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*W. D. Washington,*[1] *B.S. and C. R. Midkiff,*[1] *M.S.*

# Forensic Applications of Diamond Cell-Infrared Spectroscopy. I: Identification of Blasting Cap Leg Wire Manufacturers

Infrared spectroscopy (IR) is widely used in the forensic laboratory for the identification and comparison of materials such as explosives, drugs, paints, and plastics. These materials are often encountered as trace evidence. Consequently, the total sample available is so small that conventional IR techniques, even with micro-KBr pellets, are not feasible. The use of a high-pressure diamond cell sample holder suitable for the infrared analysis of microgram-sized samples was reported in 1961 [*1*]. Additional advantages of the diamond cell holder for use with solid samples are minimal sample preparation and applicability to a wide range of materials. Applications of the technique, however, have been limited by the commercial availability of a suitable device. Recently, studies have been reported on several materials of trace evidence interest including the characterization of vehicle paints [*2*] and the microanalysis of paints, plastics, and other materials [*3*].

The application of the diamond cell sample holder to the examination of trace quantities of residual explosives has also been shown [*4*]. In addition to traces of explosives, in the examination of evidence from suspected bombings, plastic-insulated wire is also encountered. This wire may be attributable to items at the scene prior to the blast or it may be associated with the destructive device as electrical hook-up wire or blasting cap "leg wire." When a device is constructed using an electrically initiated blasting cap, fragments of the cap and the leg wires are often recovered in the search of the scene after the blast. Occasionally, cap fragments of sufficient size are recovered and will be of value in the identification of the cap manufacturer. Characteristics of modern electrical blasting caps and their construction features have been described by Townshend [*5*] and Brucker [*6*]; however, these characteristics are most useful with intact or nearly intact caps. Sizeable cap fragments are much less common in blast scene debris than leg wire fragments. When a portion of plastic-insulated wire is located in the evidentiary examination, it is examined for type and gage to determine that it may be blasting cap leg wire. Such wire is usually tinned copper of 20, 22, or 24 gage. Iron wire is also used for special blasting applications. If a preliminary examination indicates that the wire is of the type used in electrical blasting caps, the plastic insulation is analyzed to determine the cap manufacturer.

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[1] Forensic chemists, Bureau of Alcohol, Tobacco and Firearms, Forensic Branch, U.S. Treasury, Washington, D.C.

Currently, in the United States, there are three producers of electric blasting caps: DuPont, Hercules, and Atlas Powder Co. (division of Tyler Corp.). Each of these manufacturers uses characteristic types of wire insulation material. Although the insulation material may not be unique to blasting cap leg wires, the combination of wire type, size, and insulation makes it unlikely that similar wire, not from a blasting cap, would be encountered at a bomb scene. Table 1 lists the insulation types and the cap manufacturer.

TABLE 1—*Leg wire insulation materials.*

| Plastic Type | Manufacturer |
|---|---|
| Ethyl cellulose[a] | Hercules |
| High-density polyethylene | DuPont |
| Nylon[b] | DuPont |
| Polyethylene/polypropylene (copolymer) | Hercules |
| Polyvinyl chloride | Atlas |

[a] Common military production.
[b] Nylon wire insulation may have an outer covering of Teflon®.

Of the instrumental techniques employed to identify the composition of plastic leg wire insulation, the most common are infrared examination of pressed films and pyrolysis gas chromatography (PGC). Our laboratory has for several years utilized hot-pressed thin films which can be examined by IR. The preparation of the film, however, is somewhat inconvenient even though proper operating conditions have been established.[2] In addition, a sizeable sample of wire insulation is required to insure production of a usable film [*7*]. More recently, pyrolysis gas chromatography using a digital log electrometer readout has been found to provide more rapid analysis and lessened sample constraints [*8*]. The use of a diamond cell sample holder manufactured by High Pressure Diamond Optics, Inc.[3] offers even greater convenience by eliminating the need for film pressing and allowing smaller samples than those required for PGC.

