Determination Method of Asbestos in Electrical and Electronic Products by using a Scanning Electron Microscope with a X-Ray Diffraction

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Abstract: Asbestos is a proven carcinogen. It can able to exist in fibrous form, and be suspended in atmosphere and water for weeks or months, it constantly causing pollution on a large scale. Therefore, the technology of testing for asbestos in products is particularly important, receiving great attention. In this paper, the method of using a scanning electron microscope with a X-ray diffraction is used to identify the asbestos, and this method is simple, reliable and suitable to be widely applied.

1 INTRODUCTION

Asbestos is a proven carcinogen, able to exist in fibrous form, and be suspended in atmosphere and water for weeks or months, constantly causing pollution on a large scale. Long-term intake of asbestos fiber or fibril at a certain amount can lead to asbestosis, lung cancer, pleural endotheliomas, gastrointestinal cancer, etc (Shi H Y, Mao L, 2009; ISO 22262. 1: 2012). Therefore, testing for asbestos in products is particularly import for ensuring human health and living environment.

At present, conventional technologies of testing for asbestos mainly involve count-concentration, X-ray diffraction, microscopic, thermogravimetric, infrared spectrum, and neutron activation methods (Zhang M, Gao X L, et al, 2010; Zhenglong Chen, Hongwei Hu, Shizhong Hou, et al, 2013; Hossein Kakooei, et al, 2009). The components of asbestos are structurally complicated, and thus are very difficult to accurately identify by a single technology, while the methods that can serve arbitral purpose are over-dependant on expensive instruments, failing to be widely used (Hossein Kakooei, Masode Yunesian, Hossein Marioryad , Kamal Azam, 2009; Selikoff, I.J. et al, 1966) Therefore, in this article, multiple methods are used together to qualitatively identify asbestos. In this way, not only can instruments are applied in a highly universal manner, but results also accurate and reliable, and as a result, this way is suitable to be widely applied.

2 EXPERIMENT

2.1 Methods Overview

Scanning electron microscopes and X-ray diffractometers are used for qualitative analyses to determine whether asbestos is found in analytical specimens. If failure to find totally 300 asbestos fiber particles after three parallel measurements by scanning electron microscopes, it will be determined that no asbestos is found. If any asbestos is found, an energy spectrum analysis will be conducted. If the fibrous particle does not contain such elements as magnesium, silicon, and oxygen after an energy spectrum analysis, X-ray diffractometers will be used for testing. If peaks characteristic of asbestos diffraction are found after testing by X-ray diffractometers, it will be determined that asbestos is found. Otherwise, it will be determined that no asbestos is found (as shown in Figure1).

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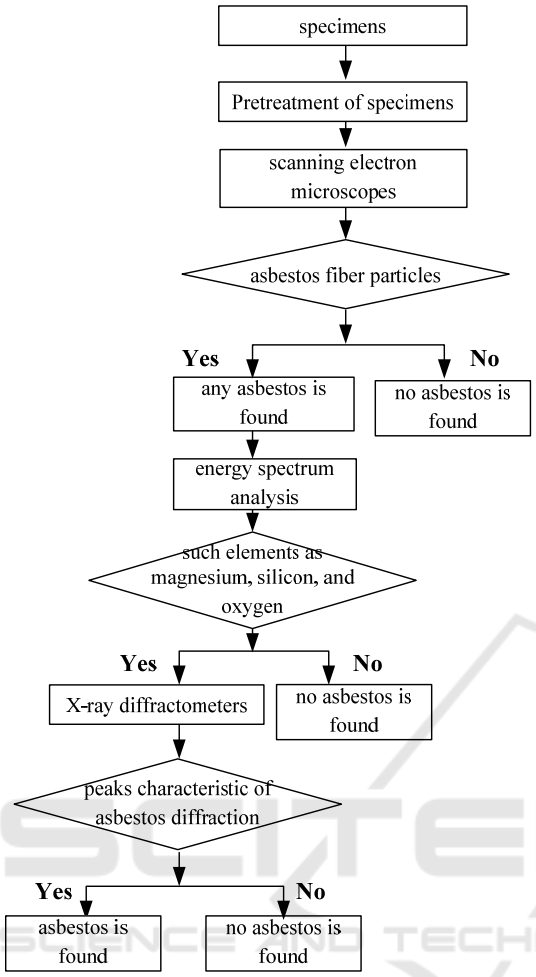


Figure 1. Determination procedures with scanning electron microscopes and X-ray diffractometers.

