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## Is It a Petroleum Product? How Do You Know?

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**ABSTRACT:** Rapid developments in the production of hydrocarbons and alcohols from nonpetroleum sources are leading to partial or total replacement of traditional petroleum products with synthetic materials. Because of the compositional similarity of these new products to those made from petroleum, they may not readily be distinguished in routine gas chromatographic analyses of arson evidence. The report or court testimony of the analyst may require modification to reflect the impact of this new technology and accelerants should not be characterized as petroleum products unless supported by additional data.

**KEYWORDS:** forensic science, petroleum products, accelerants, arson

In arson related laboratory examinations, the report or the testimony of the expert in court, or both, frequently describe the flammable liquid detected as "a heavy petroleum distillate," "a middle petroleum distillate," or "a petroleum distillate of the gasoline type." This terminology is used because the laboratory cannot definitively identify the material by vendor product designation (for example, jet fuel, charcoal starter, paint thinner, kerosene). This limitation is imposed primarily by practices within the industry where a particular boiling range fraction may be marketed for a number of uses. Identical products may be marketed with different product designations or different distillate fractions may be sold for the same application. As a result, designation by product type cannot be made solely on analytical results [1].

On a more fundamental level, the validity of describing the flammable liquid detected in arson evidence as a petroleum product is becoming questionable. This is a result of rapid technical innovation and change in the petroleum and chemical industries.

It has long been known that liquid hydrocarbon fuels can be made from coal. During World War I, the Bergius process was developed and used in Germany to produce synthetic fuels. One ton of gasoline could be produced by the destructive hydrogenation of 1.5 to 2 tons of coal. The gasoline produced was reported to contain about 74% paraffins and 22% aromatics and to have an octane rating of 75 to 80 [2].

Work by Fischer and Tropsch in 1933 involved the catalytic hydrogenation of carbon monoxide made from coke to produce a complex mixture of hydrocarbons. At least 120 specific compounds have been identified in the F-T reactor effluent, including C1-C12 paraffins and olefins, alkyl aromatics, and C1-C4 alcohols [3]. Of these, over half boil in the gasoline range. The higher boiling fraction has a cetane rating of 85 and is well-suited for use in diesel engines [2].

Until about 1974, the low cost and general availability of petroleum feedstocks made

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synthetic fuels unattractive. Sharp price increases in petroleum feedstocks since that time have, however, somewhat shifted the economics of synthetic fuel production. Political considerations in a number of countries make alternative fuels attractive, both to reduce reliance on potentially unreliable outside sources and to improve the nations's balance of payments.

In 1980, the Sasol Two facility in South Africa began production of oil from coal [4]. This facility, using the Fischer-Tropsch synthesis, has tripled in size since 1982 and has significantly reduced South Africa's dependence on imported oil. It was recently reported that the operation is profitable and production is being shifted to emphasize diesel fuel [5]. In the United States, Dow Chemical has an active program to develop catalysts to upgrade products from the Fischer-Tropsch synthesis. The new catalysts are shape selective zeolites which permit upgrading of by-products to olefins and aromatics [6]. Such upgrading will result in traditional petroleum-based liquids being replaced by synthetics in both fuel and chemical products.

Of perhaps greater significance in the production of automotive fuel was the development of a process to convert methanol into gasoline. Early in 1978, Mobil Oil Corp. demonstrated a pilot plant which would convert methanol made from coal or natural gas into high octane gasoline. Cost was estimated as 40 to 50 cents per gallon higher than a comparable product made from petroleum [7]. For a country such as New Zealand with abundant natural gas but limited petroleum, the process could be attractive. The Mobil process could produce half the nation's gasoline needs at a cost competitive with imported oil [8]. Recently, Mobil announced the operation of a pilot plant in West Germany using a fluidized bed reactor. The yield of raw gasoline was reported as 90% with an octane rating  $[(R+M)/2]$  of 90.25. A commercial plant is currently being designed, with design completion targeted for mid-1985 [9]. Interest in methanol conversion technology is indicated by the publication of a recent book on the topic [10] and a symposium at the 1984 National Meeting in Philadelphia [11].

Other potential sources of nonpetroleum derived fuels, solvents, and chemicals include coal liquefaction, coal or plant derived liquids, and biomass waste, as well as natural gas. Synthesis gas from natural gas sources can be used economically to produce mixed alcohols with octane ratings of up to 120. These mixed higher alcohols have considerable potential as blenders in motor fuel to boost octane at costs 30 to 50% below boosters made by other processes [12]. An interesting development involving biomass was the announcement by Battelle-Northwest of a process to convert sewage sludge into a No. 2 fuel oil equivalent product [13]. This process may have commercial potential, not only because of the fuel produced, but primarily because of an 80% reduction in the final volume of waste requiring disposal.

Although natural gasoline, from natural gas, has been produced and used as a motor fuel for many years, it represents a relatively minor portion of the total. As a result, it was reasonable to consider motor fuels as petroleum products. Other products, such as solvents, may or may not have been rigorously petroleum derived, having been produced entirely or in part from natural gas. This, too, is a minor point because the distinction between petroleum and natural gas liquids is somewhat arbitrary. Fuel and related hydrocarbon products made from coal, biomass, or waste products such as sewage sludge are distinctly different. These are not petroleum products. At this point, however, it is doubtful that the analyst conducting a routine examination of residues recovered from arson evidence, particularly if packed rather than capillary columns are used, would be able to distinguish these products from those made from petroleum.

A cursory examination of the pertinent literature shows that gas chromatographic (GC) patterns for the synthetic products, even with capillary columns, bear a strong resemblance to equivalent products made from petroleum. There are differences which can be observed, but with the large number of individual compounds available, careful cutting at the refinery or product blending could make even this distinction extremely difficult.

Although it is true that fuel, lubricant, and solvent products available in the United States are made primarily from petroleum, there is both current use (such as synthetic motor oils and blenders in unleaded gasolines) and indicated interest in synthetic fuels. The military maintains an active interest in the use of synthetic fuels [14] and has recently offered support in their development [15].

With the increasing use of synthetic products in fuels and chemicals, it appears that there are potential problems in the analyst routinely testifying that the material detected was identified as a petroleum product. In most instances, he or she is unlikely to have done sufficient testing to establish this fact. If the product is a narrow refinery cut, such as a solvent, or is a blended fuel, a GC analysis will not demonstrate that a product is made from petroleum. A GC analysis does not even demonstrate that a given component of a mixture is a hydrocarbon. The use of gas chromatography/mass spectrometry (GC/MS) will provide definitive identification of components but does not provide information on whether an individual hydrocarbon or alcohol was made from coal, natural gas, oil, or biomass. Techniques are available to assist in this determination, but with the amount of material available in most situation and the requirements for sophisticated equipment, these types of determinations are unlikely to be regularly made in the forensic science laboratory. As a practical matter, it is not essential that the analyst determine whether the accelerant detected is petroleum or nonpetroleum derived. The analyst should, however, limit his or her conclusions to those supported by the analytical data.

With the present production technology and active support by governmental agencies in many nations, synthetic fuels are becoming a reality. It would thus appear that, based upon the tests normally conducted, there is no basis for testimony by the forensic scientist that "to a reasonable scientific certainty" the product detected was derived from petroleum. Future laboratory reports and court testimony may need to be modified to eliminate the characterization of a detected accelerant as a petroleum product unless this can be conclusively demonstrated.

To evaluate the scope of the problem, laboratory testing of several synthetic fuels is planned and results will be reported in the *Journal*.

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