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Detection of Airborne Asbestos by Fluorescent-labeled Protein Probe and Its Application to Quick Monitoring

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Extended Abstract

Asbestos is made up of microscopic bundles of silica fibers that can become airborne when damaged or disturbed. The most commonly used method for airborne asbestos detection relies on phase contrast microscopy (PCM). While simple and cheap, PCM has a number of limitations. It cannot detect asbestos fibers thinner than about 0.25 μm and is not able to distinguish asbestos fibers from other natural or man-made fibers of similar dimensions. Electron microscopy-based methods (EM) are more sensitive but also expensive, and require much more time for sample preparation and analysis. Polarized light microscopy (PLM) analysis is used for asbestos identification in building materials, but is not sensitive enough to detect airborne asbestos fibers. Recognizing the limitations of the existing methods for asbestos detection and identification, National Institute for Occupational Safety and Health (NIOSH) has identified development of improved analytical methods for asbestos fibers as a strategic research goal.

Recently, we discovered that bacterial proteins DksA and HNS can specifically bind to chrysotile and amphibole asbestos, respectively. Based on our findings, we developed a fluorescence microscopy-based (FM) method for selective and highly sensitive detection of airborne asbestos fibers. This method relies on staining of the asbestos fibers collected on the filter membrane using fluorescently-labeled DksA and HNS proteins. Our method relies on portable LED-based epifluorescence microscope, whose operation is almost as easy as that of PCM. Airborne asbestos detection using FM method has several advantages over PCM, PLM and EM methods.

1. Sensitivity: FM can offer sufficient sensitivity to detect single chrysotile fibrils as thin as 30-35 nm. We can therefore conclude that FM is able to detect all countable asbestos fibers, thus approaching the sensitivity of SEM. In our experience, thin chrysotile fibers are not easy to detect under PCM and impossible under PLM.
2. Reliable asbestos identification: Since PCM does not differentiate between asbestos and non-asbestos fibers, PCM tests can not conclusively confirm that asbestos levels are above regulatory limits. Our tests of the developed probe using various fibers found in the air samples from demolition sites indicated high specificity (less than 5% false positive rate) and sensitivity (less than 2% false negative rate). FM will provide more accurate and reliable estimates of asbestos contamination.
3. Automated counting: FM has an obvious advantage as a platform for automated fiber counting using image processing. Phase contrast optics produce haloes around particles and air bubbles in the sample, which could be misidentified as fibers during image processing. FM images are generally free of such artifacts, and do not require any specific processing to remove or distinguish these artifacts from fibers.

With a portable fluorescence microscope, FM method could be used for rapid on-site monitoring of airborne asbestos, for example during demolition work. While we do not expect FM to rival the advanced fiber identification capabilities of electron microscopy, our method allows simple, speedy, selective and highly sensitive detection of all asbestos types, which is sufficient for routine asbestos monitoring.

References

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