Dust Characterization: dust and fibers in the indoor environment

Chin S. Yang, Ph.D.

Dust accumulation on indoor surfaces is frequently observed by building occupants or by environmental professionals conducting indoor environmental quality investigations. The types of dust particles and fibers and their quantities in percentages can be analyzed by optical microscopy and used to determine their possible sources and whether their presence is usual or not.

This technical information discusses the possible sources of each of the identified particles and fibers and the various uses of such information during a building evaluation and investigation.

When to sample for dust characterization

If there is visible dust accumulation on shelves and other horizontal surfaces in a building, whether commercial or residential, which has been the subject of complaints of poor air quality; it is a good practice to take samples of that dust for analysis.

How to take samples for dust characterization

There are two ways to collect surface samples for dust characterization. The first method is tape-lift sampling with a piece of clear, transparent cellophane tape approximately 3-4" long. This is similar to the tape-lift sampling for direct microscopic examination for fungi. However, the thin sticky surface of the tape is easily overloaded by dust. Therefore this method may not be the most appropriate when a thick coat of dust is observed or when taking samples from carpets. The interior of air-duct surfaces, whether with or without insulation, is likely to have a thick coat of dust accumulation. In such cases, the second method, which is to vacuum up dust with a typical membrane filter cassette, 25-mm or 37-mm, may be more appropriate. This method will collect dust from surfaces with a thick layer of dust or from a carpet.

What do the results mean?

The results include identification of particles and fibers and their individual percentages as observed under the microscope. Biological stains are used to help the identification. Iodine based stain is used for confirmation of starch grains. Weak acid (lactic acid) is used to differentiate gypsum dust and carbonate mineral deposits from sand or quartz particles. However, the analysis is not designed to determine the chemical compositions of particles and fibers.

Some dust particles and fibers are natural and logical components of indoor dust. For example, skin flakes are abundant in indoor dust because humans are the sources. Human hairs are common, because of human occupancy, but are not necessarily abundant.. Cellulose fibers are common because they are used in paper products, drywall and other building materials (e.g., ceiling tiles).

The following list includes commonly identified particles and fibers in indoor dust.

Animal hairs: Hairs from furry pets, such as dogs and cats, are the most likely sources. However, furs or clothing and fabrics (such as cashmere or rugs) of animal origin are another major source. Their presence indoors is not uncommon and indicates the presence of furry pets or furs, clothing and fabrics of animal origin.

Carbonaceous particles: These particles are likely from combustion sources, such as automobile exhaust and oil burning. However, ink from laser printers is another common source in an office setting. They are common indoors but typically at low percentages. Buildings with oil heat, near heavy traffic or with heavy printing needs are likely to have a higher frequency of detection at higher percentages.

Cellulose fibers: Paper products and building materials, such as drywall and ceiling tile, are the primary sources of cellulose fibers. Their presence is considered normal.

Feathers: Feathers are unusual indoors but are sometimes used as decorative items indoors. However, the major concern with the detection of feathers indoors is the potential presence of birds roosting indoors. Bird droppings indoors may harbor potential sources of infectious fungi, such as *Histoplasma capsulatum* and *Cryptococcus neoformans*. An unusually high frequency or percentage of bird feathers may signal the need to check for bird screen and roosting in attics or other building cavities.

Fiber glass: Fiber glass and related materials (including mineral wools) are very common in modern buildings. They have been used extensively in insulation, in building materials (ceiling tile and a new kind of drywall called DensGlass Gold® exterior sheathing), in office furniture, and other uses. It is also the major component of interior air-duct insulation. The release of fiber glass during installation and the use of fiber glass containing materials are common. Finding pieces of fiber glass among dust indoors is not unusual. However, fiber glass may cause skin irritation in some people by contact. Unusually high percentages of fiber glass indicate construction activities or activities related to the disturbance of fiber glass containing materials, and may be associated with complaints of skin irritation. Washing with a soap bar and cold water will reduce and minimize symptoms of irritation.

Foam particles: Foam is used in furniture cushions, packing, carpet padding, or building materials (e.g. ceiling tile). Their chemical compositions may be different but they have the similar physical property of air space in the particle. Old furniture cushions may deteriorate and break down into tiny particles.

Fungal matter: Fungal spores are ubiquitous and not unusual among dust. They are easily detected in dust but are normally at a very low percentage of less than 1% (<1%). When the percentage exceeds 1%, look for water damage and hidden mold growth.

Gypsum dust/mineral deposit: Gypsum is used in the core of drywall and in plaster wall. The accumulation of gypsum dust during construction is very common. The detection of gypsum dust when cutting drywall, whether during new construction, renovation or mold remediation, is unavoidable. Carbonate based mineral deposits are commonly formed when concrete, sandstone, or cinder-concrete blocks are subjected to moisture. Calcium and magnesium ions leached from the materials form carbonate deposits upon drying. It is difficult to differentiate between gypsum dusts (containing mostly calcium sulfate) from calcium carbonates by acid test. They are reported as gypsum dust and mineral deposit.

