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EPA's Indoor Air Quality Research Update

***Engineering Solutions to
Indoor Air Quality Problems
Symposium
July 17-19, 2000
Raleigh, NC***
(See Page 11 for Call for Papers)

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FUNGAL SPORES AND THE INFLUENCE OF HUMIDITY, VELOCITY, AND AMPLIFICATION ON EMISSION RATES

Although a significant amount of work has been done to elucidate the conditions under which fungi will grow on material surfaces, little information is available that quantitatively relates surface concentrations to airborne concentration and ultimately exposure. This article discusses the impact of relative humidity (RH), air velocity, and surface growth on the emission rates of fungal spores from the surface of contaminated material.

The two factors that were anticipated to have the most impact on emissions were air velocity and RH. RH controls the release of spores by some fungi. High RH is important for those active release mechanisms that depend on the rupture of turgid cells, while tissue desiccation in low RH is important to another class of release mechanisms. The velocity of air

flowing over fungal colonies is known to be important to dissemination both as a source of energy for liberation and to enhance mass transport for humidity-driven processes.

In previous experiments, we found that fungal emissions were influenced by complex interactions among RH, surface growth, and material characteristics. RH has a tremendous impact on the dissemination of both *Penicillium* and *Aspergillus* spores. Under the high RH conditions where growth occurred, there was little or no release of spores. However, as the RH was lowered, spore release was triggered. While the data are limited to these few cases, the potential impact of the results on current control and remediation practices was profound. Lowering uncontrolled RH is almost always a recommended practice. The data in this study point out that during remediation this could be the wrong strategy and could lead to increased short-term emissions.

The objectives of this study were to: 1) initiate experiments relating surface load or concentration (for new growth) to the emission of fungal spores, and 2) measure the impact of air velocity at a variety of RHs. The experiments were conducted in the Dynamic Microbial Test Chamber (DMTC). The DMTC is a room-sized test facility designed to conduct studies on the conditions and factors that influence biocontaminant emissions and dissemination. It is a cube with inside dimensions of 2.44 m, stainless steel walls and floor, and an acrylic drop-in ceiling. Temperature (18-32°C) and RH control (55 to 95%) are provided through an air handler unit (AHU) with an air circulation rate between 1.4 and 4.8 m³/min.

The chamber was adapted to contain eight miniducts as shown in Figure 1. The blower forces the conditioned DMTC air into a High Efficiency Particulate Air (HEPA) filter, from which the air for the eight miniducts is obtained. The channel design was chosen for the miniducts to limit the total amount of air required for a single test, allowing multiple tests to be run simultaneously, and simulate flow conditions in a heating, ventilating, and air-conditioning duct.

Three newly purchased common duct materials were studied: two fiberglass duct liners (FDL-A and FDL-B) and one fiberglass ductboard (FGD). In appearance, these duct liners were very similar, with an uncoated surface intended to be attached to a rigid duct material and a polymer coated surface intended to be in contact with the moving air in the duct. FDL-B contained a permanent (bound) antimicrobial in the coating of the airstream surface. *Penicillium chrysogenum* and *Aspergillus* were selected as the test organisms. *P. chrysogenum* has been reported as one of the most frequently isolated molds from the air, housedust, and surfaces of indoor environments, and has been isolated from a number of air-
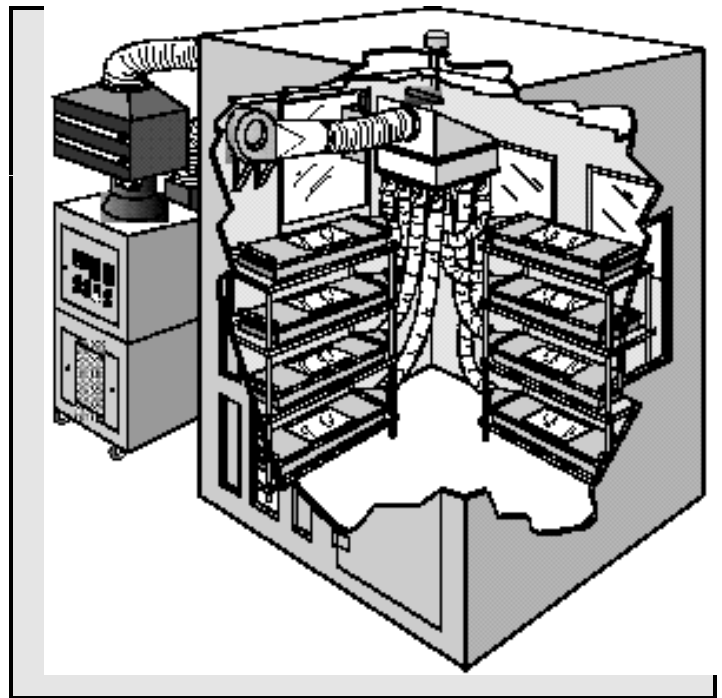
Figure 1. Dynamic Microbial Test Chamber.

