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Formaldehyde Emitted From Wood Boards and How to Measure its Concentration.

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Preface.

On the March 1st, 2015, CBS News' 60 Minutes reported that wood flooring sold by Lumber Liquidator contains levels of formaldehyde which exceed the levels permitted in the USA. The report was based on tests of samples of boards sold commercially by Lumber Liquidator in California. http://www.cbsnews.com/news/lumber-liquidators-linked-to-health-and-safety-violations/. The formaldehyde-oozing boards which tested positive for formaldehyde were manufactured in China. Global Community Monitoring tested the composite boards for formaldehyde and provided a very valuable service to the community. http://www.gcmonitor.org/llprop65pr/.

Exposure to formaldehyde causes breathing difficulties and irritates the eyes and throat. The US Environmental Protection Agency, EPA, considers formaldehyde a "human carcinogen". Therefore, a remedial action may be required in houses where an excessive concentration of formaldehyde is found. In order to reduce the exposure of dwellers of homes to formaldehyde, one has first to design a sampling procedure for the air in the house and to measure the formaldehyde concentration. The formaldehyde level has to be evaluated and used in conjunction with known standards to decide if the formaldehyde concentration presents an eminent danger to the dwellers and if remedial steps have to be taken to mitigate the danger due to the exposure.

Many of the aspects associated with obtaining the required facts on this matter are discussed below and suggestions are made relative to the best ways to reach an informed decision to address the matter based on facts rather than fear.

Equipment for Measuring Formaldehyde Concentration in Air.

Four categories of equipment for measuring formaldehyde concentration in air are used. These equipment are listed in the order of their ranking as efficient tools for determining formaldehyde in houses. **Table #1** lists their main features and **Table #2** lists their advantages and disadvantages. More explanations follows the tables.

Table #1: Main Attributes of Formaldehyde Measuring Devices.

	Category	What it Measures?	How results are obtained?
1	Direct-Read Passive Dosimeters, DRPD. The exposure to formaldehyde changes the color of the dosimeter. Larger exposure dose produces more intense color.	Exposure Dose, ppm*hr and Time Weighted Average concentration, TWA.	Visible color develops and can be seen by the user. Dosimeters can be sent back for digital analysis.
2	Passive dosimeters to collect the sample. The dosimeters have to be sent back to supplier for analysis & obtain results	Exposure dose is obtained ONLY at the end of the measurement.	The collected sample is analyzed by GC-MS days after it was collected
3	Active sampler with a pump and computing capacity	Exposure dose and concentration are measured	Concentrations and dose results are obtained on site.
4	Active sampler with a pump but without computing capacity	Collects sample. Displays concentration	Data are collected and displayed on site

Table #2: Advantages and Disadvantages of the Main Formaldehyde Measuring Devices

#	Size	Weight	Cost	Ease of Use	Supplier
1	Credit card	Very small 4 gm	Low cost	Very easy	http://formaldehydetests.com/formaldehyde-gas-exposure
2	Match box to cigarettes box	Larger 40-200 gm	More Expensive	Very easy	Many.
3	Electronic meter with computing capacity, memory	Large 250-450 gm	Very expensive	Requires trained user	Many.
4	Electronic meter Without computing capacity	Large 250-450 gm	Expensive	May require trained user	Many.

The small size of Chemsee's formaldehyde dosimeters, their low-cost and the fact that they allow a user to visually estimate the dose of formaldehyde that they were exposed to make them most suitable for use by home owners to assess the magnitude of formaldehyde in their homes.

Considerations Relative to Measuring Formaldehyde in a House and its Emission From Wood Flooring, Curtains, Carpets etc. Where and for How Long to Place a Detector/Sampler?

The formaldehyde concentration in the air of an occupied dwelling is NOT uniform in space or constant relative to time. This concentration may vary from one location to another as well as vary during the day. Air handling systems, such as air conditioners or heaters, may bring fresh air into the house through vents and distribute it in different ratios in areas close to doors or air conditioning vents within the room or the a house. Opening doors or windows brings fresh air in and dilutes the formaldehyde concentration to a greater extent than areas further away from the door. Furthermore, changes in the external air temperature changes the time interval of turning on and off heaters and air conditioners and thus influences the rate of dilution of the air inside the house. For these reasons, measuring the formaldehyde concentration at a random location and/or for a short period of time, as many common instruments do, is unlikely to provide a meaningful answer regarding the exposure level.

The locations where measurements are taken have to be selected carefully. Ideally, several measuring devices should be used at different locations. The detectors should be of a type that allows estimation of the formaldehyde dose CONTINUALLY. These devices have to remain in place for at least 24 hours to account for variations in concentrations during the day.

