Technical Note of the
SF_6-IR-Leak and SF_6-IR-Monitor

Theory and Operation of NDIR Sensors

Both devices uses a dual wavelength NDIR (non dispersive infrared absorbance) sensor to monitor SF_6. Most molecules can absorb infrared light, causing them to bend, stretch or twist. The amount of IR light absorbed is proportional to the concentration. The energy of the photons is not enough to cause ionization, and thus the detection principle is very different from that of a photoionization detector (PID). Ultimately, the energy is converted to kinetic energy, causing the molecules to speed up and thus heat the gas. Each molecule absorbs infrared light at wavelengths representative of the types of bonds present.

For example, SF_6 has a strong absorbance at 10.7 µm (947 cm^{-1}, Figure 1), and C-H bonds absorb in the range 3.3-3.5 µm depending on the structure of the rest of the molecule, and H_20 absorb in the range 5-8 µm and below 3 µm. The SF_6 absorbance band is unique and therefore highly selective. By contrast, many compounds have similar CH bonds, and this absorbance is suitable to detect a range of hydrocarbons non-selectively. Comparing Figures 1 and 2, one can see that there is no interference by water absorbance in the SF_6 measurement, because water has no absorbance at 10.7 µm (947 cm^{-1}).

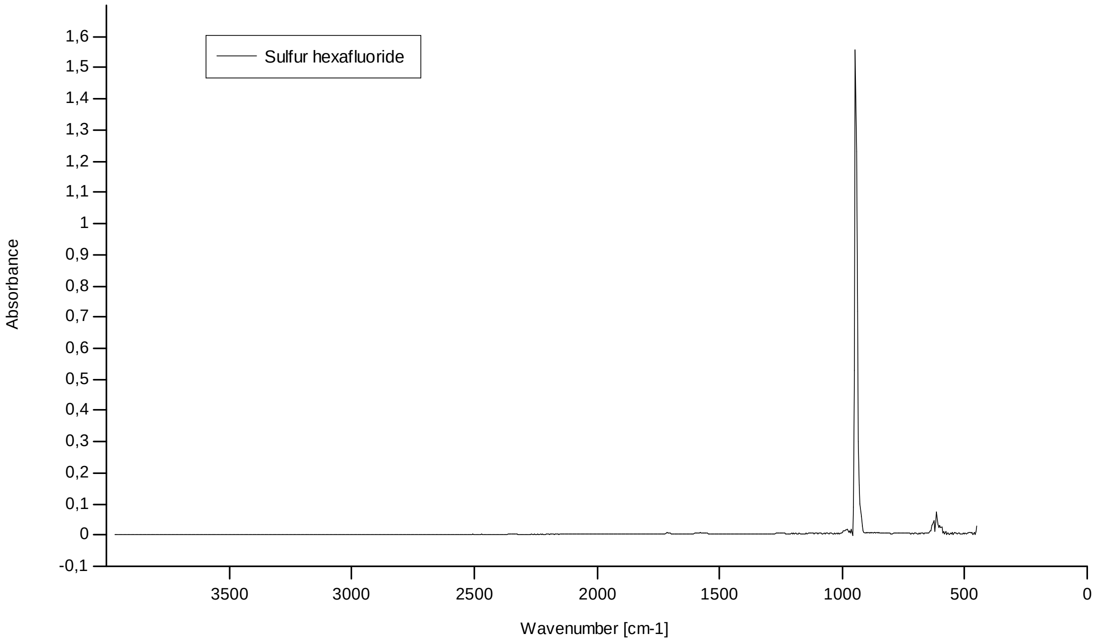

Figure 1. IR spectrum of SF_6

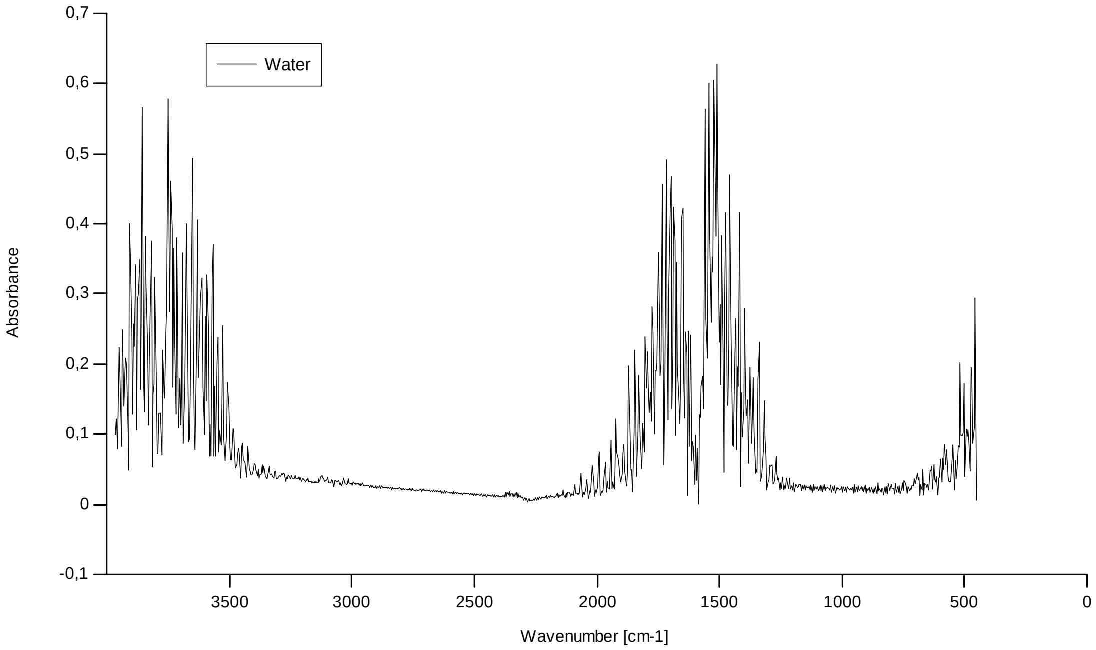

Figure 2. IR spectrum of water (gas)

The absorbance of the gas is directly proportional to its concentration, in accordance with the Lambert-Beer law:

$$A = \varepsilon \ell c$$

$$I = I_0 \ell 10^{-A} = I_0 10^{-\varepsilon \ell c}$$

