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Review

Assessment of health implications related to processing and use of natural wool insulation products

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ABSTRACT

This paper discusses possible health implications related to dust particles released during the manufacture of sheep's wool-based non-woven insulation material. Such insulation may replace traditional synthetic insulation products used in roofs, wall cavities, etc. A review of the literature concerning organic dusts in general and sheep's wool fiber summarizes dust exposure patterns, toxicological pathways and the hazards imposed by inhalation and explosion risk. This paper highlights a need for more research in order to refrain from overgeneralizing potential pulmonary and carcinogenic risks across the industries. Variables existing between industries such as the use of different wool types, processes, and additives are shown to have varying health effects. Within the final section of the paper, the health issues raised are compared with those that have been extensively documented for the rock and glass wool industries.

Contents

Abbreviations: WHO, World Health Organisation; BOHS, British Occupational Hygiene Society; D_{ae}, Aerodynamic diameter; D, Particle diameter; ρ, particle density; ρ_o, Density of water; TLV, Threshold Limit Values; HSE, Health and Safety Executive; FEV_1, Forced expiratory volume in 1 second; TNF, Tumor necrosis factor; OSHA, Occupational Safety and Health Administration; HSPP, Health and Safety Partnership Program; FVC, Forced vital capacity.

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1. Introduction

Effects specifically concerning exposure to inhaled particles, starting with coalmine dust, have been a subject of concern since 1960, when the first Inhaled Particles Symposium was held by the British Occupational Hygiene Society (BOHS). The focus started with establishing standards for controlling coalmine dust, and expanded in the 1980s to include fibers such as asbestos. This on-going international symposium is still expanding its scope to include nano-particles and toxicological mechanisms (British Occupational Hygiene Society, 2013). Lung conditions have been a serious issue worldwide, and are estimated to be the cause of 1 in 10 of all deaths, costing more than €380 billion annually in Europe at 2011 values. These data were collated by the World Health Organization (WHO) and the European Centre for Disease Prevention and Control, and is summarized in the European Lung White book (European Respiratory Society, 2013). Various agents found in the workplace are shown to be responsible for: about 15% in men and 5% in women of all respiratory cancers; 17% of all adult asthma cases; 15 to 20% of chronic obstructive pulmonary disease cases; and 10% of interstitial lung disease cases. The research concludes that assessing occupational exposure risks and diagnosis requires a detailed historical study.

1.1. Natural fiber use and concerns

The thermal insulation sector for the domestic building sector (e.g. in lofts, cavity walls, etc.) has been an important one since the compulsory push to insulate buildings and meet energy targets have been set over 30 years ago (Papadopoulos, 2005). The sector is dominated by synthetic inorganic fibrous insulation and organic foams. Although thermal properties of insulation materials have not appreciably improved over the past decade, there is a growing interest for additional functionalities by some end users: moisture buffering, mechanical durability, breathability, sustainability, etc. The popularity of the latter properties has increased the interest in natural materials.

Fibers used for non-woven insulation products can be categorized as natural or industrial as per Fig. 1. Although it can be argued that industrially produced fibers are ‘natural’ for the purpose of this paper the term ‘natural fibers’ refer to all naturally polymerized fibers of plant and animal origin; and the term synthetic fiber is used to mean fiberglass, rock or slag wool.

The use of natural fibers, including sheep's wool, is an area of increasing interest, and opportunities are being developed in new markets (Karus and Kaup, 2002; Khedari et al., 2004). Historically, natural fibers have been used extensively by the textile industries. Nowadays, accumulating research has highlighted their attractive properties and benefits: efficient thermal resistivity (Fan et al., 2008), good structural strength (Feughelman, 1997; Wambua et al., 2003), moisture buffering capacity (Watt, 1960), and the uptake of certain gasses (Curling et al., 2012).

Natural fibers as raw materials for insulation have attracted attention because of their historical use, availability, and sustainability. Their availability is evident from their large usage in textile and other industries, such as carpet manufacturing. New legislation further complements the drive to natural fiber use (UK Government, 2013) as it pushes to reduce energy usage and sequester carbon emissions (Barbier, 2010). This reflects on the natural fiber composites market, which is expected to grow to US $531.3 million in 2016 (Research and Markets, 2011). In addition, the economics of some natural fibers is structured; for example, although the demand for sheep's wool fluctuates (Boutonnet, 1999)—leading to a reduction in price and frustration among farmers—prices are regulated by the British Wool Marketing Board (British Wool Marketing Board, 2005), Australian Wool Exchange (Australian Wool Exchange, 2013), and other authorities in various countries. Therefore, it can be concluded that processing of such fibers into insulation products is encouraging from a performance, environmental, and a wider economic view.

There are many indications about the environmental benefits and actual health benefits associated with the presence of natural insulation material in buildings (Dewick and Miozzo, 2002; Korjenic et al., 2011): moisture buffering properties decrease occupant discomfort; the natural materials' characteristic odors are reported to positively influence the human psyche; and indeed the anecdotal evidence of the manufacturers appears to show that the insulation is easier and less dangerous to the health of the installer and the end user (Black Mountain Insulation, 2012; Thermafleece, 2013).

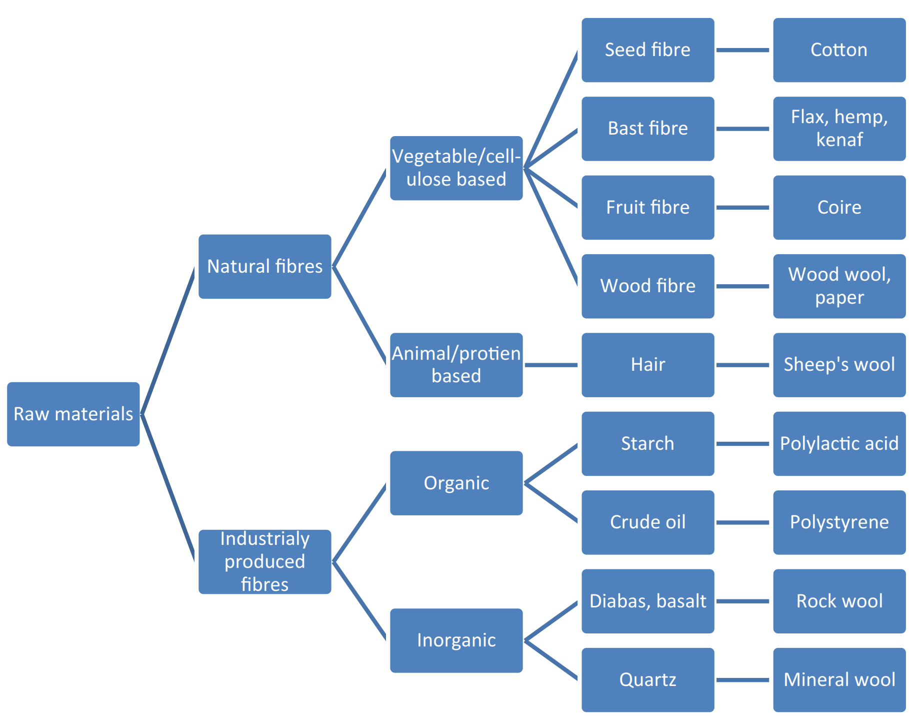

Fig. 1. Categorization of fibers used for non-woven insulation production (Müssig and Graupner, 2010).