IMPACT OF PAINT ON IAQ IN SCHOOLS

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White Paper by
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Summary

The health and comfort of students and teachers are among the many factors that contribute to learning and productivity in the classroom, which in turn affect performance and achievement. Every effort is made to achieve good indoor air quality through proper design, construction and operation of a school. A typical cause of poor indoor air quality is volatile organic compounds or 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. One of the common products contributing VOCs into the air includes paints that are 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 they can be byproducts of the paint drying process. Studies of airborne VOCs were made in a public middle school before and after painting. The primary objective of the study was to compare airborne levels of VOCs when a traditional industrial semi-gloss paint was used on interior wall surfaces versus a new formulation of low emitting semi-gloss paint. The low emitting paint was compliant with the GREENGUARD Children and Schools emissions criteria and also met the recommended California chronic reference levels (CRELS) as traditionally specified in various green building programs. Airborne measurements of VOCs were made up to 14 days following painting. The data showed significant IAQ differences among the paints applied in the schools. The low VOC paint resulted in a greater than 90% reduction in total VOCs added within the 24 hours after application in comparison to the traditional industrial paint. In addition, all of the VOCs associated with the low VOC paint were below detectable levels within 7 days whereas emissions of the traditional paint could still be observed in the air after 14 days.

A secondary study evaluated the impact of using a “prototype “ paint formulated to specifically assist in the removal of airborne VOCs. Use of this paint demonstrated a 45% reduction in a classroom airborne formaldehyde level whereas the traditional and low VOC semi gloss paints did not demonstrate significant changes in airborne formaldehyde of their respective classrooms.

Keywords: VOC emissions; paint emissions; school study; VOC exposure

Introduction

Indoor air quality in schools

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 to 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 for a child than an adult. Asthma remains the leading cause of school absenteeism and hospitalizations in children under the age of 15. In a recent study, for example, children aged 5 to 17 years with at least one asthma attack in the previous year missed 10.5 million school days in that year.

The health and comfort of students and teachers are among the many factors that contribute to learning and productivity in the classroom, which in turn affect performance and achievement. Every effort is made to achieve good indoor air quality through proper design, construction and operation of a school. A key cause of poor indoor air quality is volatile organic compounds or 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 (Rumchev et al, 2004). Other studies also have found an association between VOCs and asthma in children (CARB, 2005). The US Environmental Protection Agency and other public health advisories indicate one of the most effective ways of achieving good IAQ is “source control” which involves the selection and use of nontoxic and low emitting building materials and processes that contribute minimal VOCs into the air. This in combination with good building ventilation and controlled cleaning practices significantly reduces indoor air pollution and improves overall IAQ.

Role of interior paints

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. Paint products, a common source of VOCs, are 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 they can be byproducts of the paint drying process. Currently, high quality, “low-toxicity,” and “low-VOC” paint and coating products with required performance characteristics are available for use in school environments. These paints minimize indoor air pollution loads and reduce health risks to both workers and occupants.

A school study

A school demonstration study was designed to evaluate indoor air quality benefits of using a verified low emitting VOC semi-gloss paint in educational environments. The study was conducted at a public middle school in Savannah, Georgia, during the fall. For the primary study, 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 individual chemical requirements for chronic reference exposure levels (GEI-GGPS.002, 2011 and CDPH, 2010).

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 to taken to ensure that ventilation systems among rooms were separate and did not introduce cross contamination. VOC testing of each room was conducted prior to the paint being applied and immediately following 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 (ASTM D 5116, 2009 and GEI, GGTM. P066, 2011). Each paint was evaluated for the identification and quantitation of volatile organic compounds (VOCs), extending out to 14 days. Each of the paints contained the same tint color as to be applied in the school.

An additional study was conducted to evaluate the effectiveness of a new paint specifically formulated to remove airborne VOCs in the classroom. This paint identified as "Prototype" was used to paint a comparative classroom. The measured IAQ in this classroom was compared to that of the other classrooms painted with the traditional semi-gloss paint and the low VOC semi-gloss paint.

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 methods (USEPA Method IP-1B,1999 and ASTM D 6196, 2009) that are generally applicable to C6 - C16 organic chemicals with boiling points ranging from 35°C to 250°C. 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," (GEI, GGTM.P066, 2011) and standard guidance for VOC measurements using environmental chambers (ASTM D5116, 2010). 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.

Results

Environmental Chamber Studies

Table 1 presents the TVOC levels measured from each primary paint over a 14 day study period. The paints remained in the environmental chamber during the complete study. In addition, primary individual VOCs found emitting from each paint are presented in Table 2.

Classroom VOC Studies

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 1 hour following paint application. The primary VOCs (top 6) of each paint, as identified in the chamber emission studies, were individually tracked over time. These results are presented in Tables 3 and 4 for the low VOC semi-gloss paint and the standard industrial semi-gloss paint. While this primary study was taking place, VOCs were also measured in the classroom with the "prototype" paint for comparison purposes. These results are shown in Tables.