Operating conditions of the diamond cell sample holder have been described by Tweed et al [*3*]. In our laboratory a small portion, 0.25 mm or less, is removed from the wire insulation and placed between the faces of the diamond with the aid of a low-power microscope. The cell is closed, and the sample is compressed by hand to form a transparent film. The sample holder is placed in the IR instrument (a Perkin-Elmer Model 621 with 4X All Reflecting Beam Condenser and attenuator was used in this work), and the spectrum is scanned from 1800 to 500 $cm^{-1}$. The diamond cell absorbs strongly in the range of 2700 to 1800 $cm^{-1}$, but this poses no problems in identification since the region of interest is free of interference.

Typical spectra for blasting cap leg wire insulation are shown in Figs. 1-6. A polystyrene calibration using the diamond cell is shown in Fig. 7.

The use of a diamond cell sample holder enables very small samples of plastic material, such as blasting cap leg wire insulation, to be rapidly examined. The IR spectrum of the questioned sample is then compared to those of known leg wire insulation materials, and the plastic type and leg wire origin can be identified.

[2] Personal communication, B. W. Schultz, Illinois Bureau of Identification, Maywood, Ill.
[3] 929 Mackall Avenue, McLean, Va. 22101.

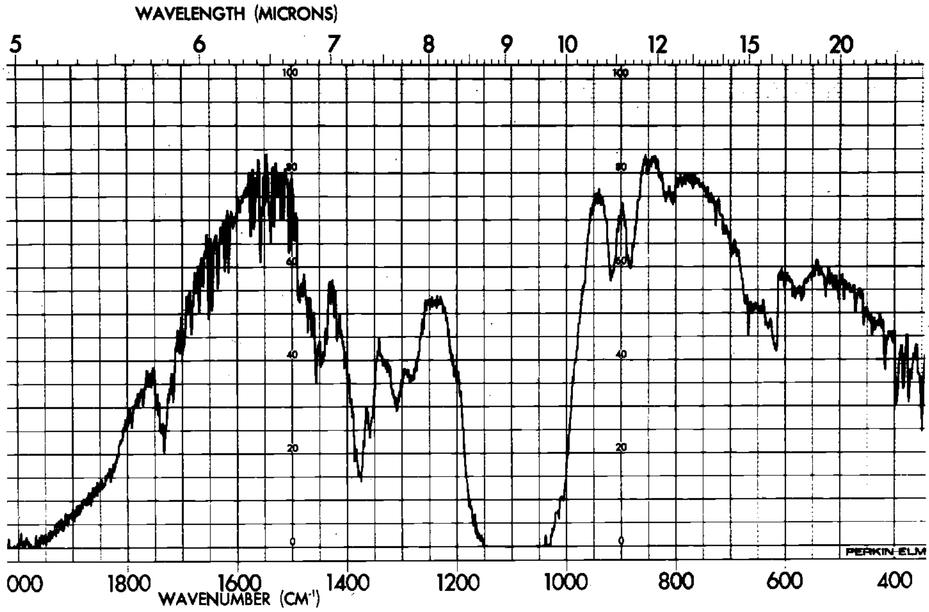


FIG. 1—*Diamond cell IR spectrum of Hercules ethyl cellulose leg wire insulation.*

