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OBSERVATIONS ON APPLICATION OF THE FIELD AND LABORATORY EMISSION CELL (FLEC) FOR LATEX PAINT EMISSIONS -- EFFECT OF RELATIVE HUMIDITY

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ABSTRACT

The U.S. Environmental Protection Agency (EPA) Air Pollution Prevention and Control Division (APPCD) has performed testing for products with different surface and mass transfer characteristics to evaluate the application of the Field and Laboratory Emission Cell (FLEC) for field studies. The goal of these tests has been to gain a better understanding of the effects of the FLEC operating parameters (e.g., high air exchange, high loading, low velocity). During recent tests, the impact of relative humidity (RH) on emissions from latex paint applied to gypsum board was investigated because RH may impact how the FLEC could be used in field studies. Dynamic emissions tests in small (53-l) chambers showed that RH levels in the chamber affected emissions of ethylene glycol, but had little impact on Texanol. The data suggested that the FLEC must be used with a humidified air source, which was demonstrated in a subsequent experiment. When operated with supply air at 50% RH, emissions measurements for ethylene glycol with the FLEC were comparable to results with small chambers, but Texanol measurements suggested that further evaluations are required.

INTRODUCTION

The Field and Laboratory Emission Cell (FLEC) was introduced to the indoor air research community approximately 5 years ago by Wolkoff et al. (1). Since then it has been shown to be a useful tool for measuring emission rates from a variety of indoor pollutant sources (2). The FLEC is a stainless steel disk with a lathed cavity having an internal diameter of 0.15 m and a volume of 3.5×10^{-5} m^3. A silicone foam O-ring seals the cell to the source integrating a surface area of 0.0177 m^2. It can be used for testing in a laboratory, but because it is portable its most useful application may be for onsite field emissions measurements.

It is well-recognized that the conditions used during emissions testing may have a significant impact on the emission rates. This is true of any type of test device, whether it be a small chamber, large chamber, or the FLEC. Operating parameters must be evaluated for each type of test method and source to be tested. Wolkoff et al. (1, 2) have evaluated the impact of various test parameters during validation of the FLEC. They have evaluated the effect of air exchange rate, air velocity, and loading factor in tests with the FLEC and by comparison to 234-l chamber testing. Other parameters, such as temperature and relative humidity (RH), may also affect emission rates. The effect of RH on emission rates from latex paint applied to gypsum board was of concern because use of the FLEC with low-cost dry air sources such as a compressed gas cylinder, although attractive from a standpoint of cost and ease-of-use, may

result in inaccurate measurements of emission rates.

Testing performed by the EPA has demonstrated a substantial effect of relative humidity for latex paint emissions in small (53-l) test chambers. In this work, tests were run with the FLEC to compare with small chamber results. The small chamber tests provide a better established and understood test method that can provide a point of comparison to demonstrate the applicability of the FLEC.

METHODS

Emissions tests were conducted in the EPA APPCD Source Characterization Laboratories using small (53-l) stainless steel chambers following established APPCD methods (3). The effect of RH was evaluated by performing 14-day tests in the small chambers using three different inlet relative humidity levels (at 23 °C). Emissions with the FLEC were evaluated in the laboratory at 50% RH and with dry air. Test conditions are described in Table 1.

Table 1 Test parameters for latex paint experiments with the FLEC and 53-l chamber

Parameters	53-l Low RH	53-l Medium RH	53-l High RH	FLEC Dry air	FLEC Medium RH
RH Inlet (%)	24	50	78	~4	50
Temperature (°C)	23	23	23	23	23
Air Exchange Rate (h^{-1})	0.5	0.5	0.5	516	571
Loading (m^2/m^3)	0.48	0.48	0.48	506	506
Wet Film Thickness(μm)	107	104	96	105	105

All tests were conducted using a single lot of flat latex paint and standard construction grade gypsum board purchased from a local retail outlet. The paint was applied with a standard paint roller.

For the 53-l chamber emission tests, the paint was applied to the gypsum board substrate and immediately placed in the chamber. The tests at low and high RH were performed over 2-week test periods. In other tests with the RH at 50%, emissions have been monitored for over 4000 hours (167 days). The FLEC test to compare use of dry air to supply air at 50% was conducted by mounting the FLECs on a piece of gypsum board that had been painted 1380 hours (58 days) prior to the test.

