

Enhancing Transportation Safety: Volatile Detection Sensors In Monitoring Vehicle Air Quality

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INTRODUCTION

Air quality monitoring in vehicles has emerged as a promising paradigm for monitoring drivers' conditions during driving. This is due to the presence of pollutants in vehicle cabins, which can cause drowsiness and fatigue in drivers. The World Health Organization (WHO) reports that approximately 1.35 million fatal accidents occur globally, of which 15% result from driver drowsiness and impaired cognition. The American Automobile Association (AAA) estimates that one in eight accident hospitalizations in the USA is due to driver drowsiness and fatigue. Restlessness, Chronic fatigue, and elevated CO₂ levels in vehicles are the reason for Drowsiness. Some studies reveal that various pollutants such as carbon monoxide (CO), carbon dioxide (CO₂), nitrogen dioxide (NO₂), and volatile organic compounds (VOC) within vehicle cabins, can impact various health issues. So it is critical to monitor in-vehicle air pollutants and assess drivers' conditions during driving.

In recent years, the incorporation of advanced technologies into vehicles has become a central focus for enhancing the overall safety and user experience. An important factor gaining prominence related to the area is the air quality inside the vehicle cabin. Volatile detection sensors are becoming a game-changer in this domain. They are designed to monitor and identify

various gases and vapors within the transportation environment, contributing to enhancing air quality, especially in public transportation systems like buses and trains. Additionally, these sensors play a crucial role in detecting fuel vapors in automotive applications, thereby reinforcing the safety measures in vehicles. However, designing an effective system capable of predicting in-vehicle air quality faces challenges, primarily stemming from the constant variations in parameters in cabin environments.

The Need for Air Quality Monitoring in Vehicles

A study in the IEEE journal reports that approximately seven million annual deaths are claimed due to air pollution. The air quality inside vehicles can be worse than outside, with continuous recirculation of external air. Volatile detection sensors, commonly used in public transport like buses and trains, monitor a variety of harmful compounds. Integrating these sensors in vehicles helps address this issue by providing real-time feedback on cabin air composition.

Benefits of Volatile Detection Sensors in Transportation

The use of VOC sensors in transportation has several benefits includes,

- To ensure the safety of passengers and drivers by detecting harmful gases within vehicles through real-time monitoring, thus we can prevent or reduce the inhalation of toxic gases.
- To improve the air quality in public transport systems where large numbers of people are transported every day.
- To reduce the emission of harmful gases into the environment by detecting leaks in fuel systems, engine malfunctioning, and other vehicle parts.

Integration into Vehicles

VOC sensors can be integrated into vehicles in several ways.

Smart HVAC Systems: Volatile detection sensors can be seamlessly integrated into the vehicle's heating, ventilation, and air conditioning (HVAC) systems to ensure user safety. Automatic adjustments are made based on real-time air quality data, ensuring a consistently pleasant and safe driving experience.

Alert Systems: VOC sensors trigger alerts and notifications when there is a rise in pollutants, allowing passengers and drivers to respond to potential hazards for enhanced safety.

Detecting Fuel Vapors in Automotive Applications

Fuel System Integrity: Volatile detection sensors have a significant role in detecting fuel vapor leaks caused by fuel system issues. They monitor system integrity, ensuring compliance with emission regulations and preventing fire hazards. VOC sensors help to reduce the emission of harmful gases into the environment by detecting leaks in the fuel system and other parts of the vehicle

Emission Compliance: Automotive manufacturers are increasingly integrating these sensors to adhere to emission standards. Accurate detection of fuel vapors helps vehicles meet rigorous environmental regulations

Currently using VOC Sensors in Transportation

Various VOC sensors are used in transportation systems, among which metal oxide semiconductor (MOS) sensor is one prevalent type. MOS is renowned for its high sensitivity and the ability to detect a wide range of VOCs. The cost-effectiveness and user-friendly option, make

MOS well-suited in the transportation sector. The Photoionization detector (PID) is another commonly employed VOC sensor in the transportation sector. These sensors utilize ultraviolet light to ionize VOCs and generate a measurable electric current. PID sensors exhibit exceptional sensitivity, capable of detecting VOCs even at minimal concentrations. In addition to MOS and PID sensors, transportation also relies on some other types of VOC detection sensors such as catalytic bead sensors, flame ionization detectors, and infrared sensors.

The utilization of VOC sensors in transportation is not limited to monitoring the air quality within vehicles. They are also applicable in overseeing the air quality in transportation hubs, such as airports and railway stations. Moreover, they are employed to monitor air quality in shipping containers and various cargo transport systems. This broad range of applications highlights the versatility and importance of volatile detection sensors in maintaining air quality and ensuring safety across various facets of the transportation sector.

Challenges and Future Developments

Sensor Sensitivity: One of the major challenges in VOC sensors is the sensitivity. Achieving the right balance in sensor sensitivity for accurate detection and differentiation between various volatile compounds is essential for detecting low concentrations of VOCs in the air.

Miniaturization: Various studies are ongoing to downsize the sensors to integrate into vehicles, to avoid space constraints.

Future aspects include the development of more sensitive, selective, smaller, and more energy-efficient sensors that can detect a wider range of VOCs. These advancements in features will help to detect volatiles in transportation more accurately and reliably.

CONCLUSION

Integration of VOC detection sensors in vehicles ensures environmental safety and human health by addressing air quality concerns and detecting fuel vapors in automotive applications. Several types of VOC sensors are used in transportation, including MOS sensors, PID sensors, and catalytic bead sensors. These sensors are also used to monitor the air quality in transportation hubs and cargo transport systems. The challenges in the application of volatile detection sensors in transportation include sensor sensitivity and miniaturization. With the development of more sensitive and selective sensors, the accuracy and reliability of volatile detection sensors in transportation will also be enhanced. These technological developments contribute to a healthier, safer, and more sustainable future for transportation.