TECHNICAL NOTE

No. FL53370

Gas-phase FTIR for smoke toxicity measurements

Relevant Standards: EN 45545-2, EN 17084, EN 5659-2, ISO 19702

The field of Fire Science determines safety standards and sets design criteria for materials in the event of fire. Fire Science researchers analyze materials for their mechanical and chemical properties under tightly defined conditions, using dedicated Smoke Chambers or Cone Calorimeters to control the combustion parameters.

One aspect of Fire Science is Smoke Toxicity, where materials are burned to determine how dangerous their gaseous emissions are. Traditionally carbon monoxide (CO) emissions were used as the key marker of smoke toxicity, but additional gases are now also monitored for their toxicity. FTIR spectroscopy provides an ideal on-line technique to analyze gases of interest in combustion research.

New **European railway/transportation regulations now require testing by FTIR** for a variety of toxic/caustic gases, particularly dangerous acids such as HCl, HBr, HCN, and HF (See Table 1 – components list, and Figure 1 – Thermo Scientific™ OMNIC™ spectra). Thermo Fisher Scientific offers a total FTIR solution to meet the EN 45545-2 Smoke Toxicity certification requirements.

Smoke Toxicity Gases	
Compound	**Symbol**
Carbon Dioxide	CO_2
Carbon Monoxide	CO
Hydrogen Fluoride	HF
Hydrogen Chloride	HCl
Hydrogen Bromide	HBr
Hydrogen Cyanid	HCN
Sulfur Dioxide	SO_2
Nitrogen Oxide	NO
Nitrogen Dioxide	NO_2
Hydrocarbons	$C^1 – C^4$
Formaldehyde	CH_2O
Acrolein	C_3H_4O

Table 1 – Smoke toxicity gases

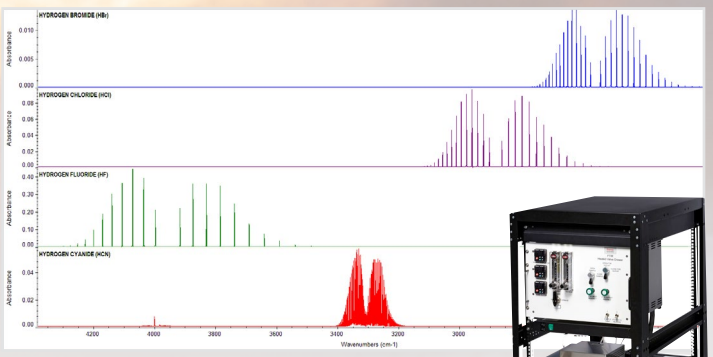

Figure 1: OMNIC spectra

The Thermo Scientific™ Antaris™ IGS system, configured with a rack-mounted Heated Valve Drawer (HVD), provides a turnkey data acquisition and analysis package (Figure 2). Key features include:

Figure 2: IGS with HVD/rack

- High sensitivity sampling of many compounds in a single measurement
- Certified Fire Science analysis method, validated to primary calibration standards
- Direct on-line sampling for real-time analysis on a second by second basis
- Ability to re-analyze stored data and/or add additional components for customized tests

The Antaris IGS/HVD system controls a constant flow of the gas sample from the smoke chamber through the FTIR gas cell. A probe is inserted into the sample “chimney,” where the smoke samples are pulled through a heated soot filter and sample transfer line using a diaphragm pump. The gas is maintained at constant temperature and pressure through the heated gas cell to eliminate sampling error and is sampled on a second-by-second basis by the FTIR.

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Another key application for FTIR Fire Science measurements is the analysis of lithium ion batteries (LiB) to monitor off-gassing or chemicals released during a fire, electrical short circuit, or other hazardous conditions. These batteries generally use a lithium-fluoride salt (LiPF6 or similar) as the electrolyte to carry charge between the electrodes. These electrolytes support very high electrical charge density but can release toxic HF and other fluorinated compounds under overtaxed conditions, such as mechanical puncture in an automobile crash.

Figure 3 shows FTIR analysis of HF gas released from burning batteries under different charge states, as compared to the heat release rate (HRR) measurement. FTIR enables LiB researchers to understand key parameters in HF generation, which enables development of safer battery technologies.

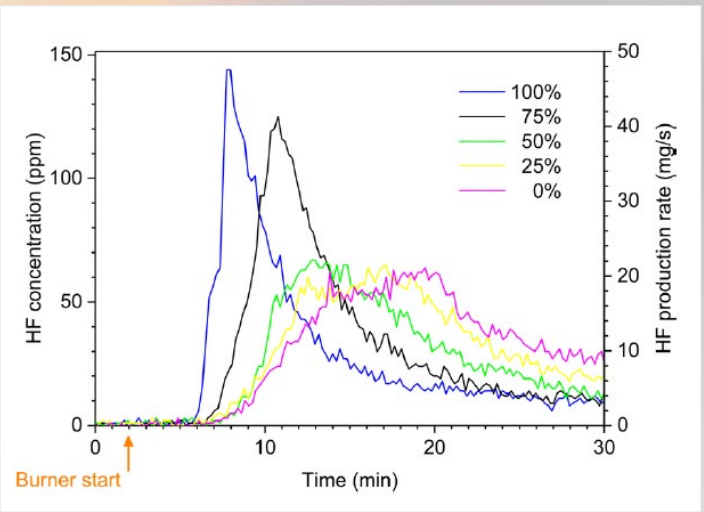

Figure 3: HF gas release from Lithium Ion Battery combustion under different charge conditions. Reference: Larsson, F., Andersson, P., **Blomqvist, P. *et al*. Toxic fluoride gas emissions from lithium-ion battery fires. *Sci Rep* 7, 10018 (2017). https://doi.org/10.1038/s41598-017-09784-z**

Summary

The Antaris IGS/HVD system is uniquely suited for analysis of toxic emissions from combustion of many materials. This system is used to meet new European regulations which specify FTIR analysis to certify material properties before they can be released onto the market. The example of HF measurement from burning lithium ion batteries shows the utility of FTIR for Fire Science safety testing.

Find out more at **thermofisher.com/igs**

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