For field use of the FLEC, a test was conducted at APPCD's Indoor Air Quality Test House, a 3-bedroom ranch house maintained for conducting indoor air experiments. The test was conducted by placing the FLEC on a bedroom wall that had been painted 1512 hours (63 days) prior to the test. In the field test, the FLEC was mounted vertically in the center of the bedroom wall. Clean air was supplied to the FLEC at 23 °C and 50% RH during the test.

Air samples were collected on Tenax TA sorbent tubes during all tests. Texanol, 2-(2-butoxyethoxy)ethanol (BEE), ethylene glycol, and propylene glycol were quantified by gas

chromatography/flame ionization detection (GC/FID) (3,4). The emission factors for individual VOCs were directly calculated from the concentration data (5).

RESULTS AND DISCUSSION

Small chamber tests of the effect of relative humidity

Small chamber emission tests were conducted at low (24%) and high (78%) RH, and the results were compared to emissions measured under the standard test conditions of 50% RH (at 23 °C) in the air supplied to the chamber (inlet air). The effect of the inlet RH on ethylene glycol and Texanol emissions is shown in Figures 1 and 2, respectively. There was a moderate effect of RH on the Texanol emissions during the 350 hour test period. The effect was much more substantial for ethylene glycol. As shown in Figure 1, the peak concentration of ethylene glycol was higher at the low RH, but after the first 12 hours, emissions of ethylene glycol were higher in the chamber with the higher RH.

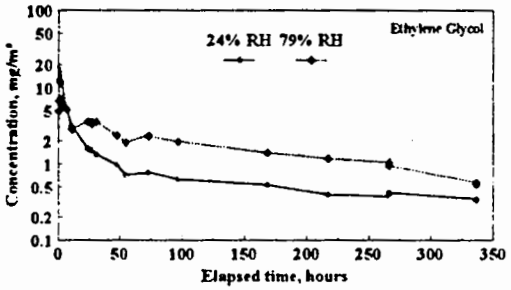

Figure 1 Effect of RH on ethylene glycol emissions from latex paint in small chamber tests.

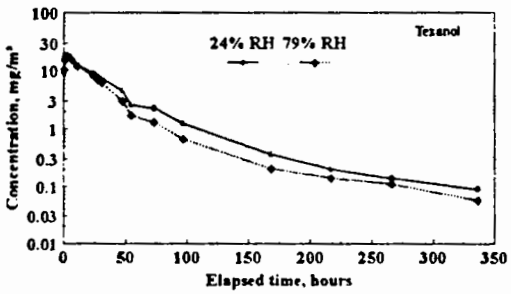

Figure 2 Effect of RH on Texanol emissions from latex paint in small chamber tests.

The impact of RH on peak concentrations is shown in Table 2. The peak concentration of ethylene glycol in the low RH test was 2.7 times higher than that in the high RH test. The peak concentration of propylene glycol was also substantially higher. RH, however, seemed to have little effect on the peak concentrations of Texanol or BEE. Despite higher peak concentrations of the glycols in tests at low RH, the total glycol emissions over the 2-week test were substantially lower at low RH, as shown in Table 3. The percent of the mass applied that was emitted during the first 2 weeks at low RH was less than half of that at the high RH for the glycols. There was no substantial difference for Texanol emissions at the different RH levels. The low percentage of the applied mass emitted from latex paint on gypsum board is related to a strong substrate effect that has been reported previously (3). The effect of RH is most substantial for the glycols, the compounds that are affected most by the substrate effect (3).

Table 2 Effect of relative humidity on peak concentrations (mg/m^3) of VOC emissions from latex paint applied to gypsum board.

Compound	Low RH (24%)	Medium RH (50%)	High RH (78%)	Ratio of Low/High
Ethylene glycol	18.4	8.95	6.76	2.7
Propylene glycol	3.11	2.04	1.61	1.9
BEE	6.34	5.31	4.66	1.4
Texanol	17.5	17.2	17.9	1.0

Table 3 Effect of relative humidity on percent of total mass emitted from latex paint applied to gypsum board during a 2-week test period.