Human hairs: Human hairs are not unexpected in human occupied space.

Insect parts: Insects, including flies and mosquitoes, may appear indoors. Their parts, upon death, may occasionally be found in indoor dust. A higher frequency of detection at elevated percentages signals insect infestation and possibly high moisture.

Paint chips: Paints of various types are often used for coating interior surfaces. Paint chips are often produced during renovation when paints are disturbed and chips are produced. The method of analysis does not differentiate paint types.

Pine pollen: Pine trees usually flower in the spring and produce abundant yellow-colored pollen. Pine pollen (including all species of pine trees) is very characteristic and relatively large in size, approximately 30-60 µm wide. A high frequency of detection at elevated percentages signals pathways for pine pollen to enter the building. The likely pathways are HVAC systems, doors and windows. Low filtration efficiency and bypass of the filtration systems are likely reasons for pine pollen to enter through the HVAC system.

Plant matter/trichome: Plants shed leaves, hairs (called trichomes), flowering parts, fruits and seeds in their life cycle. Fallen leaves, flowers, and fruits may become dry and break into pieces. Trichomes and some seeds may become airborne. These can enter a building through airborne pathways or by foot traffic. Plant matter and trichomes found in carpet or floor dust suggest foot traffic. They are likely to come from air streams if they are found in air-ducts or on surfaces above floor level. Better floor or carpet cleaning will reduce plant matter and trichomes. Higher frequency of detection at elevated percentages signals pathways for plant matter/trichomes to enter the building. The likely pathways are HVAC systems, doors and windows. Low filtration efficiency and bypass of improperly installed filtration systems are likely reasons for plant matter/trichomes to enter through the HVAC system.

Pollen: Other than pine pollen & ragweed pollen, pollens from trees, flowers and grasses are grouped as one class. Their presence is an indication of pathways for pollen to enter the building. The likely pathways are HVAC systems, doors and windows. Low filtration efficiency and the bypass of improperly installed filtration systems are likely reasons for pollen to enter through the HVAC system.

Quartz and sand particles: Quartz or sand particles are common components of soils, in building construction and as a common building dust contaminant. They are more common in carpet or floor dust than in dust from above ground level surfaces.

Ragweed pollen: Ragweed plants produce flowers and pollen from late summer until first frost in most of continental US. They are tolerant to dry, arid environments but grow very well in watered and fertilized yards. Ragweed pollen is a well known allergen and cause misery to plenty of allergy sufferers every year mostly from late summer (mid to late August to early September in Northeast) to early fall or frost. Ragweed plants prefer dry, sunny grassy plains, sandy soils and grow on disturbed soil along roadsides and vacant lots in urban, suburban, or agricultural areas. Although eradication of ragweed is considered impractical, removal of ragweed plants from your surroundings during growing season will reduce ragweed concentrations and populations over time. Ragweed pollen is commonly found in air-duct, surface or carpet dusts indoors. Their pathways to the indoors are no different from other pollen types.

Skin flakes: Skin cells and flakes are easily recognized under a compound microscope. They are very common and characteristic in indoor dust because of human occupancy. Although animal dander from dogs and cats is possible, human dander is the most common and abundant in indoor dust.

Starch grains: Starch grains are produced from plants as storage of sugars. Starch grains are used in some common household products, such as baby powders. Flour, noodles, and spaghetti are other sources of starch grains.

Synthetic fibers: Synthetic fibers, such as nylon, are common indoors. Carpets, furniture fabrics, and other fabrics used in clothing and other household materials are likely to contain synthetic fibers.

Wood chips: Wood is commonly used in building construction, particularly residential. Wood is sometimes sawed into pieces during construction. Sawdust is the byproduct. In addition, wood chips are composted into mulch. Both sawdust and composted wood chips are recognized as wood chips when observed under the microscope. When detecting wood chips in dust samples, this suggests either construction activities or mulch carried in by foot traffic.

There may be site-specific particles and fibers not discussed here. For example, shredded metal pieces may be detected when they are used in buildings. Environmental professionals should carefully observe their sample environments during inspection and sampling to determine where each of the particles and fibers may be from.

For those who are interested in learning more about dust characterization and particle and fibers identified, please refer to the article, written by Yang et al, below.

Yang, C. S., Dougherty, F. J., Lewis, F. A., Zampiello, F. A., and Mangiaracina, L. 1992. Microscopic Characterization of Settled Dusts Collected in Office Buildings in Mid-Atlantic Region. Environments for People. Atlanta: ASHRAE IAQ '92.