Characterization and assessment of the potential toxicity/pathogenicity of Russian commercial chrysotile

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ABSTRACT

Today, cancer is one of the main health issues faced in the workplace, with asbestos an important carcinogen in the occupational environment. Among the asbestos minerals, chrysotile is the main species of socio-economic and industrial relevance. Although chrysotile asbestos is classified as a “carcinogenic substance” by the International Agency for Research on Cancer (IARC), this fiber is still mined and used in Russia. The effective health hazard posed by the Russian commercial chrysotile has not been quantitatively assessed to date. In this work, the potential toxicity/pathogenicity of Russian chrysotile was quantitatively determined using the fiber potential toxicity index (FPTI) model. This model was applied to a representative commercial chrysotile from the Orenburg region, Russia, whose morphometric, crystal-chemical, surface activity, and biodurability related parameters were determined. We have quantitatively assessed that the toxicity/pathogenicity potential of Russian chrysotile (FPTI = 2.4) is lower than that of amphibole asbestos species but higher than the threshold limit set for “safe” mineral fibers (FPTI = 2.0), although it does not contain impurities of amphibole asbestos. Differences with other chrysotile samples were discussed, and it was found that the investigated Russian commercial chrysotile shares several features with the Italian Balangero chrysotile, indicating that widespread concern on commercial Russian chrysotile is justified.

Keywords: Asbestos, chrysotile, Russia, adverse effects, FPTI

INTRODUCTION

Chrysotile is a trioctahedral hydrous layer silicate with an ideal chemical formula Mg_6(OH)_2Si_5O_10. Together with lizardite and antigorite, chrysotile belongs to the serpentinite group. Its basic structure is composed of one Mg-centered octahedral sheet (O) covalently bonded to one Si-centered tetrahedral sheet (T) (Ballirano et al. 2017). The lateral size of an ideal Mg-centered O sheet is larger than the lateral size of an ideal Si-centered T sheet. The dimensional misfit causes a differential stress that is mostly released by rolling the TO layers into a tubular structure providing chrysotile its characteristic fibrous habit (Ballirano et al. 2017). Because of its fibrous crystal habit and outstanding physical-chemical properties, chrysotile is the most common asbestos mineral on Earth (Gualtieri 2017).

Asbestos is actually a commercial term designating six mineral fibers used for industrial applications: chrysotile and the five amphiboles i.e., actinolite asbestos, amosite (fibrous variety of cummingtonite-grunerite), anthophyllite asbestos, crocidolite (fibrous variety of riebeckite), and tremolite asbestos (NIOSH 2011; IARC 2012). Asbestos minerals have been used in human history to create more than 3000 asbestos-containing materials (ACM), such as electrical and thermal insulating materials (flooring and coatings), vinyl-asbestos, asbestos-cement roofs, and pipes (Ross and Nolan 2003; Gualtieri 2017). Extensive use of asbestos began in the 19th century when the mechanization of the mining activity promoted the exploitation of large chrysotile deposits in Canada (e.g., Lake Asbestos, Quebec) and Europe (e.g., Balangero mine, Italy). Modernization of the rail network enabled the intensive exploitation of the Ural asbestos mine in Russia (Vogel 2005; Marsili 2007). In 1975, Russia became the world’s leading asbestos producer, and it is still so today (Kashansky et al. 2001; USGS 2020). In the last century, about 30 million tons of asbestos fibers have been mined worldwide, and about 90% of this raw material is chrysotile (LaDou 2004; WHO 2014). Regrettably, since the beginning of the 20th century, it has become clear that the unique crystal-chemical and physical features of asbestos minerals, responsible for their exceptional properties, are related to potential pathogenicity (Gualtieri 2017). Sir Richard Doll for the first time unequivocally reported the link...