Compound	Low RH (24%)	Medium RH (50%)	High RH (78%)	Ratio of Low/High
Ethylene glycol	8.2	12	18	0.46
Propylene glycol	7.1	17	22	0.32
BEE	11	13	18	0.61
Texanol	33	27	30	1.1

Effect of RH on FLEC emission measurements

The results of small chamber emission tests at different RHs suggested that the FLEC should not be used in field studies of latex paint with a dry air source. To evaluate the impact of RH on field measurements with the FLEC, two FLECs were placed side by side on a piece of gypsum board that had been painted with the same latex paint 1364 hours prior to the FLEC test. Dry inlet air (approximately 4% RH) was used for FLEC #1. FLEC #2 was operated with supply air at 50% RH. Emissions samples were collected 24, 150, and 194 hours after placing the FLECs on the test substrate. As shown in Figure 3, the emissions measurements were substantially different for the two FLECs. Emission rates with the FLEC operated at 50% RH were comparable to previous FLEC and small chamber experiments, but were an order of magnitude lower when the FLEC was operated with dry air. To verify that the observed differences were an effect of humidity and not some other operating parameter, the air supplies were switched at 1581 elapsed hours, so that FLEC #1 was operated with inlet air at approximately 4% RH and FLEC #2 was operated with inlet air at 50% RH. Another sample was collected after 94 hours. As shown in Figure 3, switching the air supplies confirmed the effect of RH on ethylene glycol emissions from the latex paint.

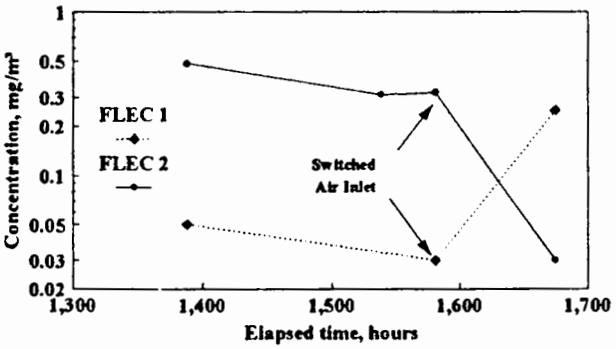

Figure 3 The effect of the change in the inlet air supply to the FLEC for ethylene glycol emissions from latex paint.

Application of the FLEC for field measurements

The FLEC was subsequently used at the EPA Indoor Air Quality Test House to measure emissions from latex paint that had been applied to gypsum board approximately 1500 hours (62.5 days) prior to the measurement. A humidified air source (23° C and 50% RH) was used to supply air to the FLEC. Results from the test were compared to previous laboratory tests with the FLEC for the same type and lot of paint and gypsum board and to interpolation predictions from small chamber data. Results of the comparison are presented in Table 4. Measurements of emissions with the FLEC at the test house agreed reasonably well for ethylene glycol and BEE with previous laboratory FLEC tests and predictions based on small chamber test data. Propylene glycol data agreed to a lesser extent. The small differences between the FLEC tests and the small chamber test may be related to variability in the substrate and paint applications, test conditions, and variability associated with the sampling and analysis method. However, as shown in the table, predicted Texanol emission rates were nearly four times higher than the laboratory FLEC measurements. The reasons for the differences are not known. Additional testing is required to better determine the relationship between emissions measurements with the FLEC and small chamber measurements.

Table 4 Emission factor comparison at 1500 elapsed hours (mg/m^2-h)

Test ID	Propylene Glycol	Ethylene Glycol	BEE	Texanol
Field FLEC Experiment[a]	0.0094	0.21	0.018	0.0041
Laboratory FLEC Experiment No. 1	0.018	0.28	0.021	0.0044
Laboratory FLEC Experiment No. 2	0.023	0.35	0.012	0.0046
53-l Chamber Experiment	0.018	0.23	0.013	0.017

[a] Average of duplicates collected 24 hours after FLEC setup (1500 hours after paint application).

SUMMARY

Small chamber emissions tests demonstrated that the RH used during testing can have a substantial impact on the emissions measured from latex paint applied to gypsum board both in small chamber tests and when using the FLEC. RH affected both peak emission concentrations and total emissions over a 2-week test period. The effect was more substantial for ethylene glycol and propylene glycol than for BEE. This effect may be due to the hydrophilic properties of the two glycols. There was little effect on Texanol.

The results of these limited tests indicate that, if the FLEC is used for field measurements, the impact of RH in the supply air must be considered. The results clearly indicate that use of a dry air source, such as a cylinder of compressed zero air, would not be suitable and will likely result in inaccurate measurement results. Additional research is required to more fully understand the impact of RH on emissions of VOCs from latex paint on gypsum board and for other indoor air pollutant sources.

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a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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Latex	Stationary Sources	11J
Paints	Latex Paint	11C, 13C
Emission	Field and Laboratory	14G
Humidity	Emission Cell (FLEC)	04B
Measurement		

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