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RESPIRABLE ASBESTOS DETECTION USING LIGHT SCATTERING AND MAGNETIC ALIGNMENT

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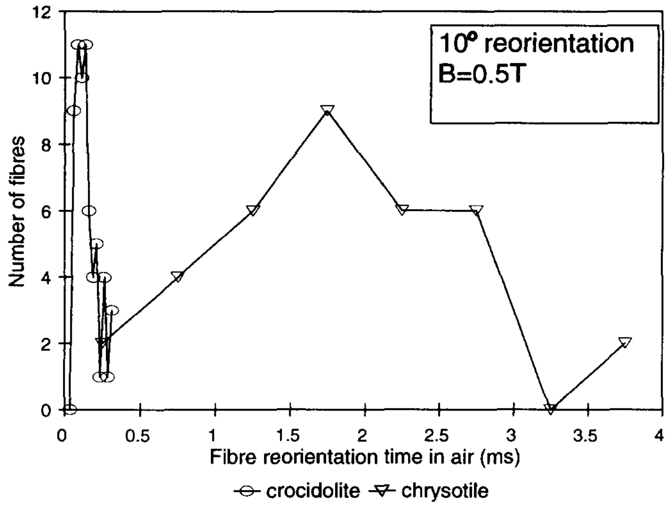
The detection of respirable asbestos fibres in the ambient environment has grown in importance as the health risks associated with this material have become more fully understood. However, there is no real-time method of identifying airborne asbestos in situ.

A light scattering instrument allowing the detection of respirable asbestos has been constructed. It captures data relating to the spatial distribution of light scattered by single particles in flow using a photodiode array containing two concentric, segmented detector rings. The data allows real-time categorization of airborne particles accordingly to their shape (Kaye *et al.* 1997). However, discrimination on the basis of morphology alone can lead to misclassification - most notably to false positive identification of asbestos. To overcome this problem, the system has been enhanced to take advantage of magnetic properties of asbestos, which are virtually unique among respirable fibres.

Magnetic alignment was first applied to studying asbestos by Timbrell (1975) who used magnetic fields for the alignment of samples of fibres in small quantities of liquids, followed by an examination under a microscope or using light scattering. However, the mechanism by which asbestos fibres undergo alignment has remained unclear. Neither have any successful attempts to use magnetic alignment as a basis for real-time characterization been reported.

Since quantitative data allowing the prediction of the dynamics of asbestos fibres in magnetic fields were also lacking, the torque on single fibres in magnetic fields was determined. A miniature rotary stage was constructed which allowed counteracting the forces on individual fibres due to a magnetic field with those due to viscous drag in an isopycnic immersion liquid. The fibres were observed, and their orientation angles measured, using an optical microscope. When reference samples of respirable UICC crocidolite and chrysotile fibres were examined, it was found that neither of these materials showed evidence of significant permanent magnetization. The alignment of the fibres in magnetic fields was consistent with the presence of anisotropy of magnetic susceptibility, with a smaller component due to shape anisotropy. The average anisotropy of volume susceptibility was $4.0 \cdot 10^{-7}$ and $8.3 \cdot 10^{-5}$ for chrysotile and crocidolite, respectively. To establish the usefulness of magnetic alignment for real time analysis, the dynamics of fibre alignment in air was modelled numerically on the basis of the measured anisotropy. Fibre reorientation times were found to be short enough to make their measurement in real time feasible. While there was some overlap between crocidolite and chrysotile, a good degree of discrimination between these materials might also be possible (see Figure).

The prototype instrument was then used to observe the reorientation of airborne crocidolite fibres in magnetic fields, with gypsum crystals as a negative control. Fibres flowing through the instrument were initially aligned parallel to the air flow due to the action of an aerodynamic focusing system. The orientation angle of individual fibres was then measured either after passing through a magnetic field or without the field by capturing the



spatial distribution of scattering using the detector array and processing the data to obtain the angle. It was found that only crocidolite fibres subjected to the magnetic field showed evidence of significant reorientation, with a magnitude close to that predicted from the measured anisotropy (see Table).

Orientation angle of asbestos fibres in air sheath flow without (B=0) and with (B=0.26T) a magnetic field

material	mean angle (degrees)		reorientation (degrees) measured	calculated	number of fibres (-)		st. dev. (degrees)	
B (T):	0	0.26	-	-	0	0.26	0	0.26
crocidolite	-1.1	7.8	8.8	10.5	1541	1606	43.5	46.3
gypsum	-1.6	0.07	1.7	0	9837	8900	46.0	47.0

In conclusion, light scattering used in conjunction with magnetic alignment can now be regarded as a strong candidate for use in real-time detection and characterization of airborne asbestos fibres. Amphibole asbestos fibres show especially strong reorientation effects, but detecting chrysotile and distinguishing it from the more hazardous asbestos types also appears technically attainable.

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REFERENCES

V. Timbrell (1975) Alignment of respirable asbestos fibres by magnetic fields, *Ann. Occup. Hygiene,* **18** 299-311.

P. H. Kaye, E. Hirst and Z. Wang-Thomas (1997) Neural-network-based spatial light-scattering instrument for hazardous airborne fiber detection, *Appl. Optics,* **36** 6149-6156 .