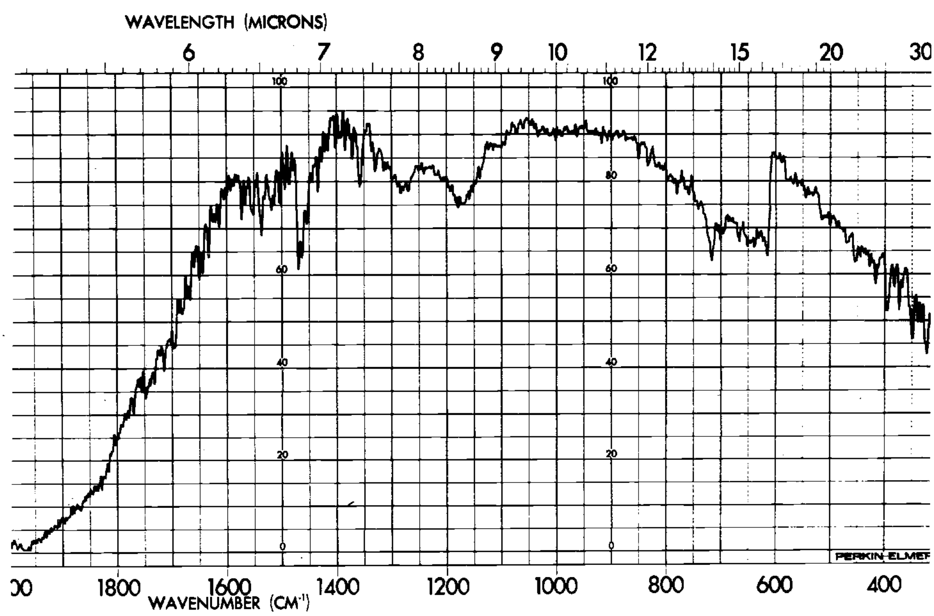


FIG. 2—*Diamond cell IR spectrum of DuPont high-density polyethylene leg wire insulation.*

