Miniaturization and performance's improvement of a formaldehyde sensor for indoor air quality monitoring

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1. SUMMARY:

Formaldehyde is the reference's indoor air pollutant for 2 main reasons : it is an ubiquitous solvent evaporated from building materials, paints, glue and home's furniture's, it is also widely used in candles, perfumes, and, of course… cigarettes. But it is also a Class 1B carcinogenic compound that affects human health at very low concentration (i.e part per billions – ppb – or micrograms per cubic meters). Unfortunately, this compound is not that obvious to specifically detect and quantify in the air. This article describes a technology using a Solgel nanoporous material that specifically detects formaldehyde, and how it is currently optimized to improve its performances (sensibility, signal/noise ratio), its life duration, and its sensibility to humidity, interfering the signal.

2. MOTIVATION :

A portable formaldehyde measuring device was developed by a spinoff of an CNRS/CEA academic lab, and provides a specific quantification of HCHO in the air, with a 7ppb Low Level Of Quantification, with a ppb resolution and a 20% accuracy. The technology is using a colour changing nanoporous material that is a silicate-based matrix, incorporated by reagents, chosen for their chemical affinity with the targeted air pollutant, and their ability to create by-products that have an absorption at 420nm. The reaction's kinetic is depending on the pollutant concentration in the ambient air, and measured by the color changing measurement through an optical sensor.

After several years of use, this technology has been proofed in field conditions, and became famous in several countries, especially due to its ability to perform continuous measurement. But the development team wanted to improve it through 2 main axes : reduce the influence of relative humidity, that affects the signal, and allow a broader use of the single-use nanoporous material, that is progressively loosing its performances (accuracy) after 7 days.

Colour changing is detected by opacimetry measurement and, after 7 days of use, the signal/noise becomes progressively degraded, as the material becomes opaque. Thus, we tried reflectometry measurement with several light sources and light sensors, in order to get a colour change signal. In the same time, a miniaturization of the sensor was conducted and will contribute to reduce its manufacturing cost. In addition to these development axes, to answer specific market needs, the team has been focusing on adapting its new sensor to active sample, allowing a shorter result delivery, very useful for specific test conditions, such as new building inspections.

3. RESULTS :

The preliminary results are very encouraging : Upon specific light, sensor and their respective angles configuration, humidity interference can be reduced, signal/noise improvement is more than 10 times better, and this performance seems reproducible during at least 2 weeks (longer characterization test to be performed). Miniaturization is another really achieved target, as the casing of the sensible sensor can include all the embedded electronic within a very limited space. Moreover, excellent repeatability is observed, announcing a potential HCHO high performance sensor, keeping it portability and (relative) low-cost.

Acknowledgement:

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References: (CNRS licenced or own patents)

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FR 2915805 (2008-11-07) : Process for detecting gaseous halogenated compounds
FR 2933703 (2010-01-15) : Nanoporous detectors of Monocyclic aromatic compounds
FR 2952436 (2011-05-13 : Material and method for trapping, detecting and quantifying heterocyclic aromatic compounds
FR 2969295 (2012-12-14) : Multifunctional detector for gaseous compounds
FR 2869036 (2005-10-21) : Porous hybrid organic-inorganic materials for the detection of halogens
FR 3050270 (2017-10-20) : Control system for air quality in indoor environment

FIGURES :

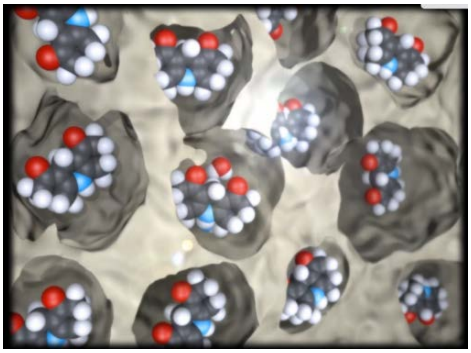

Fig1 : Silicate based nanoporous material obtain from solgel process

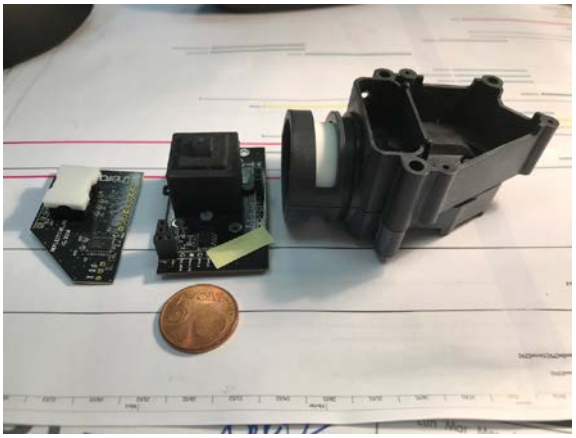

Fig2 : Miniaturization of the HCHO sensor