6. ANALYTICAL METHODS

The purpose of this chapter is to describe the analytical methods that are available for detecting and/or measuring and monitoring 2-butanone in environmental media and in biological samples. The intent is not to provide an exhaustive list of analytical methods that could be used to detect and quantify 2-butanone. Rather, the intention is to identify well-established methods that are used as the standard methods of analysis. Many of the analytical methods used to detect 2-butanone in environmental samples are the methods approved by federal agencies such as EPA and the National Institute for Occupational Safety and Health (NIOSH). Other methods presented in this chapter are those that are approved by groups such as the Association of Official Analytical Chemists (AOAC) and the American Public Health Association (APHA). Additionally, analytical methods are included that refine previously used methods to obtain lower detection limits, and/or to improve accuracy and precision.

6.1 BIOLOGICAL MATERIALS

Numerous procedures that detect-2-butanone in biological materials have been reported in the literature. A summary of.these methods is found in Table 6-l. In general, each technique appears to be capable of determining 2-butanone in any type of biological matrix given suitable modification of the sample collection/preparation step.

Since 2-butanone is a volatile compound, analysis by headspace sampling can be accomplished for both liquid matrices, such as blood and urine (Deveaus and Huvenne 1987; Perbellini et al. 1984), and solid matrices, such as soft tissue (Perbellini et al. 1984). For solid samples such as soft tissue, better results are obtained if the sample is first homogenized at low temperatures before analysis. The technique involves gently heating the sample in a closed system, followed by withdrawing a portion of the air above the sample (the headspace) by syringe. Separation of 2-butanone from other compounds that may be present is then accomplished by injecting the contents of the syringe directly into a gas chromatograph (GC). As indicated in Table 6-2, successful quantification of 2-butanone has been accomplished using a variety of detection systems, including a flame ionization detector, mass spectrometer, or Fourier transform infrared spectrometer.

Analysis of 2-butanone in liquid samples can also be accomplished by purge and trap methodology (Pellizzari et al. 1982). In this technique, an inert gas is bubbled through the sample, liberating 2-butanone. The contaminant is then trapped on an adsorbent cartridge, followed by thermal desorption directly into a gas chromatograph (GC). This technique has been successfully used for analysis of human milk samples (Pellizzari et al. 1982)

Extractive techniques can also be used for the analysis of 2-butanone in liquid samples (Kezic and Monster 1988; Van Doorn et al. 1989). The sample is shaken with an immiscible organic solvent into which 2-butanone partitions.

TABLE 6-1. Analytical Methods for Determining 2-Butanone in Biological Materials

Sample matrix	Preparation method	Analytical method	Sample detection limit (ppm)	Percent recovery	Reference
Urine	Derivatization with o-nitrophenol-hydrazine, liquid-liquid extraction by HPLC	HPLC/UV	0.10	No data	Van Doorn et al. 1989
Urine	Acidification, extraction with CH_2Cl_2 by HPLC, concentration	GC/FID	0.01	85%-91%	Kezic and Monster 1988
Urine	Headspace analysis	GC/MS	No data	No data	Perbellini et al. 1984
Blood	Heat sample to 80°C in sealed tube, obtain headspace sample	GC/FTIR	6	No data	Deveaux and Huvenne 1987
Blood	Derivatization with o-nitrophenyl-hydrazine, liquid-liquid extraction by HPLC	HPLC/UV	0.10	No data	Van Doorn et al. 1989
Blood	Headspace analysis	GC/MS	No data	No data	Perbellini et al. 1984
Milk	Purge at elevated temperatures, trap on Tenax cartridges, thermal desorption	GC/MS	No data	No data	Pellizzari et al. 1982
Soft tissue	Homogenize sample at 4°C, heat to 80°C in sealed tube, obtain headspace sample	GC/FTIR	6	No data	Deveaux and Huvenne 1987
Soft tissue	Headspace analysis	GC/MS	No data	No data	Perbellini et al. 1984
Expired air	Collect breath in Tedlar bag pump air through Tenax cartridges, thermal desorption	GC/MS	No data	No data	Wallace et al. 1984

FID = flame ionization detector
FTIR = Fourier transform infrared spectrometry
GC = gas chromatography
HPLC = high performance liquid chromatography
MS = mass spectrometry
UV = ultraviolet spectroscopy

TABLE 6-2. Analytical Methods for Determining 2-Butanone in Environmental Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Air	Pump air through sorbent tube, desorb with CS_2 - NIOSH 2500	GC/FID	4 μg	92%	NIOSH 1984
Air	Pump air through cryogenic trap, attach trap to GC, thermal desorption	GC/FID	8 ppb	No data	Jonsson et al. 1985
Water	Purge and trap	GC/FID GC/MS	10 ppb	No data	EPA 1988
Drinking water	Purge and trap on a Tenax cartridge	GC/FID	No data	No data	Wallace et al. 1984
Soil	Add water, heat to 40°, purge and trap, thermal desorbtion	GC/FID GC/MS	10 ppb	No data	EPA 1988
Sediment	Add water, heat to 40°, purge and trap, thermal desorbtion	GC/FID GC/MS	10 ppb	No data	EPA 1988

FID = flame ionization detector
GC = gas chromatography
MS = mass spectrometry

After concentrating the extract, the sample can be analyzed by different methods. 2-Butanone can first be derivitized to increase its extraction efficiency, or to make it more visible to the detection system.