2.2 Pre-treatment of Specimens

Break up the specimen to appropriate size in an appropriate way. Take about 5 g of the broken pieces of the specimen, and put them into a crucible immediately before placing it in a furnace. Incinerate them for 1 h at 450°C±10°C, and remove organic substances. Take out the crucible, and put it into a dryer to cool until it reaches the room temperature. Grind up the incinerated specimen in an agate mortar, and sift them through a metallic sieve, in which the openings are 425 μm - 500 μm in diameter.

2.3 Preparation of Analytic Specimen

Take three appropriate portions of the specimen above, and smear them evenly over the specimen holder, on which electrically conductive glue is applied, in the scanning electron microscope. Use an aurilave to blow the particles off the surface of the specimens.

2.4 The Method with A Scanning Electron Microscope

Observe the analytic specimens under the scanning electron microscope, move the field of view magnified 500 to 50000 times, and do a count. Observe 100 particles in the same area, and record the number of fibrous particles in it. Repeat the determination procedure three times, and do an energy spectrum analysis if there is any asbestos fiber among the total 300 particles observed in the three parallel determinations, and continue to do the energy spectrum analysis if the asbestos fiber particles contain such elements as magnesium, silicon, and oxygen. It will be determined that no asbestos is observed, if no asbestos fiber particle is found.

2.5 Energy Spectrum Analysis

If the results of the energy spectrum analysis indicate that the analytic specimens of fibrous particles contain such elements as magnesium, silicon, and oxygen, the elements composing the powdery substrate will need to be analyzed. If the elements contained in the powdery substrate are obviously inconsistent with fibers, it will be determined that asbestos is observed. If the powdery substrate contains such elements as silicon, magnesium, and oxygen to a higher degree, the determination procedure with the method of X-ray diffraction will be gone through.

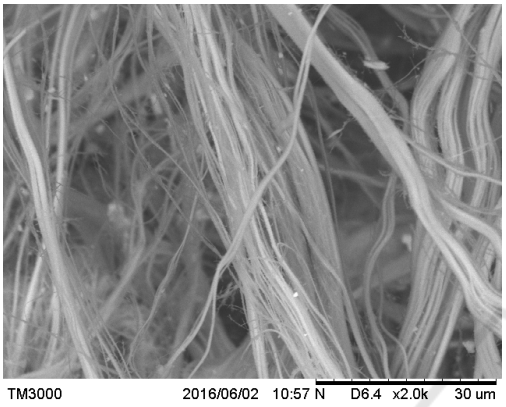
2.6 Determination with the Method of X-Ray Diffraction

Put the analytic specimens on the specimen holder, and press them until they become flat. Determine whether the analytic specimen shows any diffraction peak that is characteristic of asbestos, under the analytic conditions for X-ray diffraction in Appendix B. Repeat the test three times. If any diffraction peak characteristic of asbestos is found during any of the three tests, it will be determined that asbestos is observed. If no diffraction peak characteristic of asbestos is found, it will be determined that no asbestos is observed.

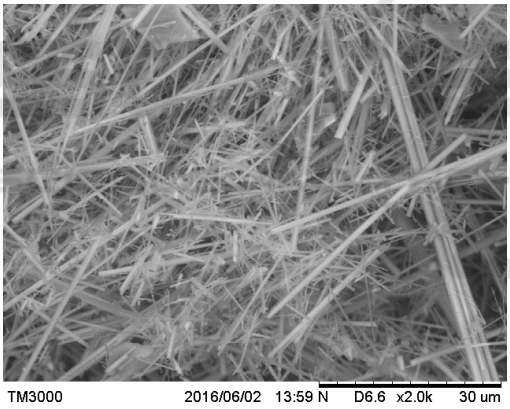
3 RESULTS AND DISCUSSION

3.1 Results of Testing for the Standard Substances in 6 Types of Asbestos

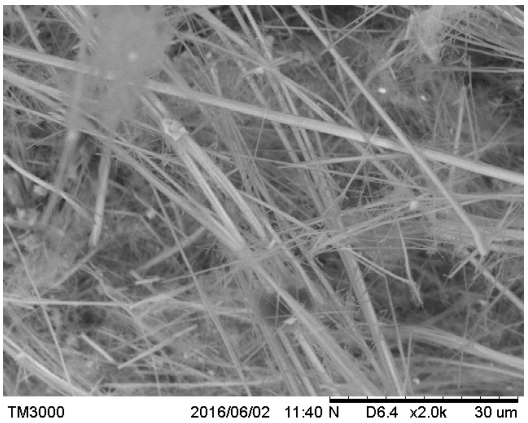
Figure2 is the picture showing the characteristic features observed under a scanning electron microscope of the standard substances in 6 types of asbestos.



