The Application of Infrared Spectroscopy in the Determination of Free Silicon Dioxide Content in Air

Abstract:

The content of free silicon dioxide is a crucial component in the determination of dust pollutants in the air. In this study, the standard curve method was employed to measure the silicon dioxide content, demonstrating a simple procedure and achieving satisfactory recovery rates.

In industries such as coal mining, gold mining, ceramic processing, refractory materials, and workplaces surrounding thermal power plants, the air often contains a considerable amount of free silicon dioxide. Prolonged exposure to such air can damage the respiratory system and may lead to serious conditions such as silicosis. Therefore, controlling and monitoring the content of free silicon dioxide in the air becomes particularly important.

The main component of free silicon dioxide in the air is α-quartz. In this study, the standard curve method was chosen for the measurement of silicon dioxide content in samples, offering a straightforward operation and accurate results.

Keywords:

Infrared Spectroscopy, Quantitative Detection, Free Silicon Dioxide

Principle:

The primary component of free silicon dioxide in the air is α-quartz. A standard curve can be established using standard α-quartz, and then the absorbance values obtained from the sample measurements are substituted into the curve to determine the content of free silicon dioxide in the sample.

Experimental Conditions：

Instruments and Accessories:

- FTIR-7600 Fourier Transform Infrared Spectrometer
- Pellet Molds
- Pellet Press
- Agate Mortar and Pestle
- Infrared Drying Oven

Chemicals:

- Standard α-Quartz (Purity: 99%)
- Potassium Bromide (KBr) - Spectroscopic Grade

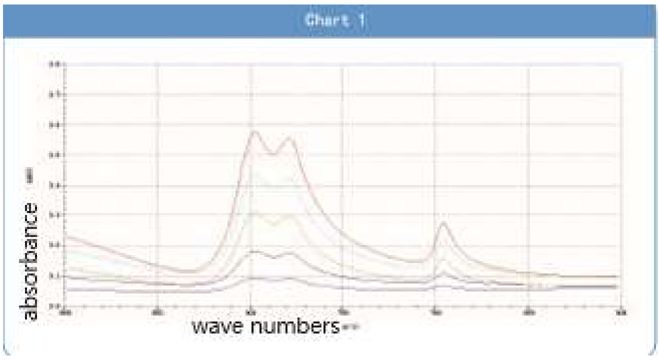
Sample Collection: Depending on the testing objectives, the locations and times of sample collection vary. When the dust collected on the filter membrane exceeds 0.1 mg, it can be directly used for the method to determine the content of free silicon dioxide.

Sample Pretreatment: Accurately weigh the mass (G) of the dust on the filter membrane. Then, fold the dust-covered side inward three times, place it in a porcelain crucible, and ash it in a low-temperature muffle furnace or resistance furnace (below 600 ℃). After cooling, transfer it to a desiccator for later use. Weigh 250 mg of a mixture of potassium bromide and ashed dust samples into an agate mortar. Grind the mixture thoroughly, then, along with the pellet molds, place it in a drying oven (110±5℃) for 10 minutes. Place the dried mixture in the pellet molds, apply a pressure of 15-20 MPa, and continue for about 1 minute. The resulting pellet is prepared as the sample. Take a blank filter membrane, treat it in the same manner as described above to serve as a blank control sample.

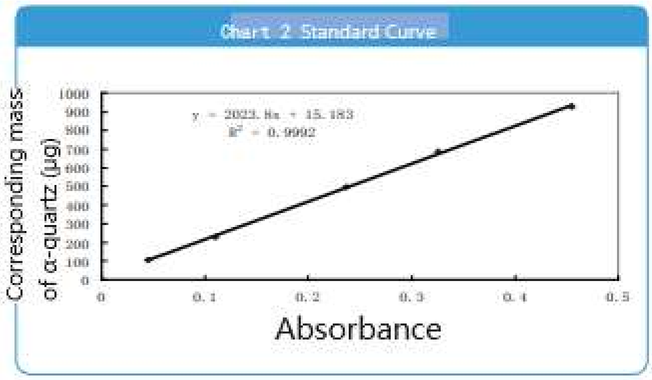
Establishment of the Standard Curve: Accurately weigh 10.0 mg, 20.0 mg, 50.0 mg, 70.0 mg, and 90.0 mg of a large sample (a mixture of standard α-quartz and potassium bromide, with a standard α-quartz content of 10 μg/mg) (see Table 1, chart 1). Add potassium bromide powder in amounts of 240.0 mg, 230.0 mg, ..., 160.0 mg, respectively. Subsequently, mix each sample thoroughly in an agate mortar and transfer all of it to the pellet molds. Press the pellets using a pellet press. Scan the resulting pellets, obtained with air as a background, and record the infrared spectra in the range of 900 to 600 cm^{-1}.

Table 1

	Weigh the mass of the large sample (g)	Corresponding mass of standard α-quartz (μg)	Absorbance value at 798 cm^{-1}
1	0.0106	106	0.0447
2	0.0228	228	0.1092
3	0.0499	499	0.2367
4	0.0687	687	0.3257
5	0.0927	927	0.4553



Using the baseline of 827 to 628 cm^{-1}, record the absorbance (A) of the standard curve at 800 cm^{-1}. Create a standard curve with the relative mass of standard α-quartz on the vertical axis and the corresponding absorbance (A) values on the horizontal axis, using 827 to 628 cm^{-1} as the baseline. Determine the equation of the curve and the coefficient of determination (R2) (see chart 1).



Accurately weigh the mass of the large sample (precisely to 0.001g), add potassium bromide powder to achieve a total weight of 250mg, and then transfer the entire mixture to the pellet molds for pellet pressing. Scan the resulting pellets with air as the background, and record the infrared spectra in the range of 900 to 600 cm^{-1}. Substitute the absorbance values around 800 cm^{-1} into the equation of the standard curve to calculate the recovery rate (see Table 2).

Table 2

ID	Weighing the mass of the large sample (g)	Corresponding mass of standard α-quartz (μg)	Absorbance value at 798 cm^{-1}	Mass obtained from the equation of the standard curve	recovery rate (%)
1	0.0207	207	0.098	0.2135	103.1
2	0.0304	304	0.1438	0.3064	100.7
3	0.0402	402	0.2036	0.4228	105.2

Summary:

The "standard curve method" for determining the content of free silicon dioxide in the air is simple to operate, accurate, and the recovery rate verification shows ideal results. It is an ideal testing method for measuring free silicon dioxide in the air.