Numerous types of detection and quantitation methods have been used in the analysis of 2-butanone in biological samples. Gas chromatography has been used to separate 2-butanone from other contaminants that may be present. Direct quantitation can be made by using a flame ionization detector (FID), tandem gas chromatography-mass spectrometry (GC-MS), or tandem GC-fourier transform infrared spectrometry (GC-FTIR). The latter two techniques also allow direct identification of the contaminants. Analysis of derivitized 2-butanone can be accomplished using high-performance liquid chromatography (HPLC) equipped with an ultraviolet (WV) detector. These detection systems are capable of measuring 2-butanone in the sub-ppm range; the limits on the GC-FTIR system are slightly greater than 1 ppm.

Given the numerous techniques available for the determination of 2-butanone in biological samples, and the lack of any standardized method for each individual matrix, the choice of an analysis technique appears to be a function of the instrumentation and personal biases of the laboratory performing the analysis. With the exception of the derivitization method, all of the techniques described above are also capable of determining the metabolites of 2-butanone (3-hydroxy-2-butanone, 2-butanol, and 2,3-dihydroxybutane) in biological samples.

6.2 ENVIRONMENTAL SAMPLES

A short description of standardized methods that can be used for the analysis of 2-butanone in environmental samples is presented in Table 6-2. It should be noted that an extensive list of methods for the analysis of 2-butanone in environmental samples can be compiled from the literature. In all of these methods, however, there is a consensus that, after the sample preparation stage, mixture separation and quantitative analysis are best determined by the use of a gas chromatograph coupled with any of an assortment of detectors (Bertsch et al. 1975; Coleman et al. 1976; Corwin 1969; Dunovant et al. 1986; Hawthorne and Sievers 1984; Isidorov et al. 1985; Jonsson et al. 1985; Jungclaus et al. 1978; LaRegina et al. 1986; Pellizzari 1982; Sawhney and Kozloski 1984; Smoyer et al. 1971; Snider and Dawson 1985; Wallace et al. 1984; Wang and Bricker 1979).

The analysis of 2 butanone in air can be accomplished by NIOSH method 2500 (NIOSH 1984). The sample is obtained in the field by the use of a pumping system to pass a measurable quantity of air (approximately l-12 L) through a tube loaded with a solid sorbent, Ambersorb XE-347. Extraction of the tube with the solvent carbon disulfide liberates the 2-butanone, and quantitation is achieved by GC using a flame ionization detector.

6. ANALYTICAL METHODS

The analysis of 2-butanone in soil, sediment, and water samples at hazardous waste sites is described in the Contract Laboratory Program manual (EPA 1988). For the soil and sediment samples, the procedure begins with the addition of a small portion of water to the sample. At this point, all three matrices are subjected to a purge and trap cycle. An inert gas is bubbled through the sample, volatilizing 2-butanone. The gas stream is then passed through an adsorbent tube that recollects the 2-butanone. The sorbent tube is attached to a gas chromatograph and heated to flush the sample onto a GC column. Quantification can be accomplished using either a flame ionization detector or a mass spectrometer, depending on the total concentration of organics in the sample. Required quantitation limits for this program are 10 ppm in all three matrices. No other standardized methods for the determination of 2-butanone in environmental samples were located.

6.3 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA as amended directs the Administrator of ATSDR in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of 2-butanone is available. Uhere adequate information is not available, ATSDR, in conjunction with the National Toxicology Program (NTP), is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of 2-butanone.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that, if met, would reduce or eliminate the uncertainties of human health assessment. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

6.3.1 Data Needs

Methods for Determining Biomarkers of Exposure and Effect. Numerous methods for the determination of 2-butanone in biological materials have been described in the literature (Deveaux and Huvenne 1987; Kezic and Monster 1988; Pellizzari et al. 1982; Perbellini et al. 1984; Van Doorn et al. 1989). These methods are also appropriate for determining the metabolites of 2-butanone, 3-hydroxy-2-butanone, 2-butanol, and 2,3-dihydroxybutane, which also serve as biomarkers of exposure. These methods display the requisite sensitivity to measure background levels in the population and levels which may indicate a concern for biological effects. Standardized methods for these procedures should be established as no standardized methods could be located. Any methodology established for determining biomarkers of exposure must take into account the short biological half-life of 2-butanone, which may render these methods inferior to direct measurements of exposure.

There are no known biomarkers of effect which are specific to 2-butanone.

Methods for Determining Parent Compounds and Degradation Products in Snvironmental Media. Numerous methods capable of detecting low levels of 2-butanone in environmental media have been described in the literature (Bertsch et al. 1975; Dunovant 1985; Hawthorne and Sievers 1984; LaRegina et al. 1986; Pellizzari 1982; Wallace et al. 1984). Appropriate standardized methods are available for the determination of 2-butanone in air (NIOSH 1984), water, soil, and sediments (EPA 1988) at levels that may constitute a concern for human health. The methods for determining 2-butanone in air, the medium that represents the most concern for exposure, are highly sensitive, accurate, and reproducible. The exact levels of detection for these methods in all media, however, are not described. There are numerous reliable methods available in the literature that have been used to determine levels of 2-butanone in environmental media and foods at levels that may cause health effects to occur, but they have not been standardized.

6.3.2 On-going Studies

The Environmental Health Laboratory Sciences Division of the Center for Environmental Health and Injury Control, Centers for Disease Control, is developing methods for the analysis of 2-butanone and other volatile organic compounds in blood, These methods use purge and trap methodology and magnetic sector mass spectrometry which gives detection limits in the low parts per trillion range.

On-going studies involving the development of analytical methods have been identified (EPA 1989b), although no specific information was provided.