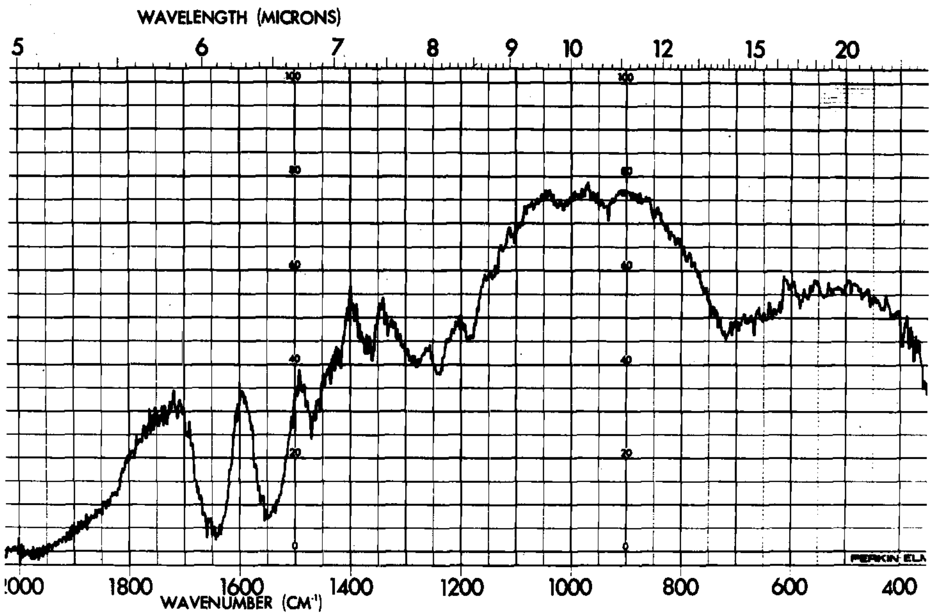


FIG. 3—*Diamond cell IR spectrum of DuPont Nylon® leg wire insulation.*

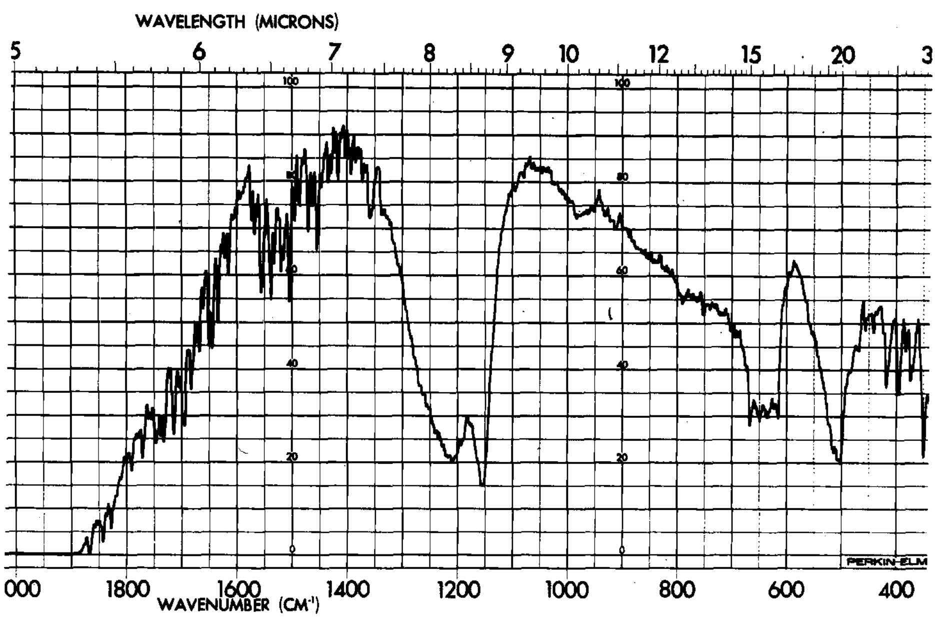


FIG. 4—*Diamond cell IR spectrum of DuPont Teflon® outer layer of leg wire insulation.*

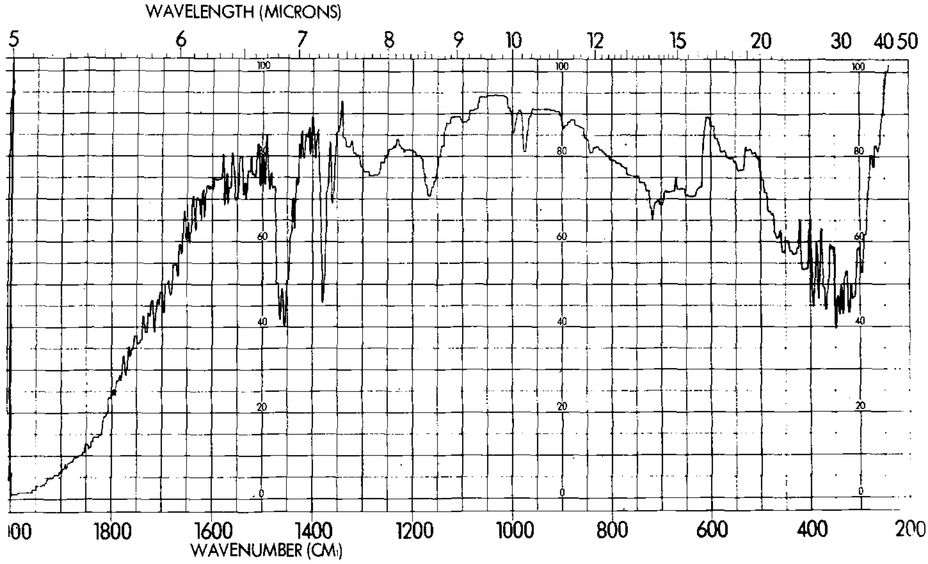


FIG. 5—*Diamond cell IR spectrum of Hercules polyethylene/polypropylene copolymer leg wire insulation.*

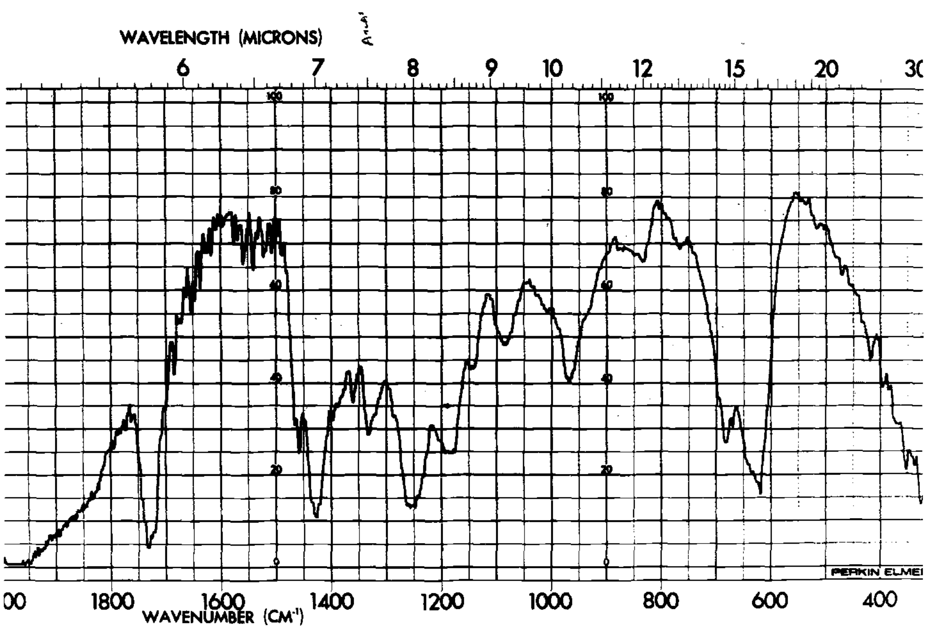


FIG. 6—*Diamond cell IR spectrum of Atlas polyvinyl chloride leg wire insulation.*

