

Sensor-based Air Quality Monitoring

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INTRODUCTION

Air quality monitoring in residences, workplaces, and other public gathering places is essential to ensure that the air we inhale is free of pollutants. The primary objective of monitoring air quality is to track the presence of pollutants such as Volatile Organic Compounds (VOCs). The surveillance of VOC emissions serves the purpose of source identification, facilitating early intervention for VOC control, and application of air quality management strategies to protect people from health issues like fatigue, nausea, dizziness, headaches, breathing problems, and irritation of the eyes, nose, and throat which are associated with exposure to high levels of such compounds over time.

In the 1980s, mobile homes constructed with particleboard and plywood, containing formaldehyde-based resins, presented a significant health hazard. Residents experienced adverse effects such as eye irritation, headaches, and respiratory issues due to the off-gassing of formaldehyde. Similarly, Sick Building Syndrome (SBS) was associated with numerous office buildings in the 1970s and 1980s. Symptoms, including fatigue and headaches in SBS cases, were attributed to elevated levels of volatile organic compounds (VOCs) emanating from building materials, cleaning products, and furnishings. The phenomenon of rapid urbanization in China, coupled with an increased prevalence of synthetic materials in homes, has contributed to elevated VOC levels. Consequently, residents have encountered respiratory problems and allergies. In such instances, the implementation of air quality monitoring would have been pivotal

in mitigating these health issues. Regular monitoring of indoor air quality enables the timely detection of harmful substances, facilitating interventions that not only enhance indoor air quality but also prevent health risks associated with exposure to indoor pollutants.

Why VOC sensors are important and how it works?

Sensors play a pivotal role in monitoring indoor air quality (IAQ) by continuously collecting data on the dynamic levels of these compounds. Fit for such a vital task necessitates equipping these sensors with the ability to provide insightful, real-time information, making it possible for inhabitants as well as building administrators to make intelligence-based decisions thereby, promoting comfort and safety.

Various technologies are employed by different devices, with one common approach relying on chemical reactions with VOCs. For instance, metal oxide sensors change their electrical properties when VOCs interact with the sensor surface. Quantifying these changes enables the determination of VOC concentrations in the air. Another prevalent method is photoionization, where VOCs are ionized by UV light, generating ions that provide information about VOC levels. The data from the sensors can be fed into monitoring systems to get real-time information on air quality. This allows rapid responses which is crucial to avoid health problems from long-term exposure to too many VOCs.

The advent of energy-efficient and hermetically sealed building structures, mandated by contemporary standards, increases the probability of indoor pollutant accumulation, particularly Volatile Organic Compounds (VOCs). Utilizing VOC sensors as an advanced early-warning system empowers occupants and facility managers to proactively address concerns related to VOC-induced air quality. Also, VOC sensors form an integral part of the laws and regulations set

concerning indoor air quality. Several countries and institutions have developed threshold values for the inhalation of indoor pollutants like those of VOCs.

CHALLENGES

Challenges encountered by Volatile Organic Compound (VOC) sensors in the context of indoor air quality monitoring primarily revolve around sensitivity and selectivity. Sensor sensitivity denotes its capability to detect low concentrations of VOCs and distinguish between various types of volatile organic compounds. Striking a delicate balance between sensitivity and selectivity is essential for accurate and reliable measurements. The issue of sensor cross-sensitivity, coupled with non-target gases, introduces the possibility of erroneous readings, data confusion, and challenges in identifying the sources of indoor air pollution. Enhanced selectivity in sensor development becomes imperative to mitigate cross-sensitivity effects and achieve a high level of measurement accuracy.

Another challenge lies in managing the diversity of VOCs, given their broad spectrum of chemical substances with varying reactivity. Some VOCs exhibit high reactivity, potentially undergoing conversion and influencing sensor responses. The varying sensitivity of sensors to different VOCs poses challenges in providing a uniform and comprehensive assessment of indoor air quality. Despite technological advancements aiming to develop sensors capable of detecting a wide range of VOCs with sensitivity to low concentrations, challenges persist.

Additionally, environmental factors such as temperature and humidity can impact the performance of VOC sensors. Changes in these conditions may alter baseline measurements and response characteristics of the sensors, emphasizing the need for reliable and stable sensors to ensure precise and consistent readings in diverse environmental scenarios.

CONCLUSION

Monitoring air quality, particularly indoors, is essential for safeguarding human health against potential hazards. The presence of numerous Volatile Organic Compounds (VOCs) originating from various sources, including building materials and household products, underscores the necessity for robust air quality management. Historical incidents, such as health risks associated with formaldehyde contamination in mobile homes during the 1980s and Sick Building Syndrome in offices in the 1970s and 1980s, emphasize the importance of proactive air quality measures. The global issue of elevated VOCs in Chinese homes during rapid urbanization further highlights the widespread nature of the problem. Regular air quality monitoring utilizing VOC sensors facilitates source identification, implementation of mitigation strategies, and protection against associated health risks. In this monitoring process, sensors play a crucial role by providing real-time information on changes in VOC concentrations. The fundamental operation of these sensors involves sensing and analyzing VOCs in the air using mechanisms like metal oxide sensors and photoionization techniques. However, challenges related to sensitivity, selectivity, cross-sensitivity to non-target gases, diversity of VOCs, and environmental factors such as temperature and humidity need to be addressed. Continuous research aimed at improving sensor technology, selectivity, and stability under changing atmospheric conditions is essential to tackle these issues.

Despite the challenges, sensors remain critical due to their ability to offer comprehensive and continuous evaluations of pollution levels within indoor environments. Early detection of hazardous chemical compounds allows for prompt intervention, preventing or mitigating potential health issues. VOC monitoring sensors also contribute to regulatory compliance, enabling businesses to fulfill their ethical responsibility of providing clean indoor air spaces. Ongoing efforts to enhance sensitivity and selectivity in sensor development are paramount for ensuring high-level measurement accuracy across the diverse nature of VOCs.