Formaldehyde Emissions from Flooring & Other Building Products: How to Test

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Introduction

Recent news has called into question the compliance of the composite wood cores of laminate flooring products produced in China to the requirements of the California Air Resources Board (CARB) Airborne Toxic Control Measure (ATCM) to control formaldehyde emissions from composite wood. Information regarding the regulation can be found on the CARB ATCM website: http://www.arb.ca.gov/toxics/compwood/compwood.htm. CARB also has published a fact sheet in response to the news regarding composite wood flooring at this link: http://www.arb.ca.gov/html/fact_sheets/composite_wood_flooring_faq.pdf.

Berkeley Analytical offers a wide range of testing services to address questions regarding formaldehyde emissions from flooring and other building products. Berkeley Analytical operates both small-scale and room-size environmental chambers and has a variety of methods in the scope of its ISO/IEC 17025 laboratory accreditation. Small-scale methods for building product samples that can be represented by small pieces are ASTM D6007, CDPH Standard Method V1.1, ANSI/BIFMA M7.1, and ASTM D5116. Large samples such as furniture items and cabinetry are tested by ANSI/BIFMA M7.1 and ASTM D6670. Additionally, very small pieces of products that are collected from buildings can be screened for formaldehyde emissions with micro-scale chambers by ASTM D7706. For all of these methods, formaldehyde is sampled and analyzed by ASTM D5197. This specific and sensitive method achieves very low detection limits, negligible blanks and high precision.

Berkeley Analytical's testing services are marketed primarily to product certifiers, product manufacturers, other levels of the product supply chain including importers, distributors, and retailers, large-scale users of products, such as home builders and contractors, and industrial hygiene companies performing building investigations. For consumers concerned about formaldehyde emissions from flooring they may have installed in their homes, we recommend they consult a fact sheet published by one of our industrial hygiene customers, Indoor Environmental Engineering, San Francisco at this link: http://www.iee-sf.com/pdf/LaminateFlooringFormaldehydeFactSheet.pdf.

To determine the most appropriate testing approach, first consider the primary objective or objectives of your investigation.

CARB ATCM Testing

If compliance of the composite wood core of a finished good such as flooring is your primary concern, then the product should be tested by ASTM D6007, which is recognized by CARB as a small-scale method for compliance testing of composite wood at the originating factory and as a quality control test method. This method produces a formaldehyde concentration in parts-per-million (ppm) that can be compared directly to the CARB ATCM Phase 2 Standard for the corresponding type of composite wood (Table 1). In most cases, the product will first need to be "deconstructed" to expose the composite wood component core. We follow the CARB standard operating procedure (SOP) procedure for finished good test specimen preparation (http://www.arb.ca.gov/enf/compwood_sop_fg_decon_091313.pdf). The size of the specimen needed for testing in our chambers varies with the type of composite wood (Table 1). Air temperature and relative humidity affect the emissions of formaldehyde from products with urea-formaldehyde resin. The standard conditions for the test are 25 ^{o}C and 50% relative humidity (RH). Small variations in these parameters are allowed and empirical conversion factors are provided in ASTM D6007 to adjust the final result to the standard conditions. The adjusted formaldehyde concentration in ppm can be converted to formaldehyde mass/volume concentration (µg/m^3) and also to an area-specific formaldehyde emission rate measured as mass of formaldehyde emitted per square meter of material per hour (µg/m^2-h) as shown in Table 1. An area-specific emission rate (i.e., Emission Factor) is a more useful metric than chamber concentration for understanding and comparing the emissions of formaldehyde from a product source. The conversion shows that the ATCM regulation allows MDF to have an emission rate that is a factor of 3.6 higher (i.e., 257 µg/m^2-h divided by 72 µg/m^2-h) than the limit for hardwood plywood (HWPW). The differential treatment of MDF by the ATCM regulation presumably results from data showing historically higher formaldehyde emissions from MDF.

Table 1. CARB ATCM Phase 2 standards in parts-per-million (ppm) for emissions of formaldehyde from three types of composite wood. Table also shows Phase 2 standards converted to mass/volume concentrations (µg/m^3) and emission factors (µg/m^2-h) at standard conditions.

