NEW SCIENCE

INDOOR AIR QUALITY

ARTICLE

IMPACT OF PAINT ON SCHOOL AIR

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INDOOR AIR QUALITY

OVERVIEW

Indoor Air Quality has been ranked as one of the Environmental Protection Agency's Top 5 environmental risks to public health. A key cause of poor Indoor Air Quality is volatile organic compounds (VOCs) that originate from construction materials, furnishings and finishes. VOCs can produce irritation such as headache, eye tearing and nasal burning and have been shown to have serious health consequences such as increased asthma among children and reproductive issues in women.

UL's team of dedicated scientists, engineers and researchers is developing New Science to help understand the health risks associated with VOCs and to minimize chemical emissions affecting Indoor Air Quality.

WHY THE IMPACT OF PAINT ON SCHOOL AIR MATTERS

Twenty percent of the U.S. population, or nearly 55 million people, spend their days in our elementary and secondary schools. Studies show that one-half of our nation's 115,000 schools have problems linked to Indoor Air Quality. Young students in particular are at greater risk of exposure to indoor air pollutants because of the hours spent in school facilities, their biological susceptibility and the inability to detect airborne hazards. Children breathe at a faster rate than adults; this coupled with their smaller body mass results in a higher dose of available pollutants when compared to adults.[1]

CONTEXT

A key cause of poor Indoor Air Quality in U.S. schools is volatile organic compounds (VOCs) that originate from construction materials, furnishings and finishes. VOCs can result in objectionable odors and produce irritation such as headache, eye tearing and nasal burning. Recent studies have shown that children exposed to high levels of VOCs are four times more likely to develop asthma than adults.[2] Other studies also have found an association between VOCs and asthma in children.[3] The U.S. Environmental Protection Agency and other public health advisories indicate one of the most effective ways of achieving good Indoor Air Quality is "source control," which involves the selection and use of nontoxic and low-emitting building materials and processes to minimize VOC emissions into the air. This, in combination with good building ventilation and controlled cleaning practices, significantly reduces indoor air pollution and improves overall Indoor Air Quality.[4]

UL's data revealed that the low VOC paint resulted in a greater than 90 percent reduction in total VOCs compared with the traditional industrial paint.[6]

Numerous products can contribute or off-gas VOCs into the air, including all flooring types, cleaning chemicals, furniture, printers, ceiling systems, wall coverings, paint, adhesives and sealants, and art supplies. One of the common products contributing to VOCs levels in the air is paint, which is frequently used to refresh school appearance and improve surface durability. The VOCs associated with paints and coatings can be either ingredients that are added to the paint to enhance product performance and shelf life or byproducts of the paint drying process.[5]

WHAT DID UL DO?

UL conducted two school demonstration studies at a public middle school in Savannah, Ga., to evaluate the impact that different types of paints have on Indoor Air Quality in educational environments. These studies were a collaborative effort among the Chatham County School District in Savannah, Ga., Sherwin-Williams Paints and Coatings, the Georgia chapter of the U.S. Green Building Council, and UL's GREENGUARD Environmental Institute. The first study evaluated the benefits of using a verified low-emitting VOC semi-gloss paint in schools, while the second study aimed to determine the effectiveness of a new paint specifically formulated to remove airborne VOCs from the classroom.

LOW-EMITTING VOC PAINT PERFORMANCE

Two separate classrooms were chosen for paint application, one with a standard industrial semi-gloss paint and one with a third-party certified low-emission, semi-gloss interior paint, meeting the requirements of the GREENGUARD Children and Schools standard, including the California 1350 Standard individual chemical requirements for chronic reference exposure levels.[7]

Paint was applied to each room by the school's maintenance staff using standard practices: Paint was applied to the walls with rollers, and brushes were used to paint trim, edges and other finishing requirements. Each room was painted at a unique time, and care was taken to ensure that ventilation systems in rooms were separate and did not introduce cross-contamination. VOC testing of each room was conducted prior to the paint being applied and following the complete application. Periodic monitoring extended for 14 days following the initial paint application.

