CHAPTER 4

CONCLUSION

Formaldehyde passive samplers were developed in this work based on the principle of Fick's law. Formaldehyde was collected via reaction with bisulfite. Analyses of the formaldehyde-bisulfite adduct were performed using CTA method and spectrophotometry.

The formaldehyde gas in the air is calculated based on the diffusion coefficient of formaldehyde in air ($1.6 \times 10^{-5} m^2/s$ at 25 °C) and the total air resistance of the passive sampler. A laminar boundary layer depth of 5×10^{-3} m is used indoors, which results in a total air resistance of 382.3 m^{-1} for a ring diameter of 13 mm.

Passive samplers collect formaldehyde on cellulose filters impregnated with 100 μL of 1% bisulfite coating solution inside the PP tube and end closed with PTFE barrier membrane to reduce meteorological effect (wind speed and humidity). During storage and transport the samplers were kept in polyethylene bag. After exposure the cellulose filters were extracted in 3 ml of DI water for 30 min.

Extraction recovery of standard spiking was 93±3% with relative standard deviation of 2.8 %. The limit of detection (LOD) for formaldehyde was 0.21 mg/m^3 for 8 hours and 0.06 mg/m^3 for 24 hours. The exposed sampler can be stored at least 3 weeks at temperature of 4 – 30 ºC with no loss of formaldehyde. The orientation position of the sampler had no effect to the sampling indoors. Moreover, the test of reverse diffusion illustrated no evidence of reverse diffusion in the sampler.

The validation of passive sampler was tested by formaldehyde exposure chamber system. The result of the passive samplers was due to variation in laminar boundary layer (LBL) with wind speed over the samplers.

The exposure chamber systems for testing passive samplers under controlled conditions of wind speed, temperature, humidity, and concentrations of formaldehyde gas have been completely constructed and partially tested. Effectively control of environmental parameters (temperature, humidity and wind speed) across relevant ranges has been demonstrated. Blank testing of the chamber system to be used for passive sampler evaluation revealed no detectable formaldehyde levels and the sampling period of concentration level is suited for 4 hours with high percent recovery.

Accuracy of the formaldehyde passive samplers is determined with an exposure chamber system under real sampling conditions in indoor air. The passive samplers measured provided percent recovery in a range of 80-120% with %RSD of ≤10%. This good agreement is within the range of experimental and analytical error and provides evidence that passive sampling is valid over a wide range of concentrations (2.5 – 18.0 mg/m^3), sampling times (4 hours) and wind speeds (0.0 – 1.5 m/s) that the total air resistance for each concentration was 382.3 m^{-1}. The accuracy of self-constructed passive sampler was tested again by comparing with a commercial passive sampler (SKC inc., USA) in workplace for 8 and 24 hours. Levels of formaldehyde detected showed good agreement with low % difference (7.2 % for 8 hours, 13.0 % for 24 hours).

Recommendations for further works

The formaldehyde passive sampling device, which has been developed in this work, has some limitations that should be improved such as capacity of the sampler, the comparison test with the commercial passive sampler both in the terms of number of test and study site and harmfulness of oxidizing reagent (concentrated sulfuric acid).

Capacity of the sampler affects to sampling period. In this work the sampler can not be used for long term sampling according to the sorbent capacity was limited. It reached the steady state within 8-24 hours at the formaldehyde concentration of approximately 1 mg/m^3. To increase the sampler capacity, larger size of sorbent must be used. However, it also depends on concentration of formaldehyde in the sampling air. Higher concentration of indoor formaldehyde will result in shorter time of steady state.

The number of comparison tests means number of test that has been performed in real environment. In this study number of test was limited due to high cost of commercial passive samplers (SKC, USA). Therefore, only 4 comparison tests have been preformed at the workplace. In order to be more confident, more tests both in terms of number of comparison tests and number of study sites should be carried out in further work.

The acid reagent (concentrated sulfuric acid) used in this study is corrosive and can impact health. Thus, a new oxidizing agent such as hydrogen peroxide can be used instead. However, the optimum conditions are needed to be test again.

The box-shaped formaldehyde exposure chamber constructed in this work also has some limitations such as range of meteorological conditions (relative humidity, temperature and wind speed), formaldehyde concentration level and the sampling period. Therefore, other shape of exposure chamber such as cylindrical shapes is expected to be more appropriate because it was no angle and formaldehyde molecules can disperse. Furthermore, heating and constantly cooling coils should be added in the exposure chamber to adjust temperature and relative humidity to reach the needed values.