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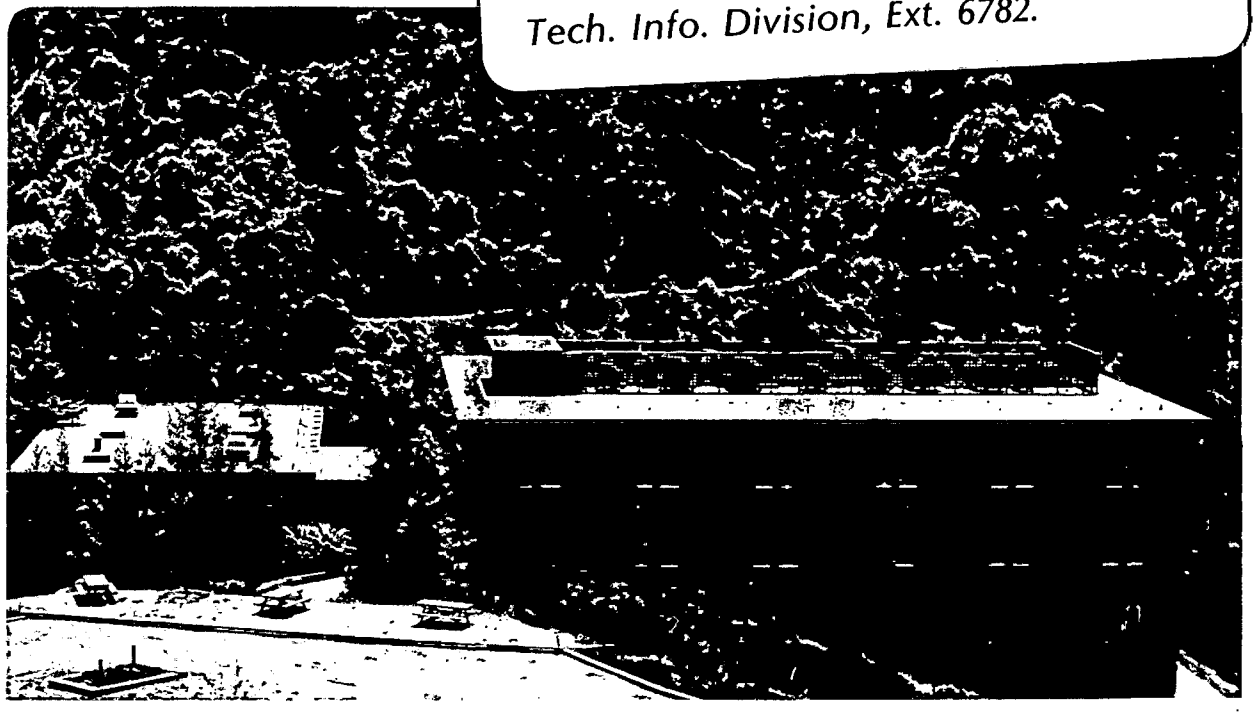

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COMPARISON OF WET AND DRY TEST METHODS FOR FORMALDEHYDE EMISSION FROM UF-BONDED WOOD PRODUCTS

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ABSTRACT:

A dry bisulfite-impregnated glass fiber collector was used in the desiccator test for measuring formaldehyde emission from five different commercial wood products. The correlation factor between the wet and dry method is $R^2 = 0.865$, and confirms the reproducibility of the current collector chemistry. The dry method allows the study of conditioning effects on formaldehyde release.

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Formaldehyde emission from UF-bonded particleboard and plywood is caused by several different chemical forms of latent formaldehyde, each of which is characterized by its own release mechanism and kinetics. Therefore, the design and validation of a laboratory test which allows empirical prediction of formaldehyde concentrations in indoor air based on formaldehyde emission from building materials is difficult.

So far, the most reliable method involves full-scale testing of commercial panels in large air chambers (10). However, this type of testing is slow and not suitable for routine production testing. In Europe, three laboratory-scale tests on small specimens are frequently used, often concurrently. The perforator test measures the total latent formaldehyde content (1), the WKI-test measures the formaldehyde release rate in a closed system (9), and the Hoetjer test measures the release rate as a function of the air change rate (3). In Japan, a carefully researched, static 24-hr. test has been developed and implemented as standard test JIS-A-5908 of 1974 (4,6). In the U.S., a cooperative effort by industry, trade organizations, and government (8) has recently led to the development of a proposed standard method (NPA-HPMA) derived from the Japanese standard test. For the proposed U.S. test, a good linear correlation has been found between large air chambers and small specimen tests for particleboard and plywood, but the slope of the correlation is different for the two materials, making the prediction of emissions from mixtures of materials difficult (11). A possible explanation proposed for the discrepancy is that back-diffusion of water vapor from the formaldehyde collection liquid may affect formaldehyde release from the specimen during the laboratory test.

