Analyse asbestos using DRIFT spectroscopy

DRIFT spectroscopy is fast, cheap and easy-to-use.

Introduction

ASBESTOS IS A GENERIC TERM for a group of naturally occurring complex crystalline silicate minerals with fibrous characteristics.

Large quantities of these asbestiform minerals have been produced commercially for their excellent physical properties as building and insulating materials.

The hazardous effects of asbestos fibre inhalation were first reported among English and French textile industry workers in the early 20th century [1]. Various forms of cancer attributed to asbestos are also well documented.

There are two basic groups: phyllo-silicates including chrysotile (white asbestos), which is the most abundant, and inosilicates including amosite and crocidolite (blue asbestos).

The most lethal is crocidolite, which has been banned in the UK since 1970. Most asbestos materials are made from chrysotile [2].

Numerous techniques, including infrared spectroscopy have been used to analyse and classify different forms of asbestos. This may be carried out using an infrared microscope or the KBr pellet method.

But alternatively, diffuse reflectance (DRIFT) measurements can be taken.

The latter has the advantage of low cost, speed, and minimal sample preparation which is crucial for hazardous samples such as asbestos fibres.

Experiment

Results were collected with the use of Specac's Selector Diffuse Reflectance Accessory, as shown in Fig. 1. This accessory is designed with an off-axis optical layout to selectively eliminate the specular component of the reflection.

The accessory requires minimal alignment between sample changes. Spectra were averaged over 30 scans averages and 4cm-1 resolution. The background spectrum was scanned using KBr powder as a reference. Asbestos fibres were compressed into the accessory's sample cup and a spectrum collected.

Results and Discussion

The basic building unit of inosilicates is $(Si_4O_{11})_n$, and of phyllo-silicates, $(Si_2O_5)_n$. The frequency correlation and vibrational assignment of these structures have been determined [3]. Approximate molecular formulae are shown in Table 1.

Characteristic absorption bands due to Si-O stretching and bending can be found at 1200-800cm^{-1} and O-Si-O scissoring below 650cm^{-1} [5,6].

The diffuse reflectance spectra (Fig. 2) of three asbestos forms, crocidolite, amosite, and chrysotile show distinct features which enable differentiation of the various forms.

These differences are due to the influence of the different cationic groups and the proximity of the hydroxyl groups in the crystal lattice causing shifts in bands and their intensities.

The weak absorption bands occurring between 1700 to 1400cm-1 are attributed to hydroxyl groups. The broad hydroxyl absorption at 605cm-1 in chrysotile is absent in both amosite and crocidolite.

Chrysotile may also be distinguished from the inosilicates by the absence of absorption bands between 950 to 750cm-1. Crocidolite may be distinguished from amosite by bands at 870, 690, and 580cm-1 and the absence of strong bands at 1000 and 460 cm-1.

Figure 1: Specac Selector Diffuse Reflectance Accessory

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"Analyse asbestos dust on filter paper without prior preparation."

Conclusion

The Diffuse Reflectance Infrared Fourier Transform (DRIFT) analysis and classification of asbestos fibres gives quick and reliable results without elaborate handling and preparation of the carcinogenic fibres.

The problems associated with the production of KBr pellets using non-isotopic samples are also eliminated. The DRIFT method is relatively inexpensive, and requires fewer specialised skills than microscopy techniques. The Specac Selector Diffuse Reflectance Accessory may also be used to analyse asbestos dust on filter paper without prior preparation due to its off-axis design.

References

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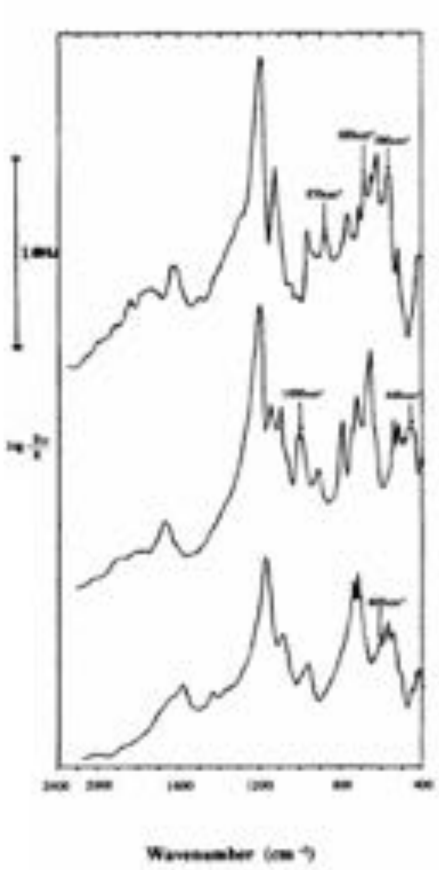

Figure 2: DRIFT Spectra of Crocidolite (top), Amosite (middle), Chrysotile (bottom)

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Asbestos	Formula
Chrysotile	$MG_3Si_2O_5(OH)_2$
Amosite	•$(Fe^{2+}/Mg)_7Si_8O_{22}(OH)_2$
Crocidolite	$Mg_2Fe_3^{2+}Fe_2^{3+}Si_8O_{22}(OH)_2$
*Variable Fe^{2+}/Mg ratio. The predominant element is placed first in the formula.	

Table 1: approximate molecular formulae of different asbestoses