TMAE work performed at NOTS, an exclusive investigator.

Low Temperature Formulation:

NOTS has developed a low temperature gelatinous formulation of TMAE which luminesces to temperatures as low as -68°C (-90°F). The present method of preparation takes two hours for the liquid to polymerize (jell).

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Availability:

Although a Navy injunction prohibits the general sale of TMAE, it can be bought through the Department of Navy, Washington, D.C., or possibly even through NOTS.

NOTS offered to prepare the low temperature or any other known compound for us.

Method of Mixing and Dispersing:

The TMAE (a liquid at room temperature) is most easily mixed with and absorbed by presized polyethylene particles which can be bought from the Division of National Distillers and Chemical Corp., 99 Park Avenue, New York 15, N.Y., under the more general name Microthene. NOTS finds it necessary to specify the high density polyethylene and also a maximum level for the antioxidant used in its manufacture, whose presence inhibits the oxidation of TMAE. The particles are not supposed to react with the TMAE but serve as a presized vehicle for dispersal. The Army disperses TMAE with a bomb made from a plastic toilet float bulb. A shell of TMAE coated polyethylene particles is placed between a center explosive and an outer shell of zinc oxide which enhances the oxidation. A luminescent area on the ground approximately 150 ft. x 100 ft., formed by dispersing 30 pounds of TMAE can easily be seen at a slant range of 45,000 ft. The cost of TMAE is $35.00 a pound.

Demonstrations:

We were exposed to several vivid demonstrations of the light emitting ability of TMAE in various forms: (a) as chalk, (b) in polyethylene particles where the light decayed in a few minutes but a fresh mixture will last for 1/2 hour, (c) in cloth saturated with TMAE which behaved like a weak flashlight, and (d) as the low temperature gelatin. All the demonstrations were performed in a photographic darkroom. An easy way to show its chemiluminescent properties is to coat some polyethylene particles with TMAE by stirring a small quantity of each together. This mixture was grossly flocculated and defied normal attempts at dispersal.

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B. What Is Not Known About TMAE:

1. Expected reaction with ozone and atomic oxygen especially in atmospheric concentrations.

2. Dispersal methods other than explosive.

3. Detection and tracking methods other than visual.

4. TMAE has not been tried at altitudes where the temperature is less than 23°F.

5. The low temperature formulation has not been tried as a tracer.

C. Recommended Program to Delineate the Possibilities of TMAE as a Tracer:

Much laboratory work would be required to determine the functional relation between the variables which affect TMAE's behavior. Also, although atmospheric pressure and temperature and to some extent composition may be simulated in a test chamber, it would be difficult, for instance, to introduce potentially influential materials like ozone and atomic oxygen in realistic quantities (NOTS believes these might be of considerable importance). Therefore, except for some preliminary temperature-altitude chamber tests, a more direct approach is suggested since it will lead more quickly, accurately and perhaps more inexpensively to answering the question - under what conditions can TMAE be used as an atmospheric tracer?

A suggested program is:

1. Temperature-Altitude Chamber Tests

Procure some TMAE and check it out in Sandia's temperature-altitude chamber. It is anticipated about three tests will be needed.

2. Tonopah Field Tests

At Tonopah Test Range, introduce small quantities of TMAE into the atmosphere at low altitudes (where the temperature is greater than 23°F) to try methods of injection; for example, disperse polyethylene saturated particles, generate a mono-dispersed (single size) aerosol of TMAE, explode bombs of TMAE

and the low temperature TMAE formulation. It should then be possible to estimate the rate of fall of cloud particles and the approximate range of particle sizes. This approach would be of most value for the bomb dispersal technique since it is the only way to determine its particle sizes. The other methods of production can be developed and demonstrated in the laboratory.

At the same time, visual, photographic, and telescopic methods of detection and tracking can be evaluated.

This program would define the altitude and experimental (particle concentration, size, fluorescent intensity, etc.) limits of operation. To measure particle positions for fairly long times after injection - long in relation to the fluorescent time of TMAE - it is conceivable that (1) advantage can be taken of the fact that injected particles of TMAE will not luminesce until the temperature is above 23°F, and (2) the TMAE formulation can be changed (thinks NOTS) to adjust the freezing point or the time for polymerization (2 hours for the -90°F compound) after which it will luminesce.

It is estimated that 5 to 7 field tests might be required to evaluate the potential uses of TMAE for atmospheric research studies.

Visit with Dr. Von Huene, Earth Science Division, NOTS

During the afternoon, R. E. Smith contacted Dr. Von Huene for the purpose of seeking information on deep ocean currents for a paper being prepared for a Sandia Corporation Oceanography course. Dr. Von Huene is preparing maps of the topography and structure of the ocean floor and it was thought he might be able to provide me with information, or sources of information on deep sea horizontal and vertical currents. Dr. Von Huene confirmed what was already generally suspected, very little data exists on deep sea currents, but he did provide me with a good reference that has some data on deep ocean currents off the California coast.

What was of particular interest, and worth reporting here is that he was intensely interested in the possibility of using a SNAP device to power some of his deep sea research vehicles. He was aware of the visit to Sandia during the previous week by Don Moore and other NOTS representatives and he stated he hoped this contact would be fruitful, and requested that I emphasize his particular interest in my trip report when I returned to Sandia. A brief discussion of his application of interest disclosed

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that he would like to use a SNAP device as a direct replacement for the lead-acid batteries he now has to use in his unmanned research vehicles. He specified that it should be able to produce at least 1 to 5 kilowatts of electrical power, it can be as large as 3-feet in diameter, and should be able to fit in a volume not larger than 50 cubic feet. I promised Dr. Von Huene I would report his interest to Sandia as soon as I returned, although we both agreed that the interest and necessary action had already probably been discussed during the previous week between NOTS and Sandia representatives.

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