The purpose of this work was to compare wet and dry formaldehyde collectors under the conditions of the NPA-HPMA test.

Experimental

Samples: UF-bonded particleboard and plywood specimens, 71 x 125 mm, were obtained from Clayton Environmental Consultants (10). These samples were from panels which had been used for interlaboratory comparison of formaldehyde measurements. Three sets of eight specimens were tested for each of four types of panels: (a) low emitting plywood, 3.6 mm thick, Southeast Asian glued, domestic factory finished lauan veneer with two glue lines, (b) high emitting plywood, 1/4" birch-veneered domestic plywood with tropical hardwood core and backing, with two blue lines, (c) high emitting 3/4" particleboard, and (d) low emitting 3/4" particleboard. All panels were manufactured in August 1981. Samples were conditioned and stored in sealed plastic bags at 20°C and 50% RH. Formaldehyde release measuerments were taken between November 1981 and March 1982 when specimens were 3 - 7 months old.

Wet Test: One set of eight specimens was placed in a 10 liter desiccator. Instructions of the proposed NPA-HPMA standard method (8), dated 9/1/81, were followed, except that 30 ml acetyl-acetone test solution (4,6) in a 50 ml beaker was used as the formaldehyde collector, rather than 25 ml distilled water in a 9 cm Petri dish. The correlation factor between the NPA-HPMA test and our modified method is $R^2 = 0.910$, as measured in our laboratory (7).

Dry Test: The dry test was conducted using the sampling configuration of the NPA-HPMA test. However, instead of 25 ml of water, a 9 cm diameter glass microfiber filter was placed in the bottom of the Petri dish. The filter had been impregnated with a 5% bisulfite solution and rapidly dried *in vacuo* (2). The reaction of formaldehyde with bisulfite is well known and produces a water soluble adduct with a low vapor pressure (6). Following exposure, filters were immediately eluted with 20 ml distilled water and stored in tightly covered capsules. To determine the formaldehyde content of a sample following exposure, an aliquot of the sample solution was centrifuged to remove glass fiber traces and analyzed following the chromotropic acid analytical method (6). This method was originally developed for monitoring formaldehyde in indoor air (2).

Results

The results of our experiments are summarized in Figure 1, which shows the amount of formaldehyde collected on the dry filters *vs.* formaldehyde content of the aqueous absorber. The correlation between the two methods yields $R^2 = 0.865$ and a slope of 0.304.

Discussion

In all of its current forms, the desiccator formaldehyde test suffers from uncertainty about the effect of moisture flux. In any wet test, diffusion of water from the collector increases the humidity in the desiccator. This causes the moisture content of the specimen to rise during the test from the initial value of 9.2 wt%. In our test, particleboard specimens gained about 1 wt% per day, and about 2 wt% per day if the NPA-HPMA Petri dish was used.

Depending on the nature of the resin or the material, the additional moisture may trap formaldehyde on the wood surface, or release formaldehyde by hydrolysis of methylol or other chemical functions in the resin. In any case, the moisture flux disturbs the test and makes the interpretation of results difficult.

Moisture gain can be avoided if dry formaldehyde collectors are used. However, all absorbers that have been previously proposed, such as molecular sieves (5), absorb not only formaldehyde but also water and thereby induce a reverse moisture flux. This causes gradual dehydration of the specimen, an effect which may also influence the release and transport mechanisms of formaldehyde. In fact, this dehydration may explain preliminary reports that for highly emitting specimens, molecular sieves can yield higher formaldehyde release rates than the wet method.

The advantage of the dry test method reported in this paper is that it neither absorbs nor emits water and thus does not alter the moisture content of the specimen during testing.

In our 2-hr. experiments, we find a correlation factor of $R^2 = 0.865$ between the dry and wet tests. Preliminary results from a 24-hr. test show similar results. This result indicates that, with uniformly conditioned samples, both tests correlate well, and thus that the effect of water is minimal in the wet test under our conditions.

It is noteworthy that the internal reproducibility of the desiccator test is far greater than that obtained when different laboratories compare samples from identical boards.

Our experiments indicate that these discrepancies need not be due to the test methods used, but may be caused by changed properties of the test specimen, possibly due to aging, storage, or conditioning. The influence of conditioning has been widely underestimated. No data is presently available on the sensitivity of the desiccator test to moisture variation, or aging. Our preliminary experiments and the results of a recent round robin study using the desiccator test (10) suggest that the 2-hr. test may be more sensitive to conditioning than the 24-hr. test. The short test may over-emphasize initial desorption of non-equilibrium formaldehyde gas from sample surfaces, masking the steady-state release mechanisms which determine long-range release properties. A thorough experimental study of the effect of conditioning is necessary. Our experiments indicate that the dry bisulfite collector used in this work is uniquely suitable for such a study, since it enables one to maintain constant humidity at any desired level in the desiccator.