conditioning systems in environments where patients were suffering from allergic disease. The materials were artificially soiled and then inoculated in an aerosol deposition chamber. The targeted amount of dust for deposition was approximately 100 mg dust/100 cm². This level has been considered moderately soiled in previous experiments and was selected to relate these data to previous experiments.

After artificial soiling and inoculation, the 30.5 x 91.4 cm (1 x 3 ft) pieces of test material were placed in the miniducts. Temperature and RH throughout the miniducts were maintained at 23.5°C and 94%, respectively. The air velocity through the miniducts was 2.5 m/s (500 ft/min). At the start of an emission rate determination, the chamber RH was lowered from 94% to the test RH (i.e., 64%) by lowering the RH setting on the AHU. Six isokinetic, 1-hour air samples were collected using the Mattson-Garvin slit-to-agar sampler for culturable bioaerosols. At the completion of each sixth hour sample, chamber RH was returned to the maintenance RH of 94%. No experiments were performed within 2 days of any other to allow the surface of the materials to recover from the decreased RH and to make certain the starting point for all emission measurements was the same. Surface samples were collected at weekly intervals, at least 1 day after the bioaerosol sample was collected.

Colony forming units (CFUs) were counted shortly after visible growth was first noted and again as moderate growth became apparent. To calculate the emission rates, the CFUs on the Mattson-Garvin plates were identified and enumerated, and the

CFUs/min were determined. The value was adjusted for the total flow rate and divided by the area of the emitting surface.

Figure 2 shows the impact of surface load during log-phase growth on the emission rates of fungal spores from the surface of the duct material using *A. versicolor* as the test organism. The test material, FDL-B, was inoculated with two different concentrations of *A. versicolor*. Emissions were measured at 64% RH. The columns represent surface growth and are referenced to the left axis as Log_{10} CFU/10 cm^2. The two levels of inoculum used are denoted as lower and higher. The lower inoculum was approximately 10^2 CFU/10 cm^2, and the higher inoculum was approximately 10^3 CFU/10 cm^2. Error bars are included for weeks 0 and 1 to show that no significant difference was measured between the levels of surface growth after the initial inoculation. The lines represent the spore emissions results and are plotted on a log scale against the right axis as CFU/m^2/min. None of the differences between the emission rates were significant except at week 3 (see error bars). When comparing the surface and the emission data, it is apparent that, for *A. versicolor* under these conditions, surface load directly influences the emission rate. In other words, as the surface concentration of organisms increased during log-phase growth, the emission rate increased until a stable population was reached, and then the emissions appeared to remain essentially constant.
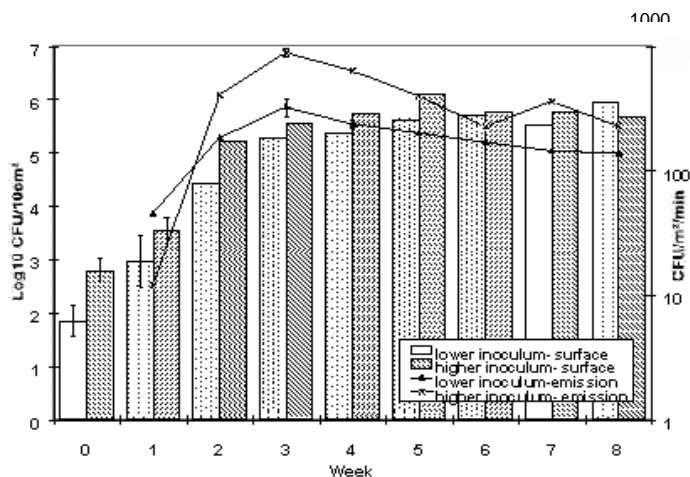
Figure 2. Surface growth vs. spore emissions for *A. versicolor* at lower and higher inoculum levels.

