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CHAIRMAN'S SUMMARY, SESSION II

CHARACTERIZATION OF EMISSIONS FROM BUILDING MATERIALS, BUILDING OCCUPANTS AND CONSUMER PRODUCTS: LABORATORY STUDIES

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Introduction

Measurements of emission rates of air pollutants such as radon, formaldehyde, volatile organic compounds or pesticides originating from building materials, consumer products, etc., are performed in many laboratories using different types of test benches and test protocols. This summary of the principles and strategies for laboratory studies on these emissions aims to outline a generally useful test protocol and the research needed to further develop the procedures.

Most tests published to date are based on protocols including an element of research in methodology, together with the aim of emission characterization. In some cases they were initiated as pretests or screening tests, where little attention was given to a discussion of the general relevance of the results. To ensure this relevance, the test protocol should discuss the relationship between the hypothesis under investigation and the experimental tool—the design and the analytical procedure to allow an extrapolation to real life situations.

To increase the cost-effectiveness of the experiment, special considerations should be given to the formulation of a test hypothesis fitting the available experimental tools. For the methodology in question this means a specification of the question: What is the emission rate of this compound from what source?

The emission rate, however, is dependent on a number of cofactors besides the amount and type of source materials. In the laboratory test one or more of these cofactors may be controlled in order to increase the sensitivity of the experimental tool, but this increases the difficulties in extrapolating the results to real-life situations. If the test results are meant for more general use, the number of controlled cofactors should be kept to a minimum or the effect of the normal cofactor variation should be measured in separate tests. Such tests may include the effects of non-uniform temperature or humidity through the source material, or the effect of surface treatments or interaction with absorbed air pollutants or dust. These relationships are not well understood at the present and should be investigated further.

The technical design

Economical or practical considerations may force the investigator to deviate from the real-life situation. A less-than-full-scale sample may be tested. For practical reasons the temperature may be increased as well as sample loading to reach detection limits. All such deviations from real-life situations increase the difficulties in interpretation of the results but do not, in most cases, add to the experimental sensitivity.

The project protocol, therefore, should justify such limitations and indicate how the results are to be interpreted in real-life situations. This discussion may include inevitable effects due to the laboratory set-up used, such as chemical reactions on the container surface or atmospheric reactions in the air, as the ratio between sample surface and container surface or volume will often be different from realistic uses of material. Another point to consider may be the relatively high fraction of edge surface in the 'bench top' test.

Test conditions

Most tests are made during equilibrium conditions and with controlled temperature and humidity, air movements and ventilations. Values of 23°C, 50% r.h., 10 cm s^{-1} and 0.5 air changes per hour is considered a normal situation.

Emission factors, however, often vary with varying atmospheric conditions in an unpredictable way. Emission factors therefore may have to be measured during different atmospheric conditions in order to establish the variation range for the emission rate.

Another variation in emissions occurs due to aging of the sample. Not all compounds emitted from the same sample decrease in concentration with the same rate, since the decay rate may depend on such factors as vapour pressure and source size for each compound. Consequently, compounds with high initial concentration and fast decay rate may result in a smaller exposure than other compounds with smaller initial concentrations but slow decay rates. When such effects are expected, the decay rate should be measured. Further, a quick decay period for a compound may be followed by a later and slow decay period. For extreme cases this late period may be of comparable importance to the initial high concentration period.

In practice the tests may have to be arranged using several equal test benches. The controlled atmospheric parameters of each should be measured with equipment regularly checked against primary standards. The samples should be allocated to the test benches in a randomized way leaving one bench to be used as a blind, or as a standard by addition of a permeation device. The standard test practice should include standard cleaning of the bench and background testing before each test, and each test should be continued until equilibrium is documented.

Finally, the test procedure should include an initial pretest period to establish analytical ranges, to test the protocol and test bench, and to validate the procedures.

Sampling strategy

Before any test can be initiated, a sampling strategy must be established, ensuring that the right type of material is selected and a sufficient number of samples collected to allow a statistically significant conclusion concerning the hypothesis established for the measurements. Different types of hypotheses may need different sampling strategies. The manufacturer may pick up random samples from one production line to keep emissions below his production standard. The researcher may *select* his samples to reflect all types of a product class. Such strategies may use market research, user survey or manufacturers' information, and should include discussion of how many samples to acquire and how often the sampling should be performed. Decisions must be made on where to sample. This may be done in private houses, at the retailer's or producer's location. A procedure for transportation and storage until the test can be done should be addressed. Finally, the sampling strategy should specify the surface or other treatment the sample should be given, or if bulk products should be sampled.

To control the sampling procedure during the experiment, quality control functions should be built up. These may include training of the sampling staff, addition of standard samples, blind samples or replicate samples.

The analytical procedure

The analytical procedure should follow normal laboratory practice with quality control functions, standard and blank samples, calibration against primary standards, etc. It should be considered to what extent a costly high-precision and accurate analytical procedure is needed. Often an unnecessarily high analytical accuracy is available compared to the accuracy for the combined sampling, testing and analytical procedure.

The analytical procedure should include measurements of all relevant emission rates as well as the controlled cofactors and environmental conditions. Preferable parallel analytical procedures should be used. Further, the procedure should include a standardized data reporting format convering all relevant sampling, testing and analytical data.

Discussion

The most cost-effective test procedure is as indicated above, obtained if the test protocol is adjusted according to each new test hypothesis. Measured emission rates according to such individual protocols however will not be comparable. If the data are included for more general use a generally accepted protocol and a set of standard testing conditions must be defined. Only then may a coherent data base be established.

It further appears from this section of the symposium that priority criteria for selection of target compounds and materials are missing, thereby increasing the risk of collection of irrelevant data. Documentation is lacking on the relevance of emission factors measured in test benches for real life as well as for accuracy and reproducibility of the combined test procedures including test sample selection, test procedure and analysis.

At the present state of the methodology, the unknown effect of the controlled cofactors means that measured emission rates generally cannot predict the emission of the same sample when installed later in a building. Further, most sampling strategies are not adequate to ensure that results from the test samples can be extrapolated to other samples of the same type used by the consumers.

When generally accepted emission rates are available, mathematical models may be developed through which concentrations in indoor environments may be estimated. If further toxicological data are available for the emission, the relative importance for human health and well-being of each building material and construction practice may be evaluated, leading to a classification of these. These models may be physical or chemical and result in actual concentrations in each room or house, or statistical in the sense that they give probabilities and concentration distributions. Such models have been outlined at the present but should be better developed and documented.