A meaningful sampling protocol has to be designed and implemented and should provide answers to the questions one is trying to address. These measurements should be oriented toward trying to find a practical and cost effective method to reduce the exposure of the dwellers. Formaldehyde detectors which allow users to estimate in real time the exposure dose near them are particularly useful. The reason is that the objective of interest in many cases is to know the amount of formaldehyde that a dweller breathed and its physiological impact on their health. In general, a sampling location should be selected that permit users to estimate the MAXIMAL exposure dose that a person may be exposed to. If this dose is smaller than that permitted for exposure of the general public, one may assume that the exposure anywhere will not endanger the dwellers.

The allowable average formaldehyde concentration that a CIVILIAN dweller may be exposed to safely is 0.075 ppm. (Parts per million) or 75 ppb, (Parts per billion). Typically, urban air may contain up to 3-4 ppb formaldehyde. As a working guide, we recommend that:

1. If the 24 hrs average formaldehyde concentration, denoted TWA24, in locations most likely to have large formaldehyde concentration, is below 5 ppb, the air should be considered safe.
2. If the TWA24 is over 75 ppb, mitigation or remediation strategy should be used to reduce the exposure dose.
3. ANYTIME that a TWA24 greater than 20 ppb, we recommend that the tests be repeated, and repeated also in different locations, to ensure that local variations in air flow or the selection of the sampling location did not bias the measurement down.

Other objectives of sampling the air may include:

a. Trying to determine if a remediation step indeed resulted in reducing the formaldehyde concentration and exposure.
b. Trying to determine the amount of formaldehyde that a floor board is emitting, and if the emission exceeds a given standard.
c. Trying to determine the difference in the formaldehyde concentration between different rooms, e. g. rooms where wood floor boards were placed versus rooms where no floor boards were placed.
d. Trying to determine the effect of changes in the ventilation, heating or air conditioning on the exposure level.

Where to Place a Formaldehyde Dosimeter and What to Do to Ensure Obtaining Reliable Results?

Formaldehyde dosimeters are placed where the information obtained is most useful. Care should be taken however to make sure that the dosimeter is NOT placed too close to an air conditioning vent line, near a door that is opened often, or in a place where the air is stagnant and is not moving at all. In all cases make sure that the side of the ChemSee.com dosimeter which has the opening in the plastic is fully open to the air. The side WITHOUT the printed color should be open to the air. Examples where to place a dosimeter are:

1. Attached to a bed sheet or frame about one foot from the floor. Make sure that the dosimeter is open to the air and NOT covered by the sheets.
2. One may attached light dosimeters such as ChemSee.com dosimeters to the collar of a person near the breathing area. The exposure recorded in this manner measures the dose that the wearer actually breathed.
3. On a support about 1-1.5 foot from the floor in areas where new wood floor or paneling was installed. Make sure that the open area of the dosimeter is fully available for air to diffuse in.
4. Hung to curtains, in particular new curtains.

Right before you are ready to start the test, not before, cut the narrow side of the metallic envelope in which the dosimeter was sent. Make sure that the envelope will be as whole as possible so that you will be able to send the dosimeter back for digital analysis. In all cases make sure to write exactly the starting time and date when the dosimeter was placed in service and the time and date when it was placed back in the shipping envelope and sealed.

Where Formaldehyde is Used?

Formaldehyde is a very volatile, water soluble common chemical which is used in many products including glues and polymers, wood and composite particle boards, flooring materials, certain carpets and curtain materials, embalming fluid in morgues, disinfectants and preserving material for biological tissues etc. The main reason for the disinfectant properties of formaldehyde is that it stunts the growth of bacteria and kills viruses. In this way, it eliminates bacteria that can react with the tissue and thus helps preserve flesh tissues, small animals etc. This has been the practice for years in biology/pathology laboratories etc. Obviously, toxic materials that can kill cells of bacteria will be toxic to human cells too.

Regulatory Aspects of Exposure to Formaldehyde.

The US Environmental Protection Agency, the US EPA, considers formaldehyde a "Known Human Carcinogen" http://www.epa.gov/airtoxics/hlthef/formalde.html, and the US Occupational Safety and Health Administration, OSHA, restricts the amount of formaldehyde vapors that workers may be exposed to during work. https://www.osha.gov/OshDoc/data_General_Facts/formaldehyde-factsheet.pdf. The occupational exposure standard for people who work eight hours a day year around in environment containing formaldehyde vapors is 0.75 parts per millions, ppm. This limit is called Permissible Exposure Limit or PEL. Exposure up to 2 ppm formaldehyde for a short time, 15 minutes, is allowed in occupational setting. This limit is called STEL, for Short Term Exposure Limit. The combined daily exposure dose may not exceed 6 ppm*hr per DAY, due to short or long term exposure. In the last 30 years, the occupational exposure limits for formaldehyde have been revised down time and again, as the biological hazards due to exposure to formaldehyde have been understood better.