Composite Wood Core Material	Phase 2 Standard (ppm)	Phase 2 Standard[a] (µg/m^3)	Q/A Ratio[b] (m/h)	Emission Factor (µg/m^2-h)	Exposed Area[c] (m^2)
Hardwood Plywood[d] (HWPW)	**0.05**	61	1.173	72	0.057
Particleboard (PB)	**0.09**	110	1.173	130	0.057
Medium Density Particleboard (MDF)	**0.11**	135	1.905	257	0.035

a. Mass/volume concentration at 25 ^{o}C, 1 atm pressure
b. Chamber inlet airflow rate (m^3/h) per square meter exposed surface (m^2) from ASTM D6007
c. For 67-L chamber operating at one air change per hour
d. Industrial HWPW panels

Test results for finished goods obtained by the finished good deconstruction SOP and ASTM D6007 likely are indicative of the formaldehyde emissions from the original composite wood core. However, it is noted that processes used in manufacturing of finished goods may, in some cases, contribute to the measured formaldehyde emissions of the core of a deconstructed product. Possible manufacturing sources of formaldehyde include application of acid-catalyzed finishes to wood veneers and use of urea-formaldehyde (UF) resin adhesives to bond finish layers to the core.

Indoor Air Quality Testing

If your primary objective is to understand the potential contribution of the flooring product or other building product to indoor air formaldehyde concentrations, then a different testing approach is required. Methods that measure the emissions of formaldehyde from the finished surface(s) of the product should be used.

In the U.S., the most widely cited and used test method and assessment standard for emissions of VOCs, including formaldehyde, from building products is CDPH Standard Method V1.1, 2010. Compliance with the CDPH Standard Method is required for the FloorScore™ certification program for hard-surface flooring materials (http://www.rfci.com/knowledge-center/floorscore/). By the CDPH Standard Method, a test specimen of a flooring material is prepared with only the top wear layer exposed to air. Berkeley Analytical prepares specimens of plank flooring, such as engineered hardwood and laminate flooring as specified in international standard ISO 16000-11 with one or two joints between adjoining planks included in the exposed surface. This helps to ensure that the test results are indicative of the VOC emissions of installed flooring as emissions from core materials can "leak" through the joints.

The CDPH Standard Method is conducted at 23 ^{o}C and 50% RH, which are considered to be representative of typical indoor conditions. Note that this temperature is two degrees lower than the tests used to determine CARB ATCM formaldehyde emissions. For urea-formaldehyde resin products, a formaldehyde concentration or emission factor measured at 23 ^{o}C can be converted to a concentration or emission factor at 25 ^{o}C by multiplying the result by 1.23 as described in ASTM D6007. The CDPH Standard Method attempts to measure the longer-term emissions of VOCs that can impact chronic inhalation exposures of building occupants. Thus, the time point of interest that determines the pass/fail outcome of a test is 14 days after the test specimen was first prepared.

For conformity assessment, chamber concentrations (µg/m^3) are measured and converted to emission factors by mass balance using the exposed surface area of the test specimen (m^2) and the chamber airflow rate (m^3/h). Then, indoor air concentrations in standardized building environments are modeled, again by mass balance, using the assumed installed product areas and the building airflow rates. The CDPH Standard Method has two standardized scenarios, a school classroom and a small private office. There also is an informative new single-family residence scenario. The guideline formaldehyde concentration in all of these scenarios is 9 µg/m^3, which is the chronic, non-cancer Reference Exposure Limit established by the California Office of Environmental Health Hazard Assessment (OEHHA). The current RELs and documentation supporting their development are available at the OEHHA website: http://www.oehha.ca.gov/air/Allrels.html.

Table 2 shows the maximum allowed formaldehyde emission factors for several categories of building products, including flooring, in the classroom, private office and residence. The residence scenario is highly conservative and serves to distinguish very low emitting products. For flooring, it assumes that the entire floor area is covered by the product under consideration and that the home ventilation rate is only 0.23 air changes per hour. Consequently, in order for a flooring product to comply with the 9 $\mu g/m^3$ limit for the residence scenario, formaldehyde emissions must be exceedingly low, i.e., 5.4 $\mu g/m^2$-h. Note that this emission factor is only a small fraction, i.e., 2%, of the CARB ATCM standard for an MDF core.

Table 2. Maximum allowable formaldehyde emission factors ($\mu g/m^2$-h) for flooring, ceilings and wallcoverings in CDPH Standard Method V1.1. Three building scenarios, a school classroom, a private office and a single-family residence, with different criteria are defined in the standard.