Prior to application of the paints in the school, laboratory emission profiles were determined for each paint, using small environmental chambers following standard test and measurement protocols.[8] The paints were then evaluated in the laboratory for the identification and quantitation of VOCs, extending out to 14 days. Each of the paints contained the same tint color that would be applied in the school.

Airborne VOC levels in each classroom painted with the semi-gloss traditional and low-VOC formulations were studied over a 14-day period following application of the paints. Initial measurements were made one hour following paint application. The primary VOCs (top six) of each paint, as identified in the chamber emission studies, were individually tracked over time.

Environmental chamber studies showed a significant difference in total VOC emissions between the two paints studied and the length of time emissions were detected. The standard industrial semi-gloss paint showed initial Total VOC (TVOC) levels approximately eight times higher than the low-VOC, semi-gloss paint, with both exhibiting decreasing emissions over time. The low-VOC paint reached non-detectable levels within seven days and the standard industrial paint within 14 days. Individual VOCs varied among the paints. Primary emissions of the standard industrial paint included various siloxanes, acrylates, alcohols and aromatic solvents, and the low-VOC paint demonstrated emissions of glycols, other alcohols and numerous alkanes. Individual VOCs associated with the standard industrial paint were typically found at levels 10 times the magnitude of those measured in the low-VOC paint.

Table 1. Primary Paint VOCs Measured in Classroom After Painting
Standard Industrial Paint Concentrations (µg/m³)

ANALYTE	TIME AFTER PAINTING			
	1 HR	24 HR	7 DAYS	14 DAYS
• Cyclopentasiloxane, decamethyl	380	121	26	16
• Acetic acid, 2-ethylhexyl ester	250	35	18	12
• 1-Hexanol, 2-ethyl	230	35	8	3
• 2-Propenoic acid, 2-methyl-, butyl ester (Butyl methacrylate)	212	32	ND	ND
• Cyclotetrasiloxane, octamethyl	190	61	15	8

*ND = NOT DETECTED

Table 2. Primary Paint VOCs Measured in Classroom After Painting
Low-VOC Paint Concentrations (µg/m³)

ANALYTE	TIME AFTER PAINTING			
	1 HR	24 HR	7 DAYS	14 DAYS
• 1,2-Propanediol (Propylene glycol)	19	2	ND	ND
• Dipropylene glycol	14	3	ND	ND
• n-Butyl ether	13	ND	ND	ND
• Undecane	7	ND	ND	ND
• 1-Propanol, 2, (2-hydroxypropoxy)	4	ND	ND	ND

*ND = NOT DETECTED

This study shows that the low-VOC, semi-gloss paint contributed very low levels of VOCs to the air when compared to a standard industrial semi-gloss paint, as had been traditionally used by the school. This low-VOC paint's highest contribution to the classroom air was propylene glycol at 19 $\mu g/m^3$. All other contributing VOCs were lower in concentration. In addition, all individual VOCs were less than 5 $\mu g/m^3$ within 24 hours after paint application, and there were no detectable paint emissions seven days after application. In contrast, the standard industrial paint showed VOC contribution greater than 100 $\mu g/m^3$ for numerous individual VOCs, and some of these VOCs were still present in the classroom 14 days after paint application. There was no attempt in this study to evaluate the potential toxicity effect of the specific chemicals detected in these studies. However, total VOC load and relative levels of VOCs can be an indicator of expected human comfort and acceptance of the air quality. Higher-quality indoor air with lower chemical exposure and greater human comfort would be expected with use of the low-VOC paint.

UL found that paint formulated to specifically assist in the removal of airborne VOCs resulted in a 45 percent reduction in a classroom's airborne formaldehyde level.[9]

VOC-REDUCING PAINT COMPARISON

Study collaborators evaluated the effectiveness of a new paint specifically formulated to remove airborne VOCs from the classroom. This paint, identified as "Prototype," was used to paint a classroom at the same time as other classrooms were painted with either the traditional semi-gloss paint or the low-VOC, semi-gloss paint.

Measurements were made prior to painting and up to 336 hours following painting. The data showed a meaningful reduction of airborne formaldehyde, as demonstrated in Figure 1, for the classroom painted with the Prototype paint.