Where I_0 is the initial light intensity emitted from the lamp (measured in pure air), I is the intensity of light reaching the end the detector (with sample gas present), A is the absorbance in units of length^{-1}, ε is the molar extinction coefficient in concentration^{-1} length^{-1}, ℓ is the pathlength (sensor cavity depth, and c is the concentration. Because ℓ and ε are fixed, measuring the light intensity before and after the sample allows a measurement of the concentration.

Non-Dispersive vs Dispersive IR Sensors

The term non-dispersive refers to the fact that all the light passes through the gas sample and is only filtered immediately before the detector. The filter in front of the detector removes all the light except that at 10.7 µm, corresponding to SF_6. By varying the light filters, it is possible to select for different classes of compounds. Typically, a 3.4 µm filter is used to select for hydrocarbons.

Dispersive IR detectors use a grating or prism to pre-select the desired wavelength of light and pass only this through the gas sample to the detector. Dispersive IR detectors are usually used in benchtop analytic instruments for their ability to scan a broad wavelength range. However, they tend to be larger, heavier, more complicated, and more costly, and therefore are less suitable for portable instruments.

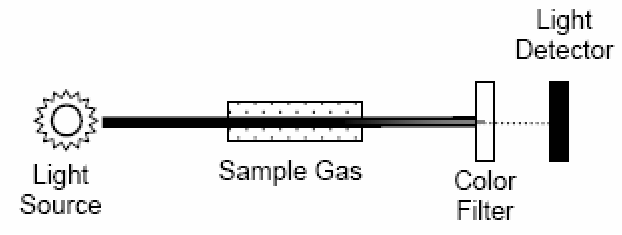

Figure 3. Non-Dispersive IR – All light goes through sample.

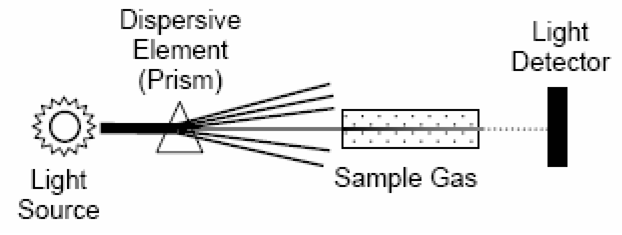

Figure 4. Dispersive IR – Only selected wavelength light goes through sample.

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G.A.S. Gesellschaft für analytische Sensorsysteme mbH

Dr. Roland Kurte
- Head of Analytical Chemistry Department -