

# Removal of Indoor Ozone by Green Building Materials

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## 1 Introduction

Major initiatives are underway to build and retrofit buildings to be more energy efficient. This often includes making buildings “tighter” in order to reduce the amount of energy needed for space conditioning. However, this also tends to trap pollutants inside buildings. The concept of Passive Removal Materials (PRM) involves indoor materials used to remove targeted pollutants from building air without a concomitant energy penalty. In this study we explore the use of several materials for removal of ozone from indoor air.

Ozone is a harmful air pollutant and numerous studies have shown links between exposure to ozone and asthma, decreased lung function and increased mortality (U.S. E.P.A., 2006; Bell et al., 2005). Exposure to ozone is also associated with exposure to the products of ozone-initiated chemistry that can also be harmful (Weschler, 2004).

In this study, activated carbon and three green building materials were placed in real environments for several months and tested periodically to measure their ozone removal and associated by-product emissions to evaluate their PRM potential.

## 2 Materials/Methods

Activated carbon mats (Gremarco Inc., model C0150) used in this study were made of non-woven polyester-based fabric coated with activated carbon. The three green building materials included materials used on large surfaces indoors: ceiling tiles (Chicago Metallic Corporation, Eurostone, model Terric), carpet (Interface FLOR, model Worn Again, 68-71% recycled content) and recycled gypsum wallboard painted with low-VOC paint (Benjamin Moore, Eco Spec).

Samples of these materials (20 cm x 25 cm) were placed in five different rooms in buildings around Austin, TX, for six months. The rooms covered a wide range of indoor environments in both residential and institutional buildings. The samples were taken from their field location and brought back to the laboratory every month for testing. Each month, the ozone deposition velocity on each sample was determined by mass balance while passing ozonated air (150 ppb inlet concentration) through a well-mixed stainless steel chamber containing the material. Since fluid mechanic conditions in the test chambers were the same throughout the study, changes in deposition velocity were attributed to changes in material reactivity (Cano-Ruiz et al., 1993). At three instances during the experimental program (before installing the samples in the field and after three and six months in the field), carbonyl emissions from the materials were also measured. Both primary and secondary (in presence of ozone, 150 ppb inlet concentration) emissions were evaluated. Carbonyl emission rates were calculated. Light carbonyls (C1 through C5 aldehydes and acetone) were sampled on DNPH tubes and analyzed using HPLC with UV detection. Heavy carbonyls (C6 through C10 n-aldehydes, o-tolualdehyde, benzaldehyde) were sampled on Tenax tubes and analyzed using thermal desorption and gas chromatography with flame ionization detection.

## 3 Results

Results show that there is little difference between ozone deposition velocities for samples placed in rooms belonging to residential buildings. However, green materials placed in an office, the only room belonging to a non-residential building, removed less ozone. The reason for this difference could not be resolved.

Figure 1 shows the evolution of ozone deposition velocities on the material samples over the course of the study. The ozone deposition velocity on the materials remained relatively consistent with the exception of a net 30% loss in reactivity for carpet.

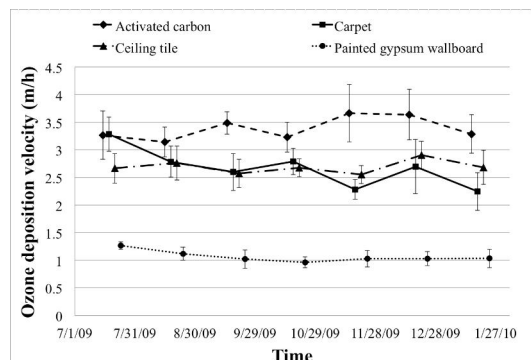


Figure 1: Ozone deposition velocity on material samples averaged over all field sites.

Carbonyl emissions are dependent on both the material itself as well as the location it is placed in. Both primary and secondary emissions from activated carbon remained very low. Other materials exhibited higher emissions, with carpet being the material with the highest (Figure 2). Secondary emissions from the green building materials were higher than primary emissions and were dominated by emissions of nonanal. This is consistent with previous studies (Wang et al., 2006; Morrison et al., 2002).

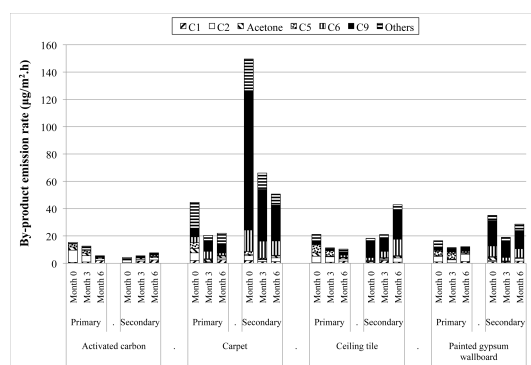


Figure 2: Carbonyl emissions averaged over all field sites for all materials

Environmental conditions also affected emissions from materials. The highest levels of secondary emissions were found in the kitchen and bedroom locations. It is possible that ozone reacted with unsaturated fatty acids from cooking or skin oils that have deposited on the sample surfaces. Previous results from the

literature confirm this possibility (Sadowska et al., 2008; Wisthaler, 2009).

## 4 Conclusions

The use of Passive Removal Materials (PRM) for ozone control could decrease or even suppress the need for active, energy consuming, control solutions. Activated carbon mats and perlite-based ceiling tiles are two examples of potentially good PRMs as they consistently remove ozone over time with low emissions.

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## 5 References

- Bell M.L., Dominici F. and Samet J.M. 2005. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality and air pollution study. *Epidemiology*, 16, 436-445.
- Cano-Ruiz J.A., Kong D., Balas R.B. and Nazaroff W.W. 1993. Removal of reactive gases at indoor surfaces: combining mass transport and surface kinetics, *Atmospheric Environment*, 27A, 2039-2050.
- Morrison G.C. and Nazaroff W.W. 2002. Ozone interactions with carpet: secondary emissions of aldehydes. *Environmental Science and Technology*, 36, 2185-2192.
- Sadowska J., Johansson B., Johannessen E., Friman R., Broniarz-Press L. and Rosenholm J.B. 2008. Characterization of ozonated vegetable oils by spectroscopic and chromatographic methods, *Chemistry and Physics of Lipids*, 151, 85-91.
- U.S. E.P.A. 2006. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final), EPA/600/R-05/004aF-cF. Washington, DC:US Environmental Protection Agency.
- Wang, H. and Morrison, G.C. 2006. Ozone-initiated secondary emissions rates of aldehydes from indoor surfaces in four homes, *Environmental Science and Technology*, 40, 5263-5268.
- Weschler C.J. 2004. New directions: ozone-initiated reaction products indoors may be more harmful than ozone itself. *Atmospheric Environment*, 38, 5715-5716.
- Wisthaler A. and Weschler C. 2009. Reactions of ozone with human skin lipids: sources of carbonyls, dicarbonyls, and hydroxyl-carbonyls in indoor air. *Proc. of the National Academy of Sciences*, 107, 6568-6575.