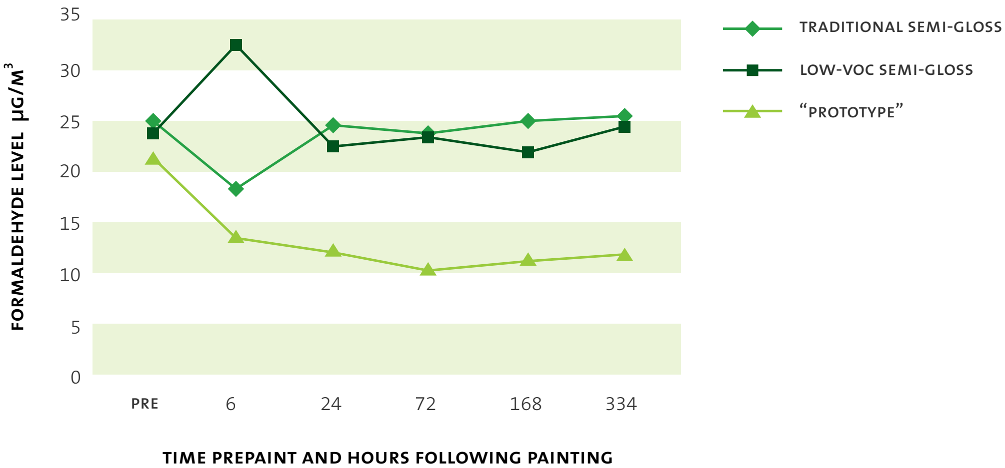
When comparing the average 5-day airborne levels for each classroom prior to painting to the 7-day (168-hour) average level, there was a 45 percent reduction in airborne formaldehyde in the room with Prototype paint. In contrast, there was no reduction of formaldehyde level in the room with the traditional semi-gloss paint and a 9 percent reduction in the room with the low-VOC, semi-gloss paint. The 9 percent reduction was not significant, because it was within the typical room formaldehyde concentration variations of 12 percent.

Table 3. Primary VOCs Measured in Classroom With Prototype Paint

ANALYTE	**TIME AFTER PAINTING**			
	1 HR	**24 HR**	**7 DAYS**	**14 DAYS**
• n-Butyl ether	11	ND	ND	ND
• Butyl propionate	6	ND	ND	ND
• 1-Butanol	4	ND	ND	ND
• Butylacetate	2	ND	ND	ND

*ND = NOT DETECTED

Figure 1. Formaldehyde Comparison Across Classrooms Following Application of Various Paints



MATERIALS/METHODS

Monitoring of VOCs: Airborne VOC samples were determined using gas chromatography with mass spectrometric detection (GC/MS). Chamber air was collected onto a sorbent tube, which was thermally desorbed into the GC/MS. The sorbent collection, separation and detection methodology had been adapted from techniques presented by the USEPA and other researchers. The technique followed standard measurement method[1/ \] 0987 0] that are generally applicable to C6-C16 organic chemicals with boiling points ranging from 35C to 250C. Measurements were reported to a quantifiable level of 1 µg/m^3. A TVOC measurement was made by adding all individual VOC responses obtained by the mass spectrometer and calibrating the total mass relative to toluene. Individual VOCs were quantified to authentic standards
if available; others were calibrated as toluene equivalents.

Product Testing and Verification: All paint products were chamber-tested according to the GREENGUARD "Standard Method for Measuring and Evaluating Building Materials, Finishes, and Furnishings Using Dynamic Environmental Chambers,"[11] and standard guidance for VOC measurements using environmental chambers.[12] The paints were applied to a standard wall substrate, and emissions of all general VOCs were measured and identified. Data from the emissions tests were used to track paint specific VOCs found in the freshly painted classrooms.

IMPACT

UL's research shows that significant improvements in Indoor Air Quality in school environments are possible by using paint products that are currently available and meet required performance characteristics for use in schools. These paints can minimize indoor air pollution loads and reduce health risks to both students and staff.

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