The PEL for formaldehyde exposure of the general public is taken as 10 % of the occupational PEL, i. e. 0.075 ppm instead of 0.75 ppm. This is because the general public includes children, elderly people, pregnant woman and people with compromised health. These groups are more susceptible to being affected by the exposure to formaldehyde. In addition, much of the general public stays in their house for more than 8 hours a day and are more likely to be exposed to the vapors for longer than 8 hours. In addition, the general health of the public at large is presumed not as good as that of working people and it is not right to expose them to harmful vapors just because they stay in their houses.

Health effects of Formaldehyde.

The adverse health effects of exposure to formaldehyde include negative effects which can be seen in a relatively short time and effects which can be seen only long time after the exposure. Breathing difficulties, tearing eyes, scratchy throat are observed in a short time if the formaldehyde concentration is high. Long term exposure increases the probability of certain types of cancer and possibly of birth defects and reduced cognitive functions. The physiological harm increases as the exposure dose to formaldehyde increases. This increase happens the exposure concentration is greater and/or when the exposure time is longer. The product of the exposure time and the time-weighted average concentration, the TWA, is the exposure dose. The physiological harm increases dramatically as the exposure dose increases, i. e. the medical harm is not linearly proportional to the exposure dose. The human body can accommodate limited exposure to small doses of formaldehyde for a short period of time without showing a negative effect in a time scale of weeks or even months. However, any incremental exposure causes physiological harm and can result in immediate sickness. Some people are much more sensitive than others to the adverse effects of formaldehyde. Professor W. C. Monte in his book "while Science Sleeps" attributes many illnesses to formaldehyde formed in the body when aspartame is digested as a sweetener.

Formaldehyde and Composite Boards or Flooring Panels.

Composite boards, flooring and other building materials use formaldehyde-based polymers in two main capacities: As the glue that holds wood particles together and as a component of coatings of the wood boards, paints and varnishes. The three most important polymers used in these capacities are urea-formaldehyde, UF, Phenol-formaldehyde, PF, and melamine-formaldehyde. MF. Formaldehyde may be emitted from these polymers if they were not properly polymerized, sealed, if unreacted residual formaldehyde was retained in the polymer and several other reasons. Vapors of formaldehyde will be emitted if "free" formaldehyde is present in the board or if conditions exist that the polymer can decompose. In general, the amounts of formaldehyde emitted will decrease as time goes by but physiological damage will inflict the breathing personnel as long as there is emission from the board. Vigorous ventilation will decrease the effective concentration breathed and may accelerate the removal of formaldehyde. However, this will come at a cost: Increased energy bills.

Information On ChemSee.com/Appealing Products Dosimeters and Detectors for Toxic Gases.

The formaldehyde detectors/dosimeters made by Appealing Products Inc., API, and sold on the Internet by www.ChemSee.com. At http://formaldehydetests.com/ we provide the best of both worlds: It is a small, low-cost device and it gives a continued accurate measure of the exposure dose to formaldehyde. http://formaldehydetests.com/index.php?route=product/product&product_id=53. Another advantage is that API's detectors can be used at home by the home owner and thus significant cost may be saved.

Appealing Products Inc. API, and Dr. Attar developed and patented some of the original Direct-Read Passive Dosimeters for the US Department of Defense and the Department of Energy. (US. Patents US4840919 and US4772560) API developed direct read dosimeters and detectors for other gases and air pollutants. Please see: http://chemsee.com/. In addition to observing the color change with the eyes, API developed also an electronic reader which allows quantification of the measured value. This service is offered for free to buyers of API's/ChemSee passive dosimeters. Using the digital reader, a quantitative analysis is available down to concentrations as low as a few ppb. (Parts per BILLION). http://formaldehydetests.com/formaldehyde-gas-exposure. Once API receives a dosimeter back, it analyzes quantitatively the exact exposure dose and submits a report to the customer via e mail. In some cases, API offers suggestions on remediation action as needed to reduce the exposure to formaldehyde, chlorine and to other gases.

API/ChemSee.com has similar direct-read dosimeters for other gases too. Please see: http://formaldehydetests.com/. Dr. Attar invented this technology and patented it. I have the patent on the technology). Please see: http://chemsee.com/exposure-monitoring/products/dosimeters/.

API/Chemsee.com developed and sells other detectors for formaldehyde, e. g. formaldehyde in food such as fish. API discovered that about 25 % of fish imported from China contains formaldehyde. Please see: http://www.newsobserver.com/2013/09/10/3183900_raleigh-researchers-create-quick.html?rh=1