Tables 1 and 2 present the first hour emission rate for *P. chrysogenum* and *A. versicolor*, respectively. The surface concentration was monitored to document that a stable population of organisms had been established on the surfaces of all the materials for at least 12 weeks.

Table 1. Emission (CFU/m^2/min) of *P. chrysogenum* spores at four different airflow rates and RHs.

MATERIAL	RH %	AIRFLOW, m/sec.			
		0.5	1.0	1.5	2.5
FDL-B	64	9	13	409	804; 2023; 1249
	70	5; 1	28	228	972; 1480
	84	1	1	59	150
	94	2	5	124;127	81
FDL-A	64	610	155	465	813; 2392; 1501
	70	27;7	30	229	710; 1385
	84	0	25	234	287
	94	26	7	145; 75	69
FGD	64	13	20	88	333; 854; 267
	70	8; 1	6	17	335; 162
	84	1	0	50	12
	94	17	0	0	47

Table 2. Emission (CFU/m^2/min) of *A. versicolor* spores at four different airflow rates and RHs.

MATERIAL	RH %	AIRFLOW, m/sec.			
		0.5	1.0	1.5	2.5
FDL-B	64	1	11	45	170; 100; 190
	70	0; 1	1	25	60; 20
	84	0	1	0	0
	94	2	0	0; 0	11
FDL-A	64	24	44	52	43; 15
	70	11; 2	26	17	8; 14
	84	1	0	10	3
	94	0	0	0; 7	20
FGD	64	0	4	138	567; 151; 543
	70	0; 0	5	66	242; 182
	84	1	0	0	22
	94	2	0	0; 0	0

The first column lists the three different materials tested, and the second column lists the four RHs at which the emissions were measured. The final four columns show the emission rates for the two test organisms at the four airflows used in the study. In a number of cases (e.g., FDL-B, 64% RH at 2.5 m/s), multiple values, separated by a semi-colon, are reported. These values are replicate measurements from different experiments. In general, these data are in good agreement.

As shown previously, the emission rates were inversely related to the RH at airflows of 2.45 m/s. In other words, as the RH decreased, the emission rate increased. The current experiment generally confirms that relationship at the lower airflow rates.

However, once the emission rate becomes too low, the natural variability overwhelms our ability to measure a difference.

When the data from the different airflows are compared, the emission rate is related to the flow rate across the contaminated surface. As the flow rate increases, so do the emission rates. This was seen at all four humidities included in the study. Overall, the emission rates were notably lower for the *A. versicolor* than the *P. chrysogenum* regardless of RH or airflow.

While additional research will be required to relate these data to exposure, the emission rates measured in these experiments support data from our previous study, and modeling the results shows that the emission rates produced room concentrations consistent with field observations reported from the literature.

In summary, the results show a complex interaction of factors. For a limited data set, emission rates are inversely proportional to RH, but directly related to airflow and surface loading. This work was performed by Research Triangle Institute under cooperative agreement number 000000. (EPA Contact: Marc Menetrez, 919-541-7981, menetrez.marc @epa.gov)

EVALUATION OF POTENTIAL P2 APPROACH FOR REDUCING PHOTOCOPIER VOC EMISSIONS

This project is studying the potential for reducing the emissions of volatile organic compounds (VOCs) from office photocopy machines, through modifications to the raw materials or the manufacturing process used in producing the toners used in these machines.

In an earlier EPA report (EPA-600/R-98-080), concentrations of selected VOCs were reported in the head space (static) above samples from three lots of nominally identical toners, raised to temperatures as high as 150 ºC (the lower end of the range at which the copier fusing mechanism typically operates). According to the manufacturer, these three toner lots nominally had the same chemical composition, and were manufactured for use in the same copy machine. Yet the samples from one of the lots consistently provided head-space concentrations 50 to 80% lower than those from the other two lots, for each of four specific hazardous organic compounds that were measured. The four VOCs – styrene, ethylbenzene, o-xylene, and m,p-xylene – are likely impurities resulting from the polymer used in manufacturing the toners.