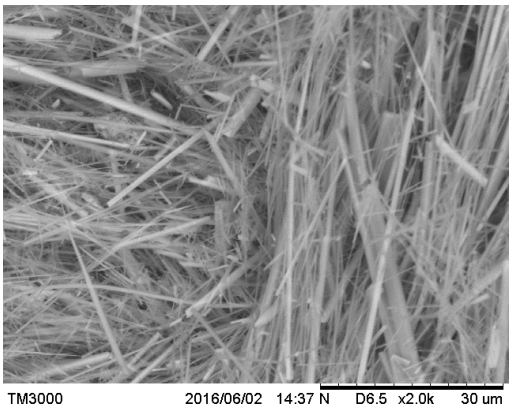
(a) The standard substances in chrysotile



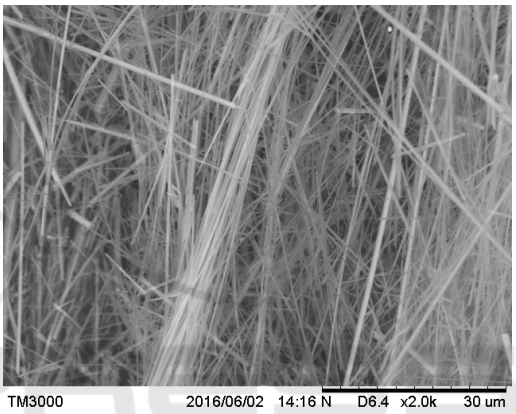
(b) The standard substances in amosite



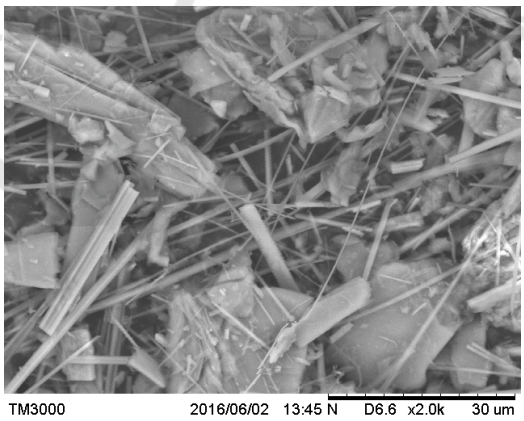
(c) The standard substances in crocidolite



(d) The standard substances in tremolite



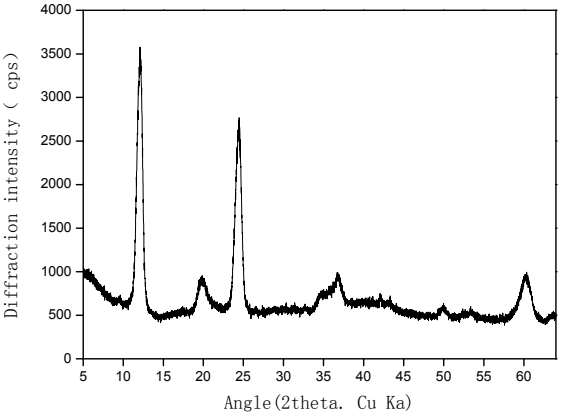
(e) The standard substances in actinolite



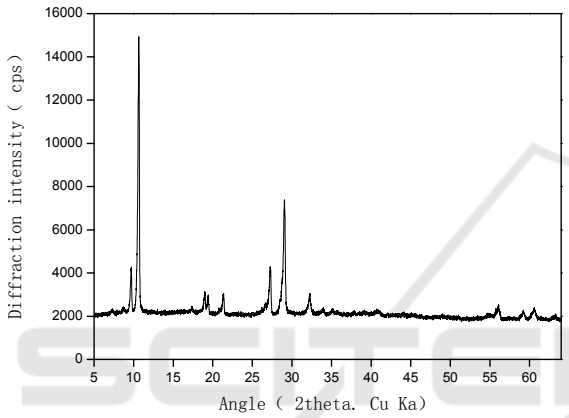
(f) The standard substances in anthophylite

Figure 2. The scanning electron microscope images for all types of asbestos.

