PCB Determinations

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The term **polychlorinated byphenyl (PCB)** refers to a class of compounds with a host molecular structure that contains a varying degree of bonded chlorine atoms. The term "biphenyl" refers to the main part of the molecule, which consists of two carbon rings, while the term "polychlorinated" refers to the "many chlorines" attached to the carbon rings. Based on one to 10 chlorine atoms per molecule, there are 209 possible combinations with varying degrees of chlorination. Each specific combination and location of chlorines attached to the biphenyl functional group is termed a PCB congener. As an example, there are 12 different combinations of a PCB molecule that contain two chlorine atoms. Each one of these combinations is chemically similar and has a similar boiling point and properties.

PCBs are man-made chemicals that were created for various industrial uses and were commonly used as insulation material for electrical equipment. PCBs were also used in adhesives, caulking pesticides, fluorescent light ballasts, coatings, asphalt roofing materials, plasticizers and other specialty applications . However, due to the suspect human toxicity and stability (persistence as a pollutant), the U.S. government banned the production of PCBs in 1979 . When PCBs were manufactured and used, they were not refined to isolate single congeners. However, mixtures of congeners were common due to the difficulty of purifying and isolating individual congeners within a processing batch. These mixtures are known as aroclors. Aroclor 1254 was one of the most commonly used of the industrial PCB fluids and contains well over 60 different congeners. Each aroclor that is commonly determined by a laboratory will also contain a mixture of congeners. In several instances, many aroclors share common congeners in their mixtures. Aroclors were commonly identified with a "mixture" number that loosely related to the degree in which the biphenyl molecule was chlorinated. For example, Aroclor 1060 contains several congeners with a low level of chlorine (mono, di, tri,tetra and penta), while Aroclor 1260 contains a much higher degree of chlorination of the biphenyl functional group (penta, tetra hexa, hepta, octa etc.). The different degrees of chlorination within an aroclor mixture yielded different industrial properties that were sought after by manufacturers. The most common use of PCBs was as dielectric fluids in transformers.

In the laboratory, PCB determinations in environmental samples are accomplished by searching for aroclor mixtures. One of the most commonly recognized procedures, **SW-846 Method 8082**, tests for seven common aroclor mixtures. This is a gas chromatographic method that uses a detector specific to the detection of halogens. Given the detector property, this method is highly sensitive to molecules that contain chlorine and virtually blind to common hydrocarbons. Chromatography is a scientific technique that involves the separation of individual compounds under a given set of conditions. As each compound is separated and detected, a graphical representation of the data is established based upon the time it takes for the detector to identify a response. This time interval is known as retention time. To calibrate the instrument, a set of calibration standards (known compounds and concentrations) are analyzed under a specific set of chromatography conditions to establish retention times of the targeted compounds. Unknown samples are then analyzed under the exact same conditions. Based on their retention time, unknowns are matched to the calibration standards. If the retention time is within established time windows, unknowns are positively identified. By comparing the response and concentration of a standard to that of the unknown sample, the concentration of the compound of interest can also be calculated in the unknown. As noted above, aroclor mixtures contain several congeners and rather than a single chromatographic response, a pattern is generated for each specific mix.

When analyzing for PCBs, aroclor mixtures are used as the calibration standards. Each aroclor mixture provides a pattern unique to that particular aroclor. To identify aroclors in unknown samples, the analyst looks for 3 to 5 responses that are unique to each aroclor. The analyst then reviews the relative proportions of each response to assist in the identification. In order to identify aroclors in unknown samples, it is common for the analyst to electronically overlay the chromatographic patterns of the aroclor standards over the unknown samples. The analyst looks for a match in the patterns to see if the correct proportions are also present. If a match is found, the concentration of the aroclor is evaluated by averaging the response of the unique responses in the known calibration standard and comparing that to the same common responses in the sample.

Several factors contribute to difficulties in PCB determinations. First, the sample matrix itself may mask some responses, making pattern recognition difficult. Efforts are made in the laboratory to use additional sample preparation steps to remove some of these interferences. Another common problem occurs when multiple aroclors are present in a sample, causing an overlap in congener responses and skewing common patterns. As in most PCB determinations, the analysis is subject to the analyst's interpretation of the data and thus, requires an experienced chemist to properly evaluate the data. If mixtures are present, alternate technical approaches may be required to properly identify and quantitate both aroclors. Additional difficulty can be encountered if weathering has occurred in the sample. The degree and extent of a weathered PCB sample can often make the determination difficult because the sample no longer matches a pure reference standard. In these cases, aroclors are commonly misidentified since the unknown's pattern may closely resemble multiple different aroclor calibration standards. When this occurs, the chemist is relied upon to make the best professional judgment possible. Another potential complication to the identification process is when an unknown sample contains a PCB pattern that does not match that of an aroclor reference. An unmatched sample results when the original aroclor mixture was formulated for a specific industrial application or was somewhat out of specifications. For these samples, the majority of the pattern may be present with part of the chromatographic responses missing. In these cases, the analysis will determine what aroclor pattern most closely resembles the unknown pattern and quantitate and report the sample results based upon the closest matching reference standard.

A final approach to PCB determinations is to perform a congener-specific analysis. The intent of this type of analysis is to separate and identify as many of the 209 congeners as possible, independent of aroclor mixtures. The congener-specific approach is commonly used for the analysis of weathered samples (i.e. sediments) and when it is necessary to associate the PCB contamination with specific health risks. Since some of the congeners are more toxic and bio-available than others, congener-specific concentrations are desirable under certain applications. There are limitations to this approach as well that include the inability to separate some of the congeners when complex matrices are involved.

The **Camp Hill Division of Microbac Laboratories, Inc.** provides PCB determinations. For more information about PCB determinations, please contact microbac_info@microbac.com.

References

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2 http://www.epa.gov/history/topics/pcbs/01.htm

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