Product Type	Area-Specific Airflow Rate, Q/A (m/h)			Allowable Emission Factor ($\mu g/m^2$-h)		
	Classroom	Office	Residence*	Classroom	Office	Residence
Flooring	2.14	1.86	0.602	19.3	16.7	5.4
Ceilings	2.14	1.86	0.585	19.3	16.7	5.3
Wallcoverings	2.02	0.62	0.226	18.2	5.6	2.0

*Informative Appendix B, Tables B-1 & B-2; four bedroom home with 211 m^2 floor area, 547 m^3 volume & 0.23 h^{-1} air change rate

Building products are tested for their emissions of just formaldehyde using ASTM Guide D5116. The specimen and chamber parameters for an ASTM D5116 test are set to match the parameters for a CDPH Standard Method test so that equivalent results are obtained. Typically, the chamber portion of an ASTM D5116 test is conducted over 24 hours with different preceding conditioning periods depending upon the objective of the test, e.g., six days of conditioning at the test temperature, RH and airflow rate followed by a 24-hour test or 13 days conditioning followed by a 24-hour test. The test result is reported as an emission factor that can be compared to the emission factor limits shown in Table 2.

Similarly, large items such as pieces of furniture or cabinetry are tested for their emissions of VOCs and formaldehyde by consensus test methods. Furniture items are tested by ANSI/BIFMA M7.1 in either full-scale or, for items such as worksurfaces that can be represented by small pieces, in small-scale. BIFMA has several different acceptance criteria for formaldehyde emissions as described in ANSI/BIFMA X7.1 and ANSI/BIFMA Furniture Sustainability Standard e3. The e3 standard is used by the BIFMA "level" certification program (http://levelcertified.org/) to distinguish office furniture that exceeds typical environmental performance standards. The formaldehyde emission factor criteria in the BIFMA standards are summarized in Table 3. Large furniture and cabinetry units are tested for their emissions of just formaldehyde using ASTM Standard Practice D6670. The specimen surface area calculations and the chamber operating para meters for an ASTM D6670 test are set to match the parameters for an ANSI/BIFMA M7.1 test so that equivalent emission factor results are obtained.

Table 3. Maximum allowable formaldehyde emission factors (µg/m^2-h) for commercial office furniture in ANSI/BIFMA X7.1 and ANSI/BIFMA e3 Sections 7.6.2 and 7.6.3. Two office scenarios, a private office and an open-plan office, with different criteria are defined in the standards.

Office Scenario	Maximum Allowable Emission Factor (µg/m^2-h)		
	ANSI/BIFMA X7.1	ANSI/BIFMA e3, Sect 7.6.2	ANSI/BIFMA e3, Sect 7.6.3
Private Office	85.1	23	12.5
Open-Plan Office	42.3	11	6.2

Industrial Hygiene Testing of Field Collected Samples

Industrial hygienists preforming field investigations may need to test samples of building products that only can be obtained from the building. Often, the amount of available material is limited and may be less than the amount needed for the small-scale chamber methods described above. These samples may be screened for their emissions of formaldehyde using a micro-scale chamber procedure described in ASTM Standard Practice D7706. Micro-scale chambers operate on the same principles as the small-scale and full-scale chambers, but the chamber volume is less than 200 cm^3. The sample size can be as small as a circle 6.4 cm (2.5 inch) in diameter. This allows a sample of a product, such as flooring, to be obtained using a hole saw of this dimension. Formaldehyde emissions from either the finished surface of a product sample or from a composite wood core can be measured. For testing of the core, the finish layer of the sample is removed. The results are presented as formaldehyde emission factors that can be compared to the values in Tables 1 – 3, as applicable.

Submitting Samples to Berkeley Analytical

Contact Berkeley Analytical at info@berkeleyanalytical.com or call us at 510-2236-2325 (toll free 888-455-0999) to arrange for testing of flooring and building products for emissions of formaldehyde. One of our experts will assist you with your testing needs. Each product sample sent to the laboratory should be accompanied by our chain-of-custody (COC) form that clearly identifies and documents the sample (http://www.berkeleyanalytical.com/forms). The required sample size depends upon the test to be conducted. For an ASTM D6007 test of a plank flooring product, the minimum size is a plank 5-inch wide by 36-inch long. For a narrower plank, two pieces 36-inch long are required. For shipping convenience, the planks may be cut in half. Stack the planks or pieces together and wrap the stack in two layers of heavy-duty aluminum foil. The laboratory shipping address is shown in the upper left corner of the COC.