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A NEW METHOD FOR MONITORING ASBESTOS FIBER AEROSOLS BY MEASURING POLARIZATION OF SCATTERED LIGHT: PRINCIPLE

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I. INTRODUCTION

A new method for monitoring air-borne asbestos fibers is studied, which measures two components of linear polarization of scattered light from fibrous aerosol aligned by high electric field. Normally incident laser light to the fiber axis has two orthogonal components with equal amplitude, which are parallel and perpendicular to the plane orthogonal to the fiber axis.

As described below, through analysis using the scattering theory, we found that measurement of polarization of the scattered light at an angle of 170 degrees (near back-scattering) is effective to discriminate between an infinite cylinder like asbestos fiber and a spherical particle. We also examined a method for discriminating a serpentine asbestos fiber from an amphibole one. Analysis on a finite cylinder model confirmed the correctness of the results obtained from the infinite cylinder.

II. DISCRIMINATION BETWEEN AN INFINITE CYLINDER AND A SPHERE BY POLARIZATION OF THE SCATTERED LIGHT

Two orthogonal components of electric field of incident and scattered light are defined in Fig. 1. A scattering plane is orthogonal to a cylinder axis because of the normal incidence. Perpendicular and parallel components are referred to the scattered plane. If T_1 and T_2 are respective elements of scattering matrix for perpendicular and parallel components, polarization (P) is defined as $P=(|T_1|^2-|T_2|^2)/(|T_1|^2+|T_2|^2)$. Scattering matrix elements are computed by the scattering programs[1] for an infinite cylinder and for a sphere.

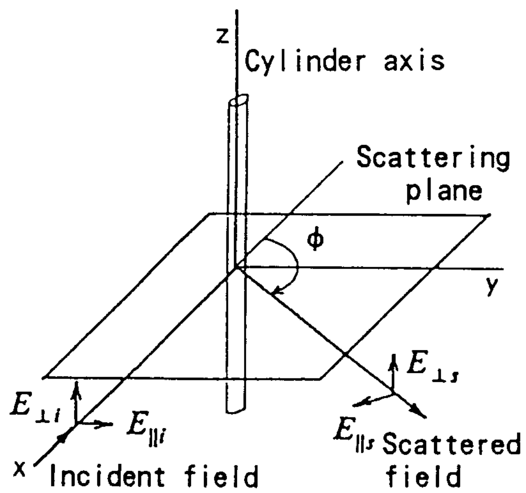

Fig.1 Definition of perpendicular and parallel components of incident and scattered electric fields.

Figure 2 displays the polarization at a scattering angle of 170 degrees as a function of a radius of the particles. Wavelength (λ) of light is 0.488μm, and refractive index (m) of the particle is 1.55 according to chrysotile asbestos. This shows the polarization of a cylinder is positive for particles with a radius smaller than 0.6 μm, whereas that of the sphere is negative for a radius smaller than 1.4 μm.

III. DISCRIMINATION BETWEEN A SERPENTINE ASBESTOS FIBER AND A AMPHIBOLE ONE BY LIGHT-SCATTERING WITH TWO WAVELENGTHS

Figure 3 shows the ratios of the parallel component at wavelength of 0.488 μm to the perpendicular one at 0.6328 μm of the light scattered by a serpentine asbestos fiber (m=1.55), and amphibole ones (m=1.68 and 1.70) as a function of a radius of the particle. This shows the ratio for the amphibole fibers is larger than that for the serpentine one in the case of a thin fiber.

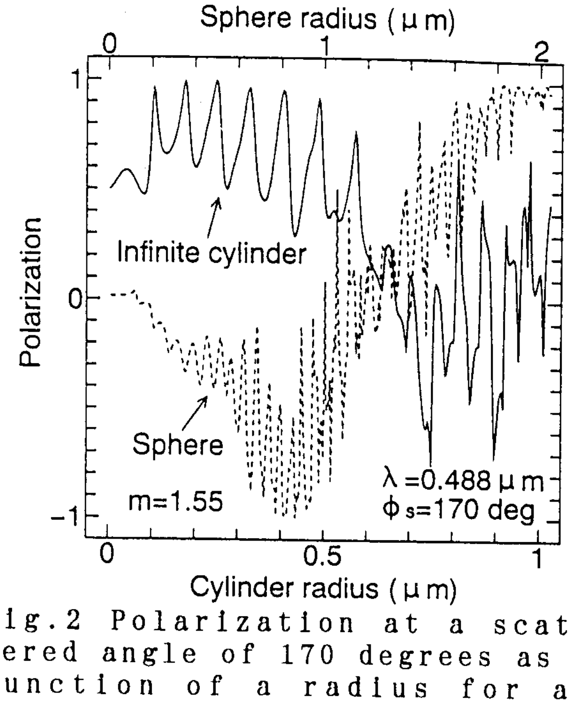

Fig.2 Polarization at a scattered angle of 170 degrees as a function of a radius for an infinite cylinder and a sphere.

IV. COMPARISON WITH THE SCATTERING BY A FINITE CYLINDER

Analysis with a finite cylinder model in which the inner field is estimated by the field for the infinite cylinder[2] shows the same polarization as that for the infinite cylinder. The angular width of the scattering in θs, inclination from the cylinder axis, around 90 degrees is smaller than 2.5 degrees if the cylinder length is larger than 10 times the wavelength of light. This angular width can be covered by a cone of solid angle of a measuring detector. The conclusions on the infinite cylinder above are correct for fibers with finite length.

REFERENCES

1)Bohren, C. F. and Huffman, D. R., "Absorption and Scattering of Light by Small Particles", (A Wiley-Intersci. Publi.) (1983).

2)Karam, M. A., Fung, A. K., and Antar, Y. M. M., IEEE Trans. Geosci. Remote Sensing, 26(6), 799-808 (1988).

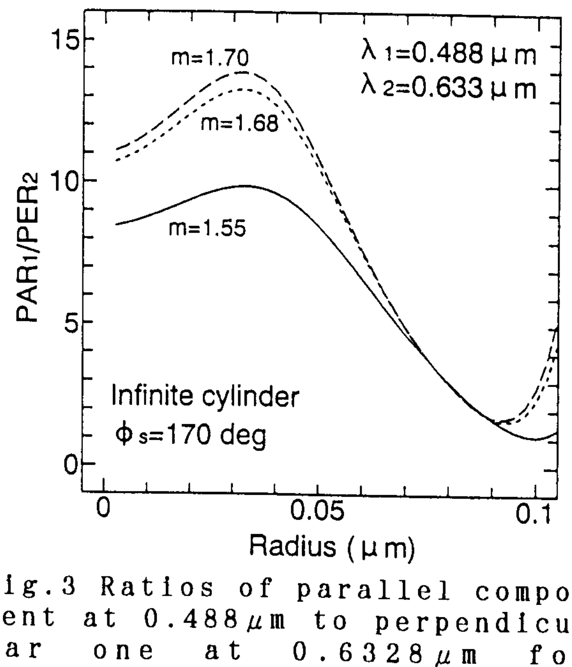

Fig.3 Ratios of parallel component at 0.488μm to perpendicular one at 0.6328μm for chrysotile (m=1.55), amosite (m=1.68), and crocidolite (m=1.70).