In the earlier report, it was noted that the toner lot producing the lower head-space concentrations had been manufactured using a continuous extrusion process, whereas the other two had been manufactured at different facilities using a batch process involving Banbury mixers. No information was available regarding the purity of the specific polymer feedstocks used in these manufacturing processes at different sites.

A follow-on study is now underway to better define the extent to which modifications to the toner manufacturing process might offer pollution prevention (P2) opportunities for reducing VOC emissions from photocopiers. This follow-on effort initially involves head-space testing on toner samples, as did the earlier effort discussed above, but addresses a larger number of samples in an effort to systematically separate out the effects of the different variables that could be impacting the observed results. These variables include:

1) *Manufacturing process.* Three processes appear to be commonly employed: continuous extrusion under vacuum; continuous extrusion at atmospheric pressure; and batch mixing (e.g., using a Banbury mixer).
2) *Purity of the feedstock polymer.*
3) *Time at which the toner sample was collected during the manufacturing run.* At issue is the inherent variability in toner characteristics over the course of a given run, with a fixed process and feedstock.
4) *Manufacturer and/or the machine for which the toner is being produced (which would impact the nature of the polymer and chemical composition of the toner).* If the manufacturing process or the feedstock purity is having a major impact on VOC emissions, is this impact consistent between vendors and toner types?

This study will address specific VOCs, in addition to the four listed above, if other compounds are also found at high levels in the head space.

If the results from this head space testing define an important and consistent impact of one or more variables on head space VOC levels, the study may be extended to include small chamber testing of VOC emissions from copied paper produced by a machine using both the lower- and the higher-emitting toners. The objective would be to assess the extent to which the lower-emitting toners would reduce VOC emissions into the office space from copied paper after it has left the photocopier room. (EPA Contact: Bruce Henschel, 919/541-4112, henschel.bruce@epa.gov)

TESTING OF IAQ SIMULATION SOFTWARE

An IAQ simulation software package, tentatively named the *Simulation Tool Kit for Indoor Air Quality and Exposure* or STKi, has recently started its beta test. STKi is a collection of Microsoft Windows-based IAQ simulation programs with similar user interfaces. It consists of a general-purpose simulation program and a series of stand-alone, special-purpose simulation programs.

The general purpose simulation program is designed to give the user the flexibility to simulate a wide range of indoor air pollution scenarios. It is capable of making multi-zone and multi-pollutant simulations and allows gas-phase chemical reactions.

The special purpose simulation programs deal with mass transfer models. In recent years, modeling of indoor sources has gradually shifted from simple, statistical models to more complex, fundamentally based models. While the latter provide improved accuracy and validity, their usefulness has been hindered by their increased complexity. Potential users may want to avoid unfamiliar equations and the tedious calculations behind them. The special-purpose simulation programs in STKi help resolve this problem by shielding the users from mathematical details and allowing them to concentrate on IAQ-related issues.

An array of good IAQ simulation programs have been developed and some can be easily obtained. STKi is not designed to replace them. Instead, it complements and supplements them. STKi is targeted mainly for advanced users, those who are directly involved in IAQ exposure estimation, risk assessment, or IAQ research. STKi is not an expert system. It is the user's responsibility to determine what model parameters to choose. Several emissions databases are being developed in Europe and North America. Those databases plus other sources can be useful tools in parameter selection. STKi does not predict the air movement inside a building, either. However, it does allow the user to input the airflow data from existing air infiltration or computational fluid dynamic models. The first public release of STKi is expected in the winter of 1999 and will include the five programs shown in Table 3.

Table 3. Programs included.

Carpet.EXE	a model for VOC emissions from new carpet
GPS.EXE	general-purpose simulation program
PM.EXE	a model for indoor particulate matter
Spill.EXE	models for indoor solvent spill
VBX.EXE	models for predicting VOC emissions from solvent-based indoor coating materials based on product formulation

The whole package will be developed in a cumulative manner. More special-purpose programs will follow. Some candidate programs currently under consideration are listed in Table 4.

Table 4. Programs proposed.