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Figure 1: Correlation between formaldehyde collected with wet and dry sampling methods in desiccator test for three sets of samples of five different materials:

- ○ low emitting plywood, 3 months old
- ● high emitting plywood, 3 months old
- ▲ low emitting particleboard, 3 months old
- △ same as ▲ , but 6 months old
- ◆ high emitting particleboard, 7 months old
- ◇ high emitting particleboard, 3 months old

(◆ and ◇ are different materials)

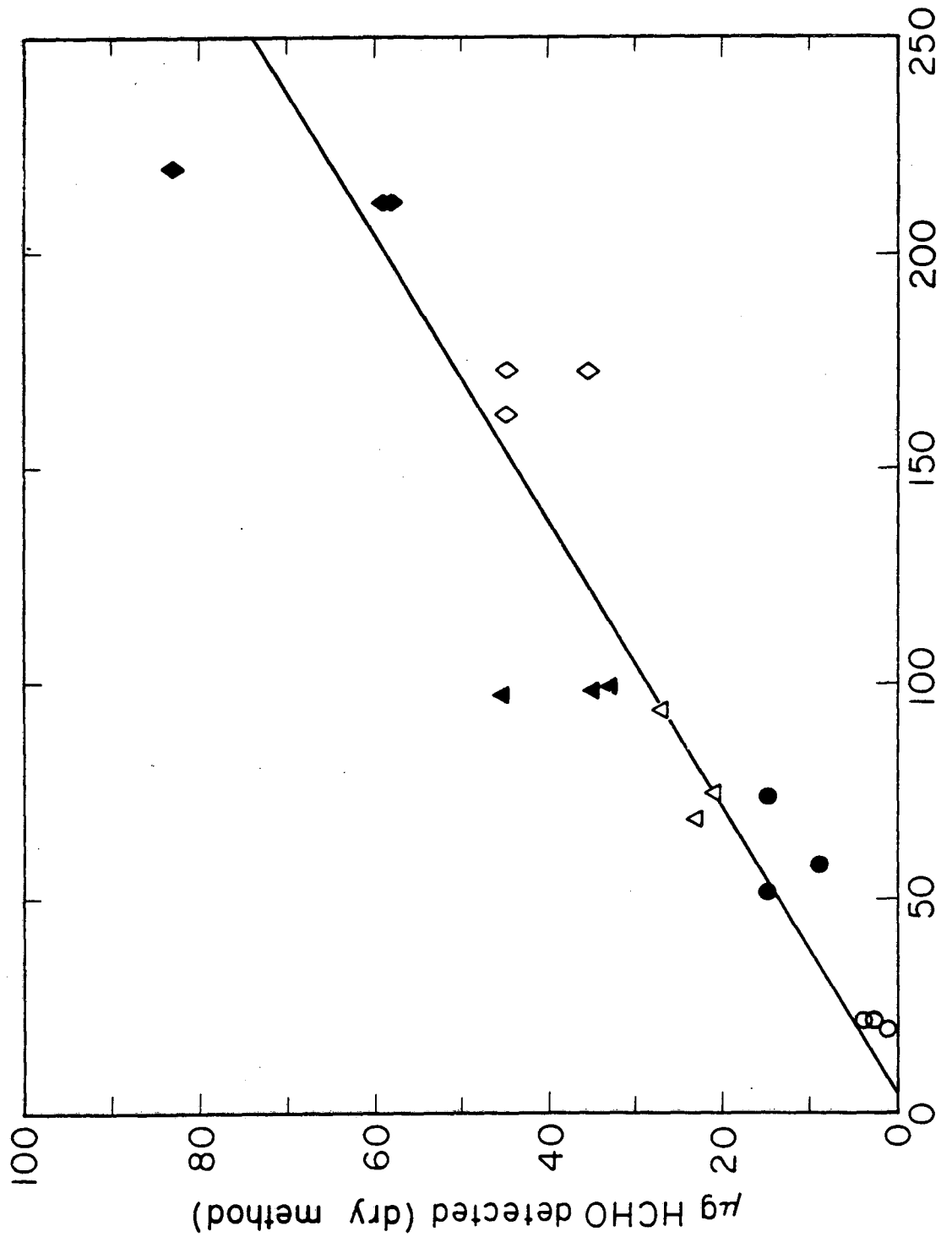

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Figure 1

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