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# Black Soot Deposition: How It Impacts IAQ

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*While soot can be caused by incomplete combustion of any carbon-containing fuels, candles have been identified as a common source of this problem*

BY DAVID KRAUSE

lso referred to as ghosting, carbon tracking, carbon tracing and dirty house syndrome, black soot deposition has become an increasingly common complaint of homeowners and apartment residents throughout the United States. Since 1992 the occurrence rate of complaints received at the Florida Department of Health has risen from two a year to two a week.

Several factors are believed to contribute to the deposition of carbon soot and several theories on its cause have been suggested, but a full understanding of the cause and mechanism is still forthcoming.

Soot is a product of incomplete combustion of carbon-containing fuels,

Until recently, the amount of soot produced by candles had not been measured. Results from a recent experiment using a controlled chamber revealed that certain candles, with predictable regularity, could produce up to 100 times more soot than low-soot-producing candles.

In effect, burning one of these candles can be equivalent to burning 100 candles at once. It also was determined that a candle placed in an air draft can increase its soot production by a factor of 50.

The assumption by most consumers that candles could not produce enough soot to cause the damage seen in their homes is unfounded. In fact, soot production from certain candles can be significant and may cause indoor levels of airborne soot to exceed levels allowed in outside air by the U.S. Environmental

typically petroleum-based. In theory, complete combustion, which is evident by a blue flame, would produce practically no soot or carbon monoxide. This applies to all types of combustion processes, including natural gas flames, wood fires and candle flames.

While soot can be generated by any combustion process, most flames seen in homes, such as a gas stove's blue flame, are either vented or carefully controlled. Through interviews with more than 50 homeowners who have experienced black soot deposition, it became evident that candles are a common source of soot.

Protection Agency.

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### Why Does Soot Deposit Itself?

When particles collide in the air and grow in size, they gain enough mass to deposit due to gravity. When soot builds up in the air it eventually deposits itself when it collides with surfaces. Other environmental factors might possibly shorten the time needed for soot to settle, but understand that eventually the soot will land somewhere.

Factors such as a home's low ventilation rate, the use of electronic air cleaners and excessive turbulence due to undersized air ducts may increase the rate at which soot deposits, but further research is necessary to establish their exact influences.

Soot created by candles is .06 to 0.1 microns in diameter. Particles of this size can penetrate almost all home air conditioning filters and can severely reduce an electronic air cleaner's ability to remove them from the air. Some of the particles are captured by air conditioning filters and internally lined ducts, appearing as black, oily deposits that clump together.

Soot also is attracted to cooler surfaces due to thermophoresis, a process by which particles migrate under the influence of forces created by a temperature gradient. This contributes to soiling of wall surfaces over studs and air conditioning supply vents. These particles also are attracted to electrically charged surfaces such as injection molded plastic items including medicine cabinets, internal surfaces of freezers, plastic blinds and computers.

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## What Are Possible Health Concerns?

While soot is suspended in the air, room occupants are at risk of inhalation exposure. Since the particles are less than 1 micron in diameter, they can penetrate the deepest areas of the lungs.

Some studies have looked at the health risks associated with microscopic soot generated from diesel exhaust and factory emissions, but none have considered the residential exposure from burning candles. The greatest exposure to soot produced by candles is expected during candle burning, so increasing ventilation by opening windows would reduce an occupant's exposure.

Once the soot particles are deposited they tend to remain attached and are unlikely to be inhaled. Removing soot from surfaces is difficult, but can be accomplished with polar solvents. For hard plastic surfaces, rubbing alcohol (isopropyl) is effective at removing soot deposits.

Few evaluations on the effects of soot ingestion (swallowing) have been conducted. EPA and California have recognized microscopic soot particles, however, as being responsible for aggravation of respiratory illnesses in the general population. Caution is warranted until specific health impacts are studied since the soot created by candles is small enough to enter the lower respiratory tract and alveoli.

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## What Remedies Exist?

First, cease candle burning and periodically ventilate the home by opening windows. Install an improved air conditioning filter, such as a pleated electret media filter. Consult a cleaning service experienced in fire restoration for cleaning surfaces.

Keep in mind that candles with the following characteristics have the potential to produce excessive soot:

- Candles poured into glass jars or ceramic containers.
- Soft wax containing unsaturated hydrocarbons.
- Aromatic (scented) wax containing volatile aromatic hydrocarbons.
- Thick, long wick or one with a wire core.
- Soot deposits on the mouth of the jar.
- High, erratic flame when burned.
- Visible soot emitted from an erratic flame.
- Located in an air draft created by a fan or a/c vent.

- Pillar candle with signs of uneven burning or thick, erect wicks.
- Multiple wick candles with thick, erect wicks.

Which candles don't cause soot damage? Candle soot has been a problem since the era of Colonial America. All candles that emit a yellow flame produce some soot, but usually at a rate that does not cause high indoor concentrations. Tell your customers to consider using candles with the following characteristics:

- Hard wax containing mostly saturated hydrocarbons.
- Thin, braided wick that curls over when burned.
- Low aromatic properties.
- Tapered and votive candles with thin wicks.
- Those that have a low, even flame when burned.

Part two of this article will address what can be done to avoid problems created by soot deposition, as well as how to fix those problems once they're discovered.

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