Indoor Air Quality and Volatile Organic Compounds

Experts in Environmental Sensing

SENSIRION

Summary

Awareness of the importance of good air quality in our living and working environments is becoming increasingly important to individuals and governments. People spend 90 % of their time indoors where VOCs account for one of the main contributors to bad air quality. Sensirion's VOC measurement concept has been established as a practical time and cost-effective method of surveying indoor environments for contamination. Sensirion's SGP40 VOC sensor enables measurement of VOC events and thus helps to increase the efficiency of ventilation and air purification, and increases awareness of VOC sources and indoor air pollution.

What are VOCs?

VOCs are one of the main contributors to bad air quality. Modern building materials and methods result in better insulation, and thus improved energy efficiency, but on the other hand they limit the air exchange with the outside world and hence lead to higher VOC concentrations indoors. Exposure to high and/or hazardous levels of VOCs can be avoided by appropriate ventilation or by identifying and eliminating the pollution source. Nowadays, most people spend more than 20 hours per day indoors where VOC concentrations are more than five times higher than outdoor concentrations[1].

VOCs originate from a number of different possible sources, like building materials, tobacco smoke, people and their activities, and indoor chemical reactions. Exceptionally high VOC levels are typically found in new buildings or after renovation. Further, when using products that contain VOCs, such as air fresheners or cleaning agents, people expose themselves and others to high pollutant levels that can persist long after the activity has finished. VOCs include a wide range of chemical compounds, the most common of which are listed in **Table 1** below.

Typical VOC Sources	Compound Class	Example Compounds
Cleaning agents	Aliphatic hydrocarbons, organochlorides	Tetrachloroethylene
Solvents	Aliphatic and aromatic hydrocarbons	Heptane, decane, toluene, xylene
Cosmetics	Terpenes, ketones	Eucalyptol, limonene
Consumer products	Terpenes, aromatic hydrocarbons	Limonene, α-Pinene, toluene
Carpets and flooring	Esters, aliphatic and aromatic hydrocarbons	Butylacetate, heptane
Paints	Alcohols, aldehydes	Isobutanol
Human occupants		Acetone, methanol, ethanol

Table 1 *Typical indoor VOCs and their sources*[2]

[1] *EPA – the total exposure assessment methology (TEAM) study (1987), Saarela et al., Atmosph. Environ. 37, 5563 (2003)*
[2] *See e.g. Kataoka et al. – Chap. 9 in Mass Spectrometry, Advanced Gas Chromatography – Progress in Agricultural, Biomedical and Industrial Applications (2012)*

Potential Health Effects of High VOC Concentrations

SENSORY IRRITATION

A number of systematic human exposure studies have shown various adverse health effects caused by exposure to elevated VOC levels[3]. Among the effects reported by participants are dryness and irritation of the eye, the nose and the throat, headaches, and dizziness.

COGNITIVE ABILITIES

Poor indoor air quality can lead to decreased cognitive function resulting in significant impacts on productivity, learning, and safety. Recent studies have demonstrated clear negative effects of elevated VOC levels on cognitive abilities such as strategic thinking and decision making[4].

SICK BUILDING SYNDROME

The sick building syndrome[5] includes a variety of health and comfort effects associated with the time spent in buildings with, among other factors, elevated VOC levels. Symptoms of the sick building syndrome include headaches, mucous membrane irritation, asthma-like symptoms, skin irritation and dryness.

Steps to Reduce VOC Levels

VENTILATION

Regular ventilation is an effective way to reduce exposure to VOCs. This can be done either by an automatic demand-controlled ventilation system equipped with suitable sensors, or by natural ventilation through open windows and doors.

SOURCE CONTROL

Most national governmental bodies provide guidelines and recommendations on avoiding and removing VOC sources in indoor environments[6].

AIR PURIFICATION

Air cleaning devices equipped with suitable filters are an effective way to reduce the concentration of VOCs in indoor air, in particular in locations where ventilation with outside air is not appropriate.

[3] *Molhave, Indoor Air 4, 357 (1991), Kjaergaard et al. Atmosph. Environ. 25a, 14 17- 1426 (1991), Otto et al, Neurotoxicol. Teratol., 12, 649 (1990)*
[4] *Allen et al., Environ. Health Perspect. 124, 805 (2016)*
[5] *Godish, T.: Sick Buildings – Definition, Diagnosis and Mitigation, Boca Raton: Lewis Publishers (1995)*
[6] *See e.g., https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality*

The Benefits of Measuring VOCs

An effective reduction of VOC exposure requires monitoring of the evolution of VOC levels using suitable sensors. A large number of applications such as ventilation controls, air purifiers, or Internet-of-Things devices benefit from the integration of VOC sensors.

CREATE AWARENESS

Indication of the indoor VOC levels helps people to better understand their living environment and to identify possible sources of indoor air pollutants.

MAKE DEVICES SMARTER

Enable the operation of autonomous devices; for example, automatic operation of an air purifier.

MAKE DEVICES ENERGY EFFICIENT

Save energy by operating ventilation and air purification devices only when needed; for example, demand-controlled ventilation.

