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Assessment of the pathogenic potential of asbestiform vs. nonasbestiform particulates (cleavage fragments) in *in vitro* (cell or organ culture) models and bioassays

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Abstract

Asbestos fibers are highly fibrous silicate fibers that are distinguished by having a large aspect (length to diameter) ratio and are crystallized in an asbestiform habit that causes them to separate into very thin fibers or fibrils. These fibers are distinct from nonasbestiform cleavage fragments and may appear as thick, short fibers which break along cleavage planes without the high strength and flexibility of asbestiform fibers. Since cleavage fragments of respirable dimensions have generally proven nonpathogenic in animal studies, little data exists on assessing well-characterized preparations of cleavage fragments in *in vitro* models. The available studies show that cleavage fragments are less bioreactive and cytotoxic than asbestiform fibers.
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Keywords: Asbestiform; Cleavage; Fibers; Fibrous

1. Introduction

'Asbestos' is a commercial and regulatory designation for a family of naturally occurring asbestiform fibers. Asbestos fibers are recognized as human carcinogens and also cause pleural and pulmonary fibrosis, i.e., asbestosis in occupationally exposed individuals (**Mossman et al., 1990; Mossman and Churg, 1998; Mossman and Gee, 1989**). Mineralogical and biological differences exist between various types of asbestos fibers, and much research has focused on the characteristics of fibers that are associated with the causation of lung disease. The different types of asbestos include chrysotile [Mg_6 Si_4 O_{10} $(OH)_8$], the only asbestos in the serpentine family of minerals, and other types of asbestos classified as amphiboles. These include crocidolite [$(Na_2$ $(Fe^{3+})_2(Fe^{2+})_3$ Si_8 O_{22} $(OH)_2$], asbestiform grunerite or amosite [$(Fe,Mg)_7$ Si_8 O_{22} $(OH)_2$], anthophyllite [$(Mg,Fe)_7$ Si_8 O_{22} $(OH)_2$], tremolite [Ca_2 Mg_5 Si_8 O_{22} $(OH)_2$], and actinolite [$(Ca_2$ $(Mg,Fe)_5$ Si_8 O_{22} $(OH)_2$]. These formulae are indeed ideal, and natural amphiboles differ to varying degrees from these as the chemical environment, pressure, and temperature at the time of formation control the mineral chemistry. Other factors such as shear stresses and directed pressures determine whether or not an amphibole that crystallizes is asbestiform. Although various types of asbestos are different chemically, structurally, and biologically, they are common in that they are highly fibrous silicate minerals that are crystallized in an asbestiform habit, causing them to separate into thin fibers or fibrils (**Klein, 1993; Veblen and Wylie, 1993**). In addition, asbestos fibers are distinguished by having large aspect (length to diameter) ratios, generally from 20:1 or higher for fibers >5 μm in length. Smaller fibers (<0.5 μm in width) appear by microscopy as very thin fibrils, as defined by the American Society of Testing Materials in 1990. In contrast, nonasbestiform cleavage fragments, although sometimes elongated with aspect ratios of >3:1 which can be defined as fibers, have widths much larger than asbestos fibers of the same length.

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