Chem. EXE	model shell for indoor air chemistry
Latex.EXE	latex paint emission models
Pest.EXE	fugacity models for indoor application of pesticides
Water.EXE	models for VOC emissions from water use (e.g., shower, washing machine, and dish washer)
WBC.EXE	models for water-based cleaners (liquid pool and wet film)

We welcome input from potential users, especially about their needs and the programs they would like included. (EPA Contact: Zhishi Guo, 919-541-0185, guo.zhishi@epa.gov)

EVAPORATIVE EMISSIONS IN VENTILATED ROOMS

VOCs are emitted from building materials, especially in many new buildings. Emissions occur in a chainlike process: diffusion inside the emitting material; crossing the surface-air interface; transport across the mass transfer boundary layer; and mixing into the bulk air. In any particular material, one of these processes may be rate controlling. For freshly applied liquid films, emissions are generally controlled by evaporation from the surface and depend on local airflow parameters such as temperature and velocity.

Experiments at different air velocity levels were performed in a full-scale ventilated chamber to investigate the influence of local airflow on evaporative emissions from a surface. The experiments included velocity measurements of the flow over the surface and measurements of chamber air concentrations. The research was conducted in IEMB's large chamber by Claus Topp of Aalborg University and was supported by the Danish Technical Research Council.

Experiments were performed at EPA in a full-scale ventilated chamber (4.0 x 2.8 x 2.6 m; 29 m^3). Four slots provide supply air to the chamber, one at the foot of each wall. Three of the inlet slots direct the flow upward along the wall, and the fourth inlet slot directs the flow along the floor. The return is located at the center of the ceiling.

The experiments were performed at two different velocities with temperature and RH kept fixed. In all experiments, the air exchange rate was 1 air change per hour (ACH), and the amount of recirculating air was changed to obtain different velocity levels in the chamber. Two experiments were performed at a total supply flow rate of 5 ACH (recirculation rate of 4 h^{-1}), and two experiments were performed at a total supply flow rate 2 ACH (recirculation rate of 1 h^{-1}).

In each of the experiments, a 1.48 m^2 wood board was placed at the center of the chamber floor. After conditioning, pure decane ($C_{10}H_{22}$, equilibrium vapor pressure $C_v = 12115$ mg/m^3 and molecular diffusion coefficient $D = 0.0207$ m^2/h) was applied to the top surface of the board. Smoke tests showed that the flow over the wood board was parallel to the surface. Velocity profiles were measured to obtain detailed knowledge of the boundary layer flow over the wood board. The profiles were measured with a hot-wire anemometer at the center of the wood board and at 250 mm east, west, north, and south of the center, respectively. The airflow in the chamber was from east to west.

The concentration of decane in the chamber air was determined by gas chromatography. Chamber air was pulled through sorbent traps at a known flow rate using mass flow controllers and a vacuum pump. Analytes were extracted from the traps with carbon disulfide (CS_2), and the concentration of decane in the extract was determined by injecting a subsample of the extract onto the column of a gas chromatograph equipped with a mass selective detector.
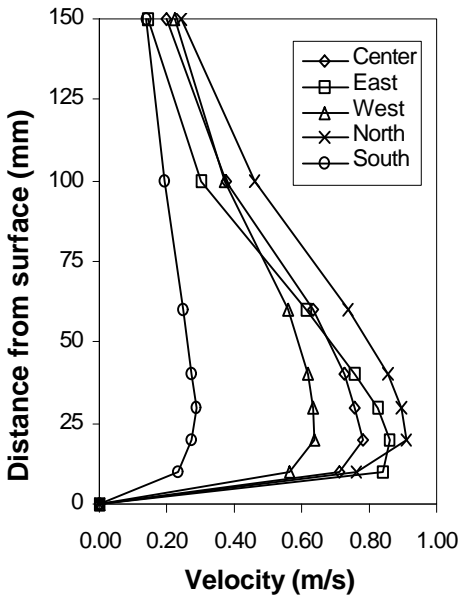
The velocity profiles over the wood board are shown in Figures 3 and 4, for 2 and 5 ACH, respectively. As expected, the maximum velocity decreases with distance from the inlet. The velocities at the north and south locations, though, are somewhat different indicating that the flow is not symmetric around the board. The difference increases with the flow rate. For 2 ACH, the maximum velocities occur approximately 3 cm above the surface and, for 5 ACH, they occur 2 cm above the surface. As the flow rate is decreased, the maximum velocities drop accordingly as shown in Table 5.

Table 5. Maximum velocities over the wood board.