Sensirion's VOC Measurement

Sensirion's powerful VOC Algorithm analyzes VOC events detected by the SGP40 sensor and maps them to a VOC Index. This VOC Index provides a practical quantification of VOC events relative to each individual sensor's average indoor environment. In this way, it behaves similarly to the human nose, which is highly susceptible to changes in odor, but it also detects VOC events that are not perceived by humans. The VOC Index indicates to what extent the indoor air quality has deteriorated (VOC Index > 100) or improved (VOC Index < 100) compared to the sensor's average VOC environment of the past 24 h.

This information can be used, e.g., for gradually controlling the fan of an air treatment device or to provide users with feedback on their daily activity profile.

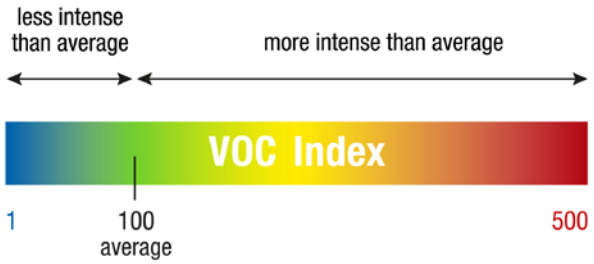
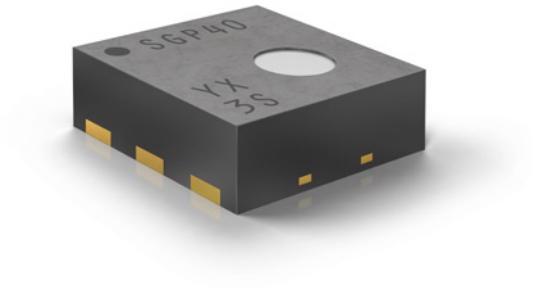


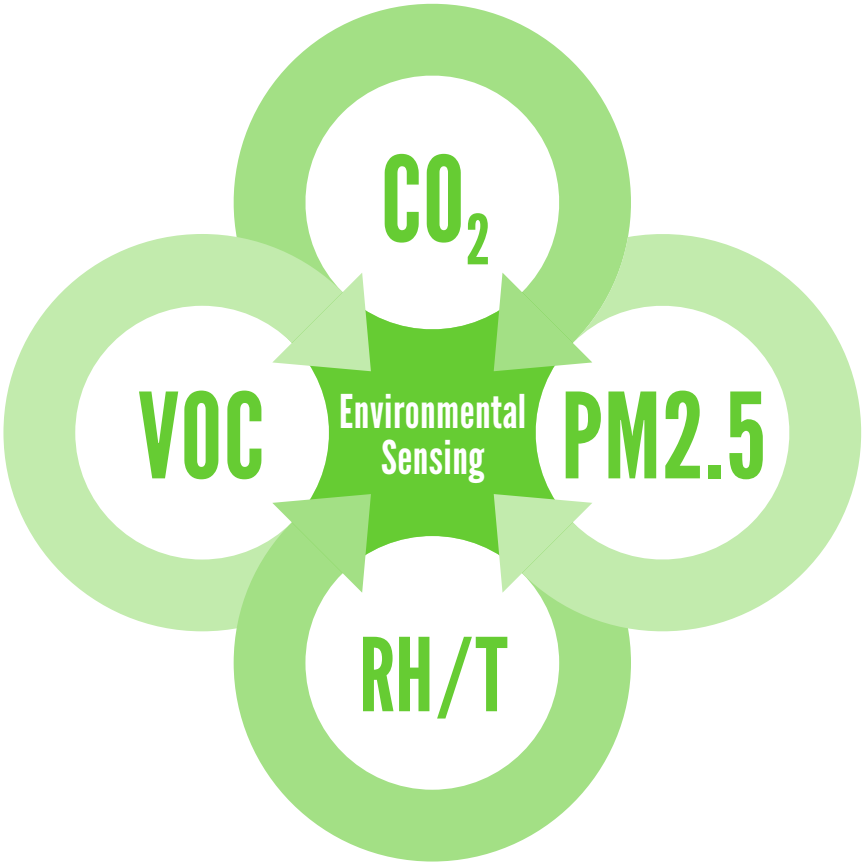
Figure 1 *The indoor air quality can be monitored thanks to the VOC Index output of the SGP40 sensor.*

Sensirion's Environmental Sensor Solutions

With the SGP40, Sensirion provides a metal-oxide based VOC sensor for indoor air quality applications. The sensing element features an unmatched robustness against contaminating gases present in real-world applications. This enables a unique long-term stability and low drift. The SGP40 features a VOC Index signal via an I2C interface, a small DFN package (2.44 × 2.44 × 0.85 mm^3), and a dust and water protection membrane. Furthermore, the SGP40 has a low-power consumption of 2.6 mA at 3.3 V. These characteristics make the SGP40 easy to integrate into a large variety of applications such as air purifiers or smart home devices.



Sensirion's sensor solutions provide detailed and reliable data on further key environmental parameters such as humidity, temperature, particulate matter (PM2.5), and CO_2. Sensirion's portfolio of environmental sensors opens up numerous possibilities to create smarter devices that improve our comfort and well being, and increase energy efficiency in various applications.



1-900061-01 / 2009-VOC-EN