A Brief Overview of the Hazards and Detection Techniques of VOCs (Volatile Organic Compounds)

1 What are VOCs?

Most VOCs have distinctive, unpleasant odors and possess toxic, irritating, teratogenic (causing birth defects), and carcinogenic properties. Notably, compounds such as benzene, toluene, and formaldehyde can cause significant harm to human health. VOCs are crucial precursors in the formation of urban smog and photochemical smog. Their primary sources include coal and petroleum chemical industries, fuel and paint manufacturing, and solvent production and use.

Typically, VOCs encompass various categories such as alkanes, lipids, aldehydes, and ketones. Important constituents within VOCs include benzene series, organic chlorides, freon series, organic ketones, acids, esters, and amines. These substances in the air can severely impact the human respiratory, cardiovascular, and nervous systems, posing a serious threat to human life and safety under severe conditions.

2 Primary Sources of VOCs

The primary sources of volatile organic compounds (VOCs) vary depending on the environment. Outdoors, industrial emissions, vehicle exhaust, and photochemical pollution are significant contributors. Indoors, VOCs originate from a range of sources including combustion products from fuels like coal and natural gas, smoking, various building materials, furniture, household appliances, automotive interiors, cleaning agents, and emissions from human activities.

During interior decoration processes, paints, coatings, adhesives, and solvent-based release agents are prominent sources of VOCs. These compounds can also be emitted from common indoor items such as building materials, carpets, printers, and cosmetics. Lack of adequate ventilation exacerbates indoor air pollution, sometimes leading to VOC concentrations ten times higher than outdoor levels.

3 Dangers from VOCs

VOCs pose significant dangers to human health and the environment. Exposure to high levels of VOCs can lead to a variety of acute and chronic health effects. Short-term exposure to VOCs can cause irritation of the eyes, nose, and throat, as well as headaches, dizziness, nausea, and fatigue. Prolonged exposure or exposure to high concentrations of VOCs may lead to more severe symptoms such as respiratory issues, neurological effects, and damage to the liver and kidneys. Certain VOCs have been linked to the development of cancer and other serious health conditions, making them a major concern for public health.

In addition to the direct health risks, VOCs also contribute to the formation of ground-level ozone and fine particulate matter, which are major components of air pollution. Furthermore, VOCs can react with other pollutants in the atmosphere to form secondary pollutants such as smog and harmful airborne particles, further worsening air quality.

4 VOC Detection Techniques

The main methods for detecting Total Volatile Organic Compounds (TVOCs) in the air include Gas Chromatography (GC), Fourier Transform Infrared Spectroscopy (FTIR), Flame Ionization Detection (FID), and Photoionization Detection (PID).

Flame Ionization Detection FID

When the monitored VOC gases pass through a high-temperature flame generated by burning hydrogen (H2) and air, they undergo chemical ionization. This process generates an electrical signal proportional to the concentration of the VOCs in the sample, allowing for the determination of VOC emissions. This technique is responsive to various VOC components, particularly hydrocarbons or carbon-based VOCs, making it highly sensitive and suitable for monitoring these types of VOC emissions. However, FID devices are typically large and heavy, require hydrogen as an auxiliary, posing a safety risk, and are therefore not commonly used for field monitoring. Additionally, the presence of gaseous water, oxygen (O2), nitrogen (N), oxygen (O), and halogen atoms in VOC emissions can lead to errors in the monitoring results.

PID

VOCs in the gas emissions are ionized by a UV lamp in the detector, forming positive and negative ions. These ions are converted into an electrical signal through gas charge measurement. The concentration of the target gas is then calculated based on the linear relationship between the gas concentration and the electrical signal. This monitoring instrument is fast-responding, highly sensitive, does not require hydrogen or air as an auxiliary, and is portable, making it highly suitable for emergency field monitoring, indoor monitoring, and hazardous gas warnings. However, the response for certain types of VOC gases is limited by the UV lamp's energy. For example, the response to short-chain alkane VOCs is slow, and sometimes they cannot be detected at all.

Gas Chromatography

Depending on the VOC components, a chromatographic column separation method is used, and different detector systems are selected to monitor and analyze multiple components. The electrical signal generated after the VOC gases pass through the FID/PID is output to a recording instrument, producing a chromatogram where the peak area is proportional to the mass of the organic compound. This chromatogram is used for qualitative and quantitative analysis of VOC emissions.

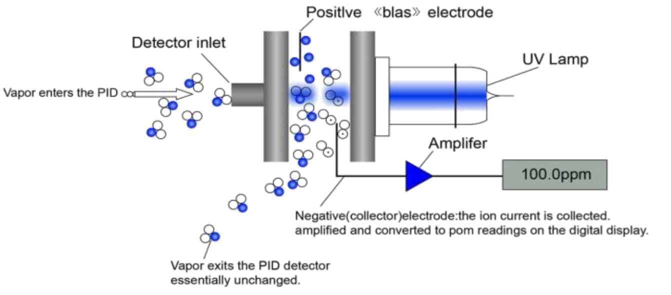
This technique uses temperatures over 120°C to heat the sample collection and transmission processes, using highly corrosion-resistant and inert materials to significantly reduce adsorption during sample transmission. It is highly selective and sensitive for VOC emission detection, easy to operate, and provides stable and reliable measurement results, allowing for simultaneous measurement of multiple components. This technique is widely used.

FTIR Chromatography

FTIR measures and analyzes the "fingerprint" characteristic absorption spectrum of trace gas components in the VOC emissions, allowing for qualitative and quantitative analysis of various VOC components in the sample. This technique can detect a wide range of VOC types, analyze multiple components simultaneously, has a short monitoring cycle, quick response, easy operation, and high sensitivity. However, compared to gas chromatography, it requires more maintenance and has higher maintenance costs.

5 PID Sensors

The Photoionization Detector (PID), also known as PID, is one of the most widely used technologies for detecting volatile organic compounds (VOCs) and certain inorganic gases.



The principle of PID involves using a high-energy ultraviolet light source to ionize gas molecules and generate a current signal. Only gas molecules with ionization energies lower than the energy of the ultraviolet light source can be ionized. This product's ultraviolet light source uses 10.6 eV, while major components in air such as O2, N2, CO2 typically have ionization energies much higher than this value and thus do not generate a signal. Therefore, PID can be used to monitor gases in the air with ionization energies lower than 10.6 eV without interference from air components.

When the PID is operating, the sample gas diffuses into the ion chamber of the PID. At this point, the high-energy ultraviolet light source in the PID ionizes the gas molecules in the ion chamber, generating electrons and producing a current signal. This signal is collected and processed to reflect concentration information of the sample.

HT-Nova has developed PID sensors using the industry-standard 3-pin mode, consistent with mainstream brands of photoionization sensors, making it convenient for application in various handheld, mobile, or fixed gas detection devices. Our PID sensors have significant advantages such as small size, high sensitivity, fast response, and overall shielding, allowing for easy integration into handheld, mobile, or fixed gas detection devices for safe use in industrial, commercial, and residential environments.

For more information, please email us at: info@htnova.com