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DEVELOPING PASSIVE FLUX SAMPLER WITH A COMMERCIALY-AVAILABLE CARTRIDGE FOR ON-SITE MEASUREMENT OF FORMALDEHYDE EMISSIONS

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ABSTRACT

The goal of this study was to develop a passive flux sampler (PFS) that can be used to measure formaldehyde emission rates from existing surfaces on-site using a commercially available DNPH cartridge. The performance of PFS was compared with the conventional 50-L chamber test. The formaldehyde emission rates from PFS were in good agreement with those from the chamber tests, involving 10 composite wood materials. The performance of PFS was further validated in a newly-built research house, where PFS was deployed onto 6 interior surfaces. The predicted formaldehyde concentrations based on the measured emission factors with PFS showed good agreement with the measured concentrations (17 – 22 % difference). The results show that a PFS with a commercial DNPH cartridge can be a useful tool to measure formaldehyde emission rates on-site passively for 4 – 7 days.

Keywords: formaldehyde, composite wood materials, passive, field test

1 INTRODUCTION

Passive flux samplers (PFS) are intended to measure formaldehyde (HCHO) emission rates from existing surfaces on-site and passively. A majority of PFS reported in the literature is composed of a Petri-dish lined with quartz fiber filter and coated with 2,4-dinitrophenylhydrazin (DNPH) (Blondel and Plaisance, 2010, Shinohara et al., 2007). Its relatively large surface area for sampling allows for a short-term sampling (6 - 8 hours). However, there is no information in the literature whether it can be applicable to a longer-term sampling period (4 - 7 days), which is commonly used in characterizing formaldehyde concentrations under occupancy in residential buildings. Additionally, the need for coating filters with DNPH in house is too labor-intensive for the field application involving a large number of homes. The goal of this research is to develop a PFS that is suitable for 4 to 7-day deployment in the field and uses a commercially available DNPH cartridge.

2 METHODS

2.1 Fabrication of PFS

The PFS is made of a commercial DNPH cartridge from Waters (Sep-Pak XPoSure Aldehyde sampler, 11.7 mm O.D. x 13.3 mm H of silica gel). A cylindrical stainless steel (SS) block with a cylindrical hole was fabricated to hold the cartridge (Figure 1). The cylindrical hole consists of an upper part for the cartridge to be inserted (11.7 mm I.D. x 18.5 mm H) and a lower part with an air gap for formaldehyde to diffuse through (10 mm I.D. x 14.8 mm H). The larger opening of the cartridge was uncapped and inside the SS block, facing towards the air gap for passive sampling of formaldehyde emitted from a surface. The smaller opening of the cartridge was outside and capped.

2.2 Chamber test

The PFS was used to measure HCHO emission factors from 10 composite wood products, including 4 medium density fiber boards (MDF), 3 plywood materials, 1 MDF moulding, 1 decorative wall panel of high density fiber board (HDF) and 1 finished door. Multiple PFS units were placed on top of a test specimen that was housed in a 50-L chamber (Chamber 1) under 24 °C, 50% RH and 1 air change per hour. One PFS was taken out at 1, 2, 4, 6 and 7 days. The same material (0.36 m²/m³) was tested in a separate 50-L chamber (Chamber 2), in accordance with the conventional small-scale chamber method

(ASTM, 2010) under the same conditions for PFS. One air sample (~ 50 L) was taken with a DNPH cartridge from Chamber 2 at the same time when a PFS unit was removed from Chamber 1.

2.2 Research house test

The performance of PFS was further validated in a newly-built duplex, where PFS was deployed onto 6 interior surfaces for 7 days. The indoor levels of HCHO were also passively measured for 7 days with DNPH cartridges. The test was conducted twice at 3 and 8 months after construction. The measured emission factors were used to predict the indoor air concentration, in combination with the measured material surface areas and ventilation rates.

3 RESULTS

Figure 2 compares the emission factors (EFs) of HCHO from the chamber test with those from PFS measured at 4 – 7 days. The resulting slope was 0.9634, indicating good agreement between the two tests. Figure 3 shows that the EFs of HCHO measured in two units of the duplex at 3 months were similar with a mean difference of 23%. The predicted HCHO concentrations agreed well with the measured concentrations in Unit E (22 vs. 28 $\mu\text{g}/\text{m}^3$ at 3 months and 8.3 vs. 10.1 $\mu\text{g}/\text{m}^3$ at 8 months), supporting the accuracy and usefulness of PFS.

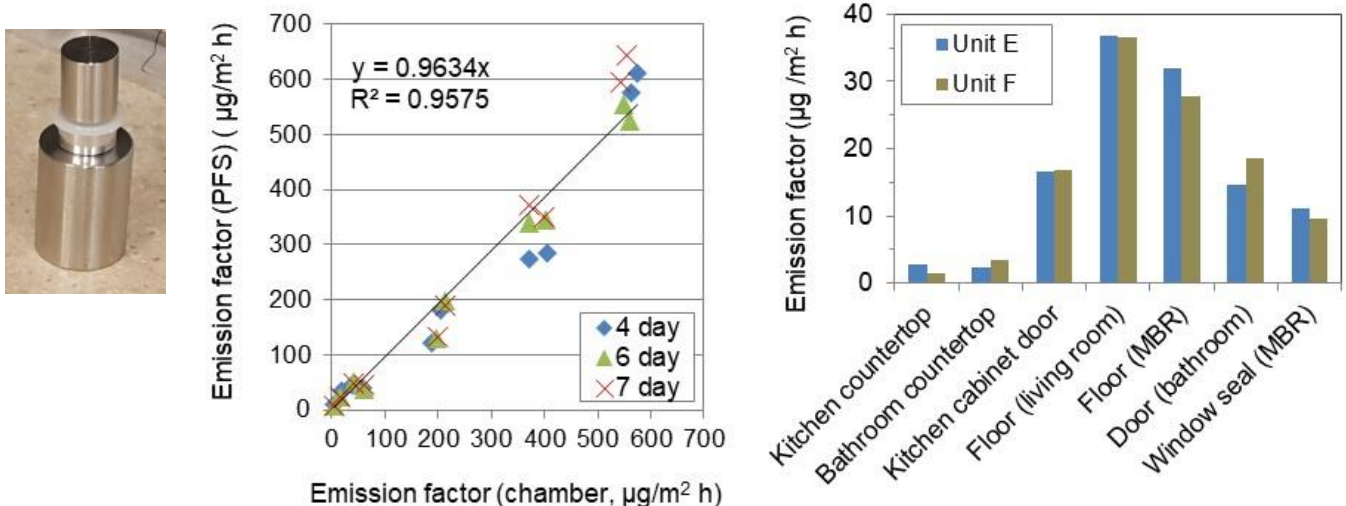


Figure 1. Photo of PFS
Figure 2. Emission factors of formaldehyde from chamber and PFS testing

Figure 3. Emission factors from PFS placed on 6 surfaces in a newly built duplex (Unit E & F)

4 CONCLUSIONS

This study shows that a passive flux sampler with a commercial DNPH cartridge can be used to measure the formaldehyde emission rates on-site in the field. This technique can be useful to identify major formaldehyde sources in occupied homes without destructive tests.

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