Young CJ, Zhou S., Siegel JA, Kahan T. Illuminating the dark side of indoor oxidants. Accepted to *Environmental Science: Processes & Impacts*. DOI: 10.1039/c9em00111e.

Abstract

The chemistry of oxidants and their precursors (oxidants*) plays a central role in outdoor environments but its importance in indoor air remains poorly understood. Ozone (O3) chemistry is important in some indoor environments and, until recently, ozone was thought to be the dominant oxidant indoors. There is now evidence that formation of the hydroxyl radical by photolysis of nitrous acid (HONO) and formaldehyde (HCHO) may be important indoors. In the past few years, high time-resolution measurements of oxidants* indoors have become more common and the importance of event-based release of oxidants* during activities such as cleaning has been proposed. Here we review the current understanding of oxidants* indoors, including drivers of the formation and loss of oxidants*, levels of oxidants* in indoor environments, and important directions for future research.

Environmental Significance

A clear understanding of oxidants and their precursors in indoor environments is necessary to investigate much of the chemistry that can occur indoors. Most indoor oxidant studies have focused on ozone, since oxidation indoors was thought to be dominated by ozone reactions. Recent measurements have demonstrated that other oxidants could be of equal or greater importance under many conditions, and that episodic chemistry (e.g., initiated by cooking or cleaning) could be critical to oxidation indoors. This review describes the considerations important for indoor oxidant formation and loss, as well as observations and models of oxidants indoors. Important areas of future research are also identified.

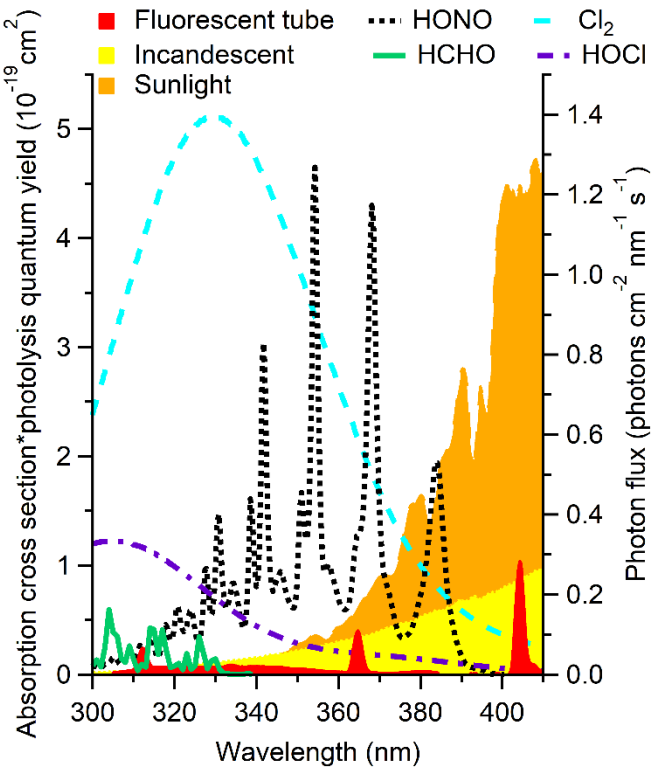

Figure 1. Photon flux of common indoor light sources (right axis) shown with the product of absorption cross section and photolysis quantum yield of likely indoor oxidants* (left axis). Data from ref. 34, 39–42.

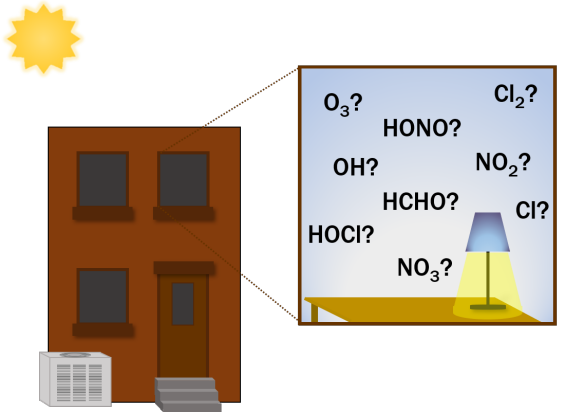

Table 1 Measured average levels of indoor oxidants* in North American residences, major known production sources, and sources of uncertainty. Measurements are reported in parts-per-billion-by-volume (ppbv), defined as 10^{-9} mol mol^{-1}. At 25 °C and 1 bar, 1 ppbv is equivalent to approximately 2.5×10^{10} molecules per cm^3

Oxidant	Mixing ratios (ppbv)	References	Major indoor sources	Sources of uncertainty
Nitrogen dioxide (NO_2)	1–394	Ref. 22 and references therein	Emission from gas appliances and transport from outdoors	A few highly time-resolved measurements; measurements subject to HONO interference
Nitric oxide (NO)	0.8–400	Ref. 22 and references therein	Emission from gas appliances and transport from outdoors	A few measurements
Nitrous acid (HONO)	<1–35.9	Ref. 22 and 70 and references therein	Emission from gas appliances and surface reactions of NO_2	A few measurements
Ozone (O_3)	<1–73	22,71–78	Transport from outdoors	Commonly used levels measured in non-residential environments
Formaldehyde (HCHO)	10–70	Ref. 12 and references therein	Building and furnishing materials and residential combustion	A few highly time-resolved measurements
Nitrate radical (NO_3)	$<4 \times 10^{-3}$	79	$NO_2 + O_3$	Only one measurement