ACH	Center (m/s)	East (m/s)	West (m/s)	North (m/s)	South (m/s)
2	0.27	0.32	0.22	0.23	0.17
5	0.78	0.86	0.64	0.91	0.29
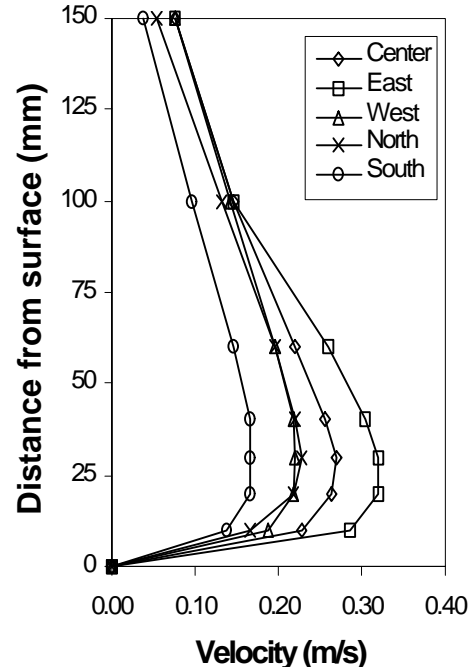
Figure 3. Velocity profiles over the wood board for 2 ACH.

Figure 4. Velocity profiles over the wood board for 5 ACH.

Table 6. Mass transfer coefficients from non-linear regression.

Experiment	k_e (m/h)	Std.Dev. (m/h)	Std. Dev (%)
1	10.29	0.84	8.2
2	11.07	1.29	11.7
3	4.01	0.19	4.7
4	3.64	0.21	5.8

Measurements of chamber concentrations over time show that chamber concentration reaches its maximum after approximately 0.5 h for 2 ACH and after 1 h for 5 ACH. Then the concentration drops rapidly within 10 h. In the early stage of the emission process, there is a significant difference between concentrations from one velocity level to another but after approximately 2 h the concentration levels are very similar. In general, there is good agreement between the experimental data and the model predictions using the mass transfer model developed by IEMB, but the model seems to predict lower peak concentrations. Concentrations from experiments with the same total supply flow rate are very similar although there is a 10 % difference between the peak concentrations for 2 ACH. For 5 ACH, there is a difference of 12 % in the amount of VOC applied but the difference in concentration is not as significant.

The emission rate can be conveniently expressed in terms of a mass transfer coefficient as shown in Table 6.The standard deviations from the regressions are within 12 %, which is satisfactory. The mass transfer coefficients from experiments with identical flow rates agree within 10 %.

Results also show that emissions, expressed in terms of the mass transfer coefficient, increase with velocity for fixed temperature, RH, and air exchange rate. This emphasizes the importance of testing materials at the correct velocity and turbulence level in order to obtain the actual emission rate for a given product.

As noted, the results agree with the IEMB model predictions and show that, after reaching its maximum, the chamber concentration drops rapidly within 10 h, which is consistent with previous results obtained by IEMB. IEMB studied the emission characteristics of a mixture of organic compounds, including decane, and concluded that the first phase of the emission process is controlled mainly by evaporation from the surface. After that, the decay rate slows as diffusion transport inside the material becomes the controlling mechanism of the emission process.

In summary, two experiments were performed at each velocity level, and the results are consistent, indicating a high level of repeatability. It was found that the velocity level in the boundary layer flow over the surface has a strong impact on the mass transfer coefficient as the mass transfer coefficient increases in proportion to the velocity. This emphasizes the importance of testing materials at the correct velocity and turbulence level to overcome scaling problems when transferring results from a small-scale test chamber to a full-scale ventilated room. (EPA Contact: Les Sparks, 919-541-2458, sparks.les@epa.gov)