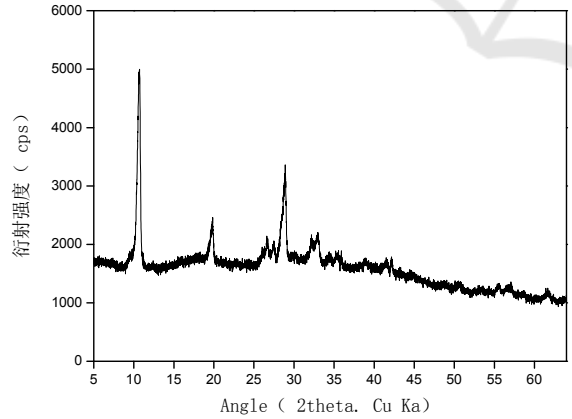
From Figure 3 we could get that the scanning images of the X-ray diffraction peaks for all types of asbestos.



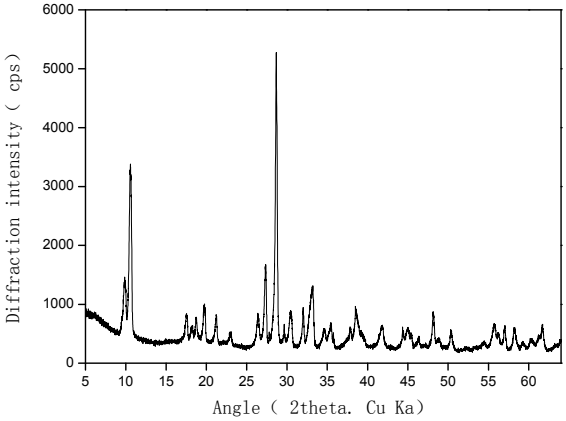
(a) Chrysotile



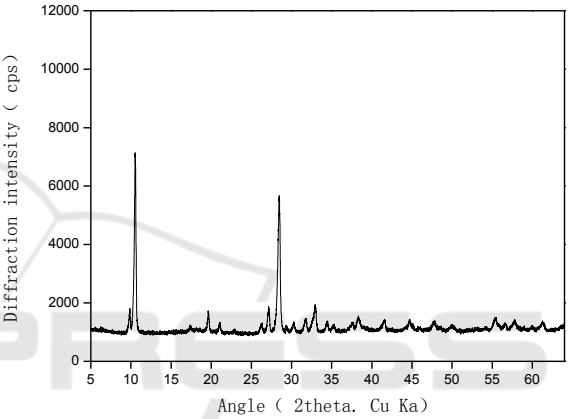
(b) Amosite



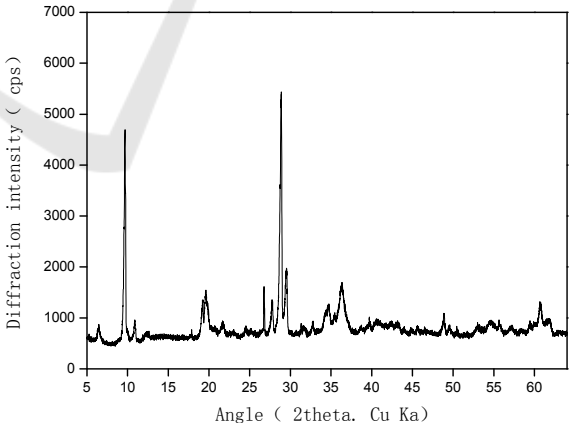
(c) Crocidolite



(d)Tremolite



(e) Actinolite



(f) Anthophylite

Figure 3. The scanning images of X-ray diffraction peaks for all types of asbestos.

Table 1. The data on the X-ray diffraction characteristics of all types of asbestos

Chrysotile		Crocidolite		Amosite	
2θ°	I CPS	2θ°	I CPS	2θ°	I CPS
12.06	100	10.68	100	10.68	100
24.50	78	28.9	67	29.17	49
60.38	28	19.84	49	27.29	29
36.85	27	33.04	44	9.65	28
19.83	27	26.62	43	18.89	22
Anthophylite		Tremolite		Actinolite	
2θ°	I CPS	2θ°	I CPS	2θ°	I CPS
28.97	100	28.6	100	10.48	100
9.73	87	10.58	60	28.42	79
36.34	31	33.12	29	33.04	27
26.82	29	9.83	25	27.09	26
19.64	28	33.14	23	9.73	25

From Table 1 we could get that the data on the X-ray diffraction characteristics of all types of asbestos.

4 CONCLUSIONS

Based on the combination of SEM and XRD methods, the method of testing for asbestos in electronic and electric products has been worked out. In this method, SEM is used to initially screen the specimens. XRD is used to identify for the second time the specimens with particles similar to those of asbestos fibers, largely improving the accuracy and reliability of the test.

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