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Effect of particle concentration and semi-volatile organic compounds on the phenomenon of 'black magic dust' in dwellings

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ABSTRACT

The spontaneous discoloration of indoor surfaces which occurs especially during the heating period has been intensively investigated in Germany since the beginning of the 1990s. On the basis of earlier studies and a questionnaire this phenomenon, referred to as 'black dwellings' or 'black magic dust' (BMD), was attributed to the presence of semi-volatile organic compounds (SVOCs) and their interaction with dust and particles. In a project funded by the German Federal Environment Agency an attempt was made to deliberately simulate this effect in suitable test chambers. To do so wall paints were used which had been doped with the plasticizers DEHP and DBP. They were applied in different quantities to appropriate wall surfaces in four room size stainless-steel chambers. In this way realistic air concentrations of these two compounds were obtained. An artificially arranged thermal bridge located above a radiator was intended to accelerate deposition of the black dust. Even when the particle concentration in the chamber was briefly increased, no discoloration could be detected. It therefore appears that a combination of dust, thermal bridges and elevated concentrations of plasticizer does not necessarily trigger the BMD phenomenon. With the aid of investigations into affected dwellings it was possible to identify different mechanisms. Strong sources of particles were identified in some apartments while in others the particle deposits were caused by convective air flows. On the basis of all results it can be concluded that the deposition of particles by thermophoresis, diffusiophoresis or sedimentation is responsible for the phenomenon.

1. Introduction

Since the beginning of the 1990s the sudden appearance of oily-greasy discolorations on horizontal and vertical surfaces in dwellings has been more and more frequently observed (see Fig. 1). In some cases they were so extensive that living quality was decisively reduced. On account of the characteristics and the sudden appearance of these discolorations, the terms commonly used for the phenomenon were 'black dwellings' or even 'black magic dust' (BMD) [1,2], although the color of the staining usually ranges from light grey to deep black. Only a small amount of scientific literature exists which deals with the subject of 'black dwellings'. Nevertheless, the sudden discoloration of surfaces by particle deposition has been known for many decades, for instance, from the museum environment [3–5]. Nazaroff and Cass [5,6] have proposed the term 'soiling' for the phenomenon, thereby characterizing the effect more appositely than 'fogging', a term which is current mostly in Germany and which originates in the automotive sector [7] where it describes the deposition of semi-volatile organic compounds (SVOCs) on inner glass surfaces [8,9].

Initially the German Federal Environment Agency conducted questionnaire-based surveys in order to identify the causes of these discolorations in dwellings. Data from more than one thousand dwellings affected by BMD were evaluated and many sources of airborne particles found in indoor air were considered [10]. This revealed not only a large number of common factors but also individual differences in the dwellings under investigation. The discolorations were found in 92% of cases during the heating period and in 86% in renovated or newly occupied dwellings (see Fig. 2). In addition, a large proportion of black discolorations were found on wall areas above radiators, in drapes and curtains, on tiles and on window seats. Furthermore the wall surface on the inside of outside walls often discolored. Even electrical appliances and plastic surfaces were affected. The most marked discolorations were often observed in the living room. In many of the dwellings investigated new carpets had been laid or walls painted just before the appearance of BMD. No major differences could be identified in the living habits of dwelling occupants, with ventilation and

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