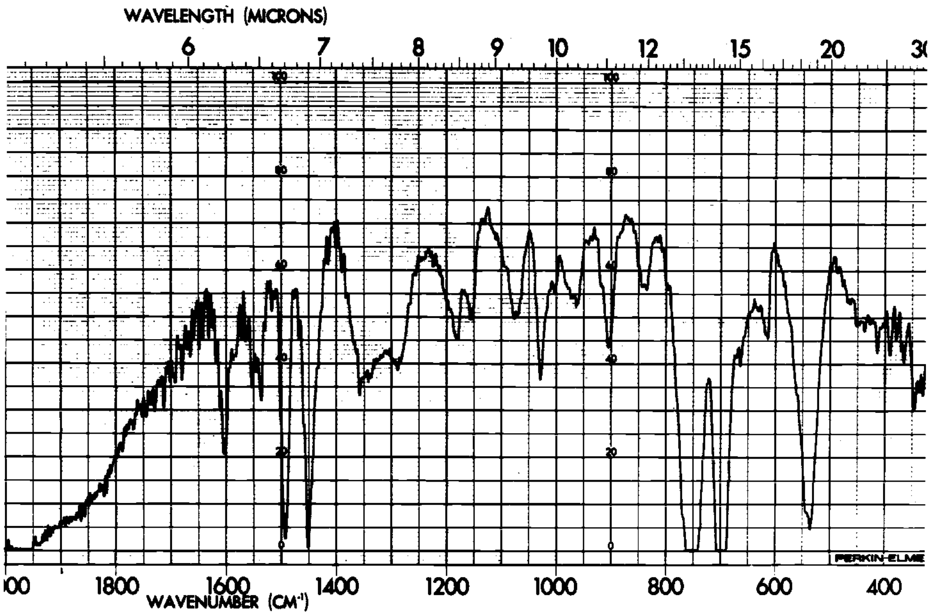


FIG. 7—*Diamond cell IR spectrum of polystyrene (calibration standard).*

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## References

[*1*] Lippincott, E. R., Welsch, F. E., and Weir, C. E., *Analytical Chemistry*, Vol. 33, No. 1, 1961, p. 137.
[*2*] Rodgers, P. G., "The Characterization of Vehicle Paints by Diamond Cell Infrared Spectroscopy," technical report, Royal Canadian Mounted Police Laboratory, Ottawa, Ontario, K1A 0R2, Oct. 1974.
[*3*] Tweed, F. T., Cameron, R., Deak, J. S., and Rodgers, P. G., *Forensic Science*, Vol. 4, 1974, p. 211.
[*4*] Midkiff, C. R. and Washington, W. D., "Systematic Approach to the Detection of Explosives Residues. IV. Military Explosives," submitted for publication, *Journal of the Association of Official Analytical Chemists*, 1976.
[*5*] Townshend, D. G., *Journal of Forensic Sciences*, Vol. 18, No. 4, 1973, pp. 405–409.
[*6*] Brucker, E. W., *Blasting Cap Recognition and Identification Manual*, International Association of Chiefs of Police, Gaithersburg, Md., 1973.
[*7*] Coakley, J. E. and Berry, H. H., *Applied Spectroscopy*, Vol. 20, No. 6, 1966, p. 418.
[*8*] Wineman, P. L., "Pyrolysis Gas Chromatography. I. Identification of Blasting Cap Legwire Insulation," presented at the 87th Annual Meeting of the Association of Official Analytical Chemists, Washington, D.C., 10 Oct. 1973.

Bureau of Alcohol, Tobacco and Firearms
Forensic Branch
U.S. Treasury
Washington, D.C. 20226