Coupling Gas Chromatography to Mass Spectrometry

Introduction

The suite of gas chromatographic detectors includes (roughly in order from most common to the least): the flame ionization detector (FID), thermal conductivity detector (TCD or hot wire detector), electron capture detector (ECD), photoionization detector (PID), flame photometric detector (FPD), thermionic detector, and a few more unusual or VERY expensive choices like the atomic emission detector (AED) and the ozone- or fluorine-induce chemiluminescence detectors. All of these except the AED produce an electrical signal that varies with the amount of analyte exiting the chromatographic column. The AED does that AND yields the emission spectrum of selected elements in the analytes as well. Another GC detector that is also very expensive but **very** powerful is a scaled down version of the mass spectrometer. When coupled to a GC the detection system itself is often referred to as the mass selective detector or more simply the mass detector. This powerful analytical technique belongs to the class of hyphenated analytical instrumentation (since each part had a different beginning and can exist independently) and is called gas chromatograhy / mass spectrometry (GC / MS).

Placed at the end of a capillary column in a manner similar to the other GC detectors, the mass detector is more complicated than, for instance, the FID because of the mass spectrometer's complex requirements for the process of creation, separation, and detection of gas phase ions. A capillary column is required in the chromatograph because the entire MS process must be carried out at very low pressures (~10^{-5} torr) and in order to meet this requirement a vacuum is maintained via constant pumping using a vacuum pump. Packed GC columns have carrier gas flow rates that cannot be as successfully pumped away by normal vacuum pumps; however, capillary columns' carrier flow is 25 or 30 times less and therefore easier to "pump down."

The high cost for the pump, ionization source, mass filter or separator, ion detector, and computer instrumentation and software has limited the wide application of this system as compared to the less expensive GC detectors (e.g., FID cost ~$3000; MS cost ~$40,000). However, the power of this technique lies in the production of mass spectra from each of the analytes detected instead of merely an electronic signal that varies with the amount of analyte. These data can be used to determine the identity as well as the quantity of unknown chromatographic components with an asssuredness simple unavailable by other techniques.

Components of the GC/MS

Leaving the entire capillary GC system aside, the major components of the mass selective detector itself are: an ionization source, mass separator, and ion detector. There are two common mass analyzers or separators commercially available for GC/MS and they are the quadrapole and the ion trap.

GC/MS Movie

The movie available at this site is a short series of steps for the process of a single analyte (already separated from the other analytes in the chromatographic mixture) denoted as ABC exiting the chromatographic column and:

- the analyte (A-B-C) undergoing ionization and fragmentation
- the charged fragments (A^+ B^+ C^+) being separated by mass
- the fragments which are focused on the mass filter's exit slit passing into the detector
- and the charged ions being detected.

In this example, the lightest fragment is B^+; the heaviest A^+. The last frame of the movie is a mass spectrum displaying only these three fragments. Their relative mass to charge ratios are specified by their relative position on the x axis (low mass/charge to left, high mass/charge to right). The relative amounts (commonly called peak intensity) of each of these fragments determined during the mass analyzer's scan is reflected by the y axis.

The QuickTime move and GIF animations are both available here: http://www.shsu.edu/~chm_tgc/sounds/sound.html

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