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PG3) Accretion of Dust to Indoor Surfaces

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1. Introduction

The deposition of dust indoors is familiar to everyone. It is a source of annoyance in the home and a concern in public places where it imposes cleaning costs(Lloyd et al., 2002) and raises health concerns at a time of the incidence of asthma in many countries. In museums and historic houses it imposes a large economic burden as these buildings need to maintain high standards of presentation to meet the expectations of visitors(Yoon and Brimblecombe, 2001). The deposits, which are often rather coarse and include large fibres can initially be removed by gentle brushing. However, dust is observed to become more strongly bound to surfaces over time(Yoon and Brimblecombe, 2006). This research aimed to understand why dust sticks to surfaces and becomes a grey 'cement' that is difficult to remove(Yoon and Brimblecombe, 2004). Earlier research showed that visitor clothing was the source of visually intrusive dust(Yoon and Brimblecombe, 2000), hence visitors impose costs. Repetitive cleaning takes time and resources so research was needed to inform decisions on when and how often to clean. The project met its objective in examining soiling processes in historic properties where sensitive materials, such as textiles, are on open display. It also determined humidity as the key environmental factor which controls increased cementation of dust to historic surfaces. We also hoped to inform decisions on cleaning frequency and methods, and the development of effective housekeeping regimes in historic houses.

2. Methodology

We collected samples of loose and cemented dust from many properties including: Dyrham Park, Castle Coole, Waddesdon Manor, Tyntesfield, Hughenden Manor, Hampton Court Palace and the National Trust Textile Conservation Studio. The samples of dust collected from various surfaces have been analysed using both optical and scanning electron microscopy and micro Raman spectroscopy. We have examined the cements that link particles to the underlying substrates and to identify bacteriologically derived exopolymers forming under humid conditions.

Dust samples were sieved to get separate material of less than 63μm. The dusts used were (i) a desert dust from Kuwait to reflect a source with low organic content (ii) a sample of from the a-horizon of an agricultural soil from Norfolk, UK and (iii) dust collected from vacuum clearers at Knole, taken to be representative of what one might find in a historic house. Larger particles in these materials were removed with a 63μm sieve Commercially available samples of kaolinite (average diameter 2.0μm with 50% of the particles <1.96μm) and montmorillonite(average diameter 8.0 μm with 50% of the particles <9.11μm) were obtained from David Ball Co Ltd, Cambridge, UK and magsil osmanthus(with 50% of the particles <17.4μm) and an Italian pumice) from Pumex (UK) Ltd, London. These samples of dust were exposed, in small vials though the winter in rooms at Knole Hampton Court and Dover Tunnel and near Sevenoaks. In some experiments we added traces of salt(NaCl) and sugar to represent the salt that is frequent component in coastal environments, while sugars are sometimes found in fibres such as cotton. In addition to the salts we also added small pre-weighed centimetre-long fibres to the dust samples before exposure. We also prepared similar samples for controlled humidity experiments in the laboratory.

3. Result and Discussion

The strong relationship between humidity and cementation suggests a range of management approaches to cleaning, for instance in properties where high humidity is largely a winter phenomenon, it may be possible to reduce cementation to bedspreads and other horizontal surfaces, by cleaning at the end of the summer visitor season. This would minimise the amount of dust available to cement to the underlying fabrics over the damper winter period. Whilst investigating the nature of the cementing material was complicated by its extremely small size, and similarities in elemental composition between the cements and the dust particles, one mechanism has been determined. The dissolution of calcite-based dust particles, and subsequent precipitation of fine grained calcite, was determined by confocal Raman spectroscopy and SEM-EDX. Thermodynamic calculations, based on salt anion monitoring in deposited dust at Dover, have shown that calcite has sufficient solubility in salt solutions to produce the amounts of cement observed. Deliquescence, of salts deposited in dust from this coastal site, was confirmed with surface wetness sensors. The current project has intensively studied the coarse particles which can be identified within dust. However, further work should address the nature of fine particles, and the way in which fine particles interact with the surfaces(colour, type and strength of bond) in addition to health and safety concerns. Since the methods ofadherence of fine particles to surfaces are not known, efficient mitigation methods cannot yet be designed. For example, it would be of great importance to know whether different types of air conditioning filters are effective in controlling fine particles, such as diesel soots on surfaces.

References

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