SUMMARIES OF RECENT PUBLICATIONS

Controlling Souces of Indoor Air Pollution Through Pollution Prevention - This paper overviews recent research on the application of P2 techniques for improved IAQ: 1) developing methods and tools that can be used to evaluate emissions from equipment or products; 2) developing generic P2 solutions; 3) identifying high-emitting raw materials or components of products; and 4) evaluating low-emitting materials. Test method guidelines for measuring emissions from office equipment were developed and then evaluated by testing four dry-process copiers in one chamber and by conducting a four-laboratory evaluation using one of the copiers. For aerosol consumer products, measurement methods and models were developed that can be used to better understand aerosol behavior so that more efficacious and less toxic products can be developed. A generic, innovative spray nozzle for use with precharged aerosol containers was developed and evaluated. The new design allows for the reformulation of selected aerosol consumer products using water and air in place of VOC solvents and hydrocarbon propellants, respectively. High-emitting components of common types of finished engineered wood products were identified by evaluating emissions at each stage of the manufacturing process. Three fiber panels and three coatings were then identified as potential low-emitting alternative materials. Four types of printed circuit board laminates were evaluated. Glass/epoxy laminates and glass/lignin-containing epoxy resin laminates emitted fewer volatile compounds than the two paper/phenolic resin-based laminates. Source: Proceedings of the ASHRAE Conference, "IAQ & Energy '98. Using ASHRAE Standards 62 and 90.1 to Provide Acceptable Indoor Air Quality and Energy Efficiency" (EPA Contact: Kelly W. Leovic, 919-541-7717, leovic.kelly@epa.gov)

Emissions of Odorous Aldehydes from Alkyd Paint - Odorous aldehyde emissions from a commonly used alkyd paint were measured and characterized. Initial formulation analysis indicated no measurable aldehydes in the liquid paint. However, small environmental chamber tests showed that, for each gram of the alkyd paint applied, more than 2 mg of aldehydes (mainly hexanal) were emitted during the curing (drying) period. The emission profiles of aldehydes were very different from those of other VOCs such as alkanes and aromatics. Since no measurable aldehydes were found in the original paint, it is suspected that the aldehydes emitted were produced by autoxidation of the unsaturated fatty acid esters in the alkyd resins. It was found that the hexanal emission rate can be simulated by a mathematical model assuming that the autoxidation process was controlled by a consecutive first-order reaction mechanism. The mathematical model was used to predict the indoor air hexanal concentrations for a typical application of the alkyd paint tested. The result indicated that the aldehyde emissions can result in prolonged (several days) exposure risk to occupants. The occupant exposure to hexanal emitted from alkyd paint also could cause sensory irritation and other health concerns. Atmospheric Environment, **32**, 20, 3581-3586, 1998. (EPA Contact: John Chang, 919-541-3747, chang.john@epa.gov)

Estimation of the Rate of VOC Emissions From Solvent-Based Indoor Coating Materials Based on Product Formulation - Two computational methods are proposed for estimation of the emission rate of VOCs from solvent-based indoor coating materials based on the knowledge of product formulation. The first method utilizes two previously developed mass transfer models with two key parameters -- the total vapor pressure and the average molecular weight for total volatile organic compounds (TVOCs) -- being estimated based on the VOC contents in the product. The second method is based on a simple, first-order decay model with its parameters being estimated from the properties of both the source and the environment. All the model parameters can be readily obtained. Detailed procedures for computing the key parameters are described by using examples. The predictive errors were evaluated with small chamber data, and the results were satisfactory. Thus, the proposed methods provide a way to predict the VOC emissions in the indoor environment without having to conduct costly chamber testing. The two proposed methods work for both TVOCs and individual VOCs. Pros and cons for each method are discussed. Source: *Atmospheric Environment*, Vol. 33, No. 8, pp. 1205-1215, 1999. (EPA Contact: Zhishi Guo, 919-541-0185, guo.zhishi@epa.gov)

Exposure and Emission Evaluations of Methyl Ethyl Ketoxime (MEKO) in Alkyd Paints - Small environmental chamber tests were conducted to characterize the emissions of a toxic chemical compound -- methyl ethyl ketoxime (MEKO) -- from three different alkyd paints. It was found that MEKO emissions occurred almost immediately after each alkyd paint was applied to a pine board. Due to the fast emission pattern, more than 90% of the MEKO emitted was released within 10 hours after painting. The peak concentrations of MEKO in chamber air correlated well with the MEKO content in the paint. Material balance showed that good recovery (more than 68%) was achieved between the MEKO applied with the paint and the MEKO emitted. The chamber data were simulated by a first order decay emission model assuming that the MEKO emissions were mostly gas-phase mass transfer controlled. The model was used to predict indoor MEKO concentrations during and after painting in a test house. It was found that the predicted test house MEKO concentrations during and after the painting exceeded a suggested indoor exposure limit of 0.1 mg/m^3 for all three paints. The predicted MEKO concentrations exceeded even the lower limit of a suggested sensory irritation range of 4 to 18 mg/m^3 with two of the three paints tested. The model was also used to evaluate and demonstrate the effectiveness of risk reduction options including selection of lower MEKO paints and higher ventilation during painting. Source *Indoor Air*, **8**, 295-300, 1998. (EPA Contact: John Chang, 919-541-3747,chang.john@epa.gov)