Measured Time Point (Hr)	Standard Industrial Paint Emission Factor (μg/M^2•Hr)	Low Voc Paint Emission Factor (μg/M^2•Hr)
6	2172	286
24	502	32
48	272	7.7
72	155	2.1
96	127	2.0
168	90	--
336	51	--

Table 1. Chamber Emission Profiles Total Volatile Organic Compounds (TVOC)

Standard Industrial Paint		Low VOC Paint	
Analyte	Emission Factor (µg/M²•Hr)	Analyte	Emission Factor (µg/M²•Hr)
1-Hexanol, 2-ethyl	476	Undecane	29
Cyclotetrasiloxane, octamethyl	449	Ethylene glycol	23
2-Propenoic acid, 2-methyl-, butyl ester (Butyl methacrylate)	206	n-Butyl ether	22
Acetic acid, 2-ethylhexyl ester	152	1,2-Propanediol (Propyleneglycol)	18
1-Butanol (N-Butyl alcohol)	134	Dipropylene glycol	17
1-Hexanol (N-Hexyl alcohol)	95	Dodecane	13
Ethanol, 2-(2-butoxyethoxy)	79	1-Propanol, 2,2'-oxybis-	11
Chloroacetic acid, 2-ethylhexyl ester	58	1-Propanol, 3,3'-oxybis-	9
Benzene, ethyl	49	Cyclohexane, 1-ethyl-2-propyl	9
Xylenes	31	Cyclohexanone, 3-butyl-	9

Table 2. Primary VOCs Measured from Paint Emission Highest Emitting

Analyte	Time After Painting			
	1 Hr	24 Hrs	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

Table 3. Primary Paint VOCs Measured in Classroom After Painting / Standard Industrial Paint / Concentrations (µg/m3)

Analyte	Time After Painting			
	1 Hr	24 Hrs	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

Table 4. 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
n-Butyl ether	11	nd	nd	nd
Butyl propionate	6	nd	nd	nd
1-Butanol	4	nd	nd	nd
Butylacetate	2	nd	nd	nd

Table 5. Primary VOCs Measured in Classroom with “Prototype” Paint

Discussion

Low VOC vs. Traditional Paint Study

Environmental chamber studies showed a significant difference in total VOC emissions among the two key paints studied and the length of time emissions were detected. The standard industrial semi-gloss paint showed initial TVOC levels approximately 8 times higher than the low VOC semi-gloss paint, with both exhibiting decreasing emissions over time. The low VOC paint reached nondetectable levels within 7 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.

VOC Reduction Study

Measured VOCs in the classrooms painted with the traditional semi-gloss and low VOC semi-gloss paints were compared to those found in the classroom painted with the "prototype" 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.

Conclusion

This study shows that the low VOC semi-gloss paint used in this study contributed very low levels of VOCs to the air when compared to a traditional industrial semi-gloss paint, as had been used traditionally used by the school. This low VOC paint's highest contribution to the classroom air was propylene glycol at 19 ug/m3. All other contributing VOCs were less in concentration. In addition, all individual VOCs were less than 5 ug/m3 within 24 hours after paint application, and there were no detectable paint emissions 7 days after application. In contrast, the standard industrial paint showed VOC contribution greater than 100 ug/m3 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. Expectations of higher quality indoor air with lower chemical exposure and greater human comfort would be expected with use of the low VOC paint.

The VOC reduction study showed that airborne formaldehyde levels were significantly reduced in the classroom using the "prototype" paint. When comparing the average 5 day airborne levels for each classroom prior to painting to the 7 day (168 hr) average level, there was a 45% 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% reduction in the room with the low VOC semi-gloss paint. The 9% reduction was not significant since it was within the typical room formaldehyde concentration variations of 12%.

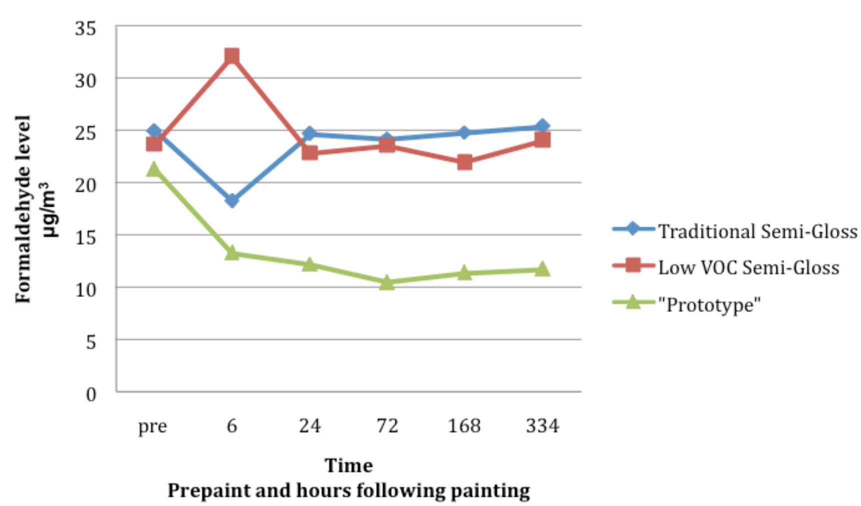

Figure 1. Formaldehyde comparison across classrooms following application of various paints

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