Indoor Emissions from Conversion Varnishes - Conversion varnishes are two-component, acid-catalyzed varnishes that are commonly used to finish cabinets. They are valued for their water- and stain-resistance, as well as their appearance. They have been found, however, to contribute to indoor emissions of organic compounds. For this project, three commercially available conversion varnish systems were selected. An EPA Method 24 analysis was performed to determine total volatile content, and a sodium sulfite titration method was used to determine uncombined (free) formaldehyde content of the varnish components. The resin component was also analyzed by gas chromatography/mass spectroscopy (GC/MS) (EPA Method 311 with an MS detector) to identify individual organic compounds. Dynamic small chamber tests were then performed to identify and quantify emissions following application to coupons of typical kitchen cabinet wood substrates, during both curing and ageing. Because conversion varnishes cure by chemical reaction, the compounds emitted during curing and ageing are not necessarily the same as those in the formulation. Results of small chamber tests showed that the amount of formaldehyde emitted from these coatings was 2.3 to 8.1 times the amount of free formaldehyde applied in the coatings. A long-term test showed a formaldehyde emission rate of 0.17 mg/m^2/h after 115 days. Source: Journal of the Air & Waste Manage. Assoc. **48**: 924-930, 1998. (EPA Contact: Elizabeth M. Howard, 919-541-7915, howard.betsy @epa.gov)

GLOSSARY

ACH - Air Change per Hour
AHU - Air Handling Unit
CFU - Colony Forming Units
DMTC - Dynamic Microbial Test
    Chamber
FDL - Fiberglass Duct Liner
FGD - Fiberglass Ductboard
GC/MS - Gas Chromatography/Mass Spectography
HEPA - High Efficiency Particulate Air
IAQ - Indoor Air Quality
IEMB - Indoor Environment Manage-
  ment Branch

MEKO - Methyl Ethyl Ketoxime
NRMRL - National Risk Management
    Research Laboratory
P2 - Pollution Prevention
RH - Relatiive Humidity
STKi - Simulation Tool Kit for IAQ
    and Exposure
TVOC - Total Volatile Organic
    Compound
VOC - Volatile Organic Compound

ERRATA

Please note the following typographical errors in the Spring/Smmer '98 issue of *Inside IAQ*. Table 4, Page 7, the first column, the entry "Formaldehyde" should be "Formaldehyde*" and the entry "Formaldehyde*" should be "Heptachlor."

Call for Papers

Engineering Solutions to Indoor Air Quality Problems

Engineering Solutions to Indoor Air Quality Problems, an international symposium cosponsored by the Air and Waste Management Association and EPA's National Risk Management Research Laboratory, will be held **July 17-19, 2000**, in Raleigh, NC, at the Sheraton Capital Center. Papers are invited on the following topics:

❗ Managing the Risk of Indoor Air Pollution	❗ Ventilation
❗ Indoor Air Source Characterization Methods	❗ HVAC Systems as Sources of Indoor Air Pollution
❗ Indoor Air Source Management	❗ Air Duct Cleaning
❗ Low Emitting/Low Impact Materials Development (Pollution Prevention)	❗ Particles and Particle Entry into the Indoor Environment
❗ Biocontaminant Prevention and Control	❗ Indoor Air Quality Modeling
❗ Indoor Air Cleaning Methods	❗ Costs of Managing Indoor Air Quality
❗ Asthma and Children's Health in the Indoor Environment	❗ Evaluation and Verification of IAQ Alternatives

The symposium will consist of one general session so that participants will be able to attend all sessions. A poster session, continuing education courses, and an exhibition of related products and services are also planned.

Send abstracts of 200-300 words by January 10, 2000, to: Michael C. Osborne, U.S. EPA, MD-54, Research Triangle Park, NC 27711; Telephone (919)-541-4113; Fax (919)-541-2157; E-mail: osborne.michael@epa.gov. Abstracts should include paper title and author(s) names, address(es), and phone, fax number(s), and e-mail address.

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