DOI 10.1007/s12273-013-0139-2

Research Article

Indoor/Outdoor Airflow and Air Quality

Mass balance modeling of building recirculation rates and filtration efficiencies effects on secondary organic aerosols derived from ozone-initiated chemistry

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Abstract

Recirculation of conditioned air is a common practice in regions with hot and humid climate. This is due to the need to reduce sensible and latent cooling loads in buildings. However, recirculating used indoor air may influence indoor air chemical reactions and products derived from the chemistry. Example of such products is secondary organic aerosols (SOA) derived from ozone initiated indoor chemistry. This present study was conducted using mass balance model to examine the impacts of four recirculation rates on ozone (of outdoor origin) and SOA derived from the ozone initiated indoor chemistry. At steady-states, it was observed that the higher the recirculation rate, the lower the ozone and SOA concentration for all modeled scenarios. At steady-state, outdoor to indoor transport of ozone, indoor ozone and SOA concentrations were found to increase with increasing outdoor ozone levels. Increase in ventilation rate was found to increase outdoor to indoor transport of ozone and steady-state indoor ozone concentration. However, higher ventilation rate resulted in lower SOA concentration at steady-state. Increasing ozone filtration efficiency of activated carbon (AC) filter was found to be effective in reducing indoor ozone and SOA concentrations. This study is relevant to building sustainability in terms of health and comfort of building occupants.

Keywords

building recirculation rates, filtration efficiency, indoor chemistry, mass balance modelling, risk assessment

Article History

Received: 13 November 2012
Revised: 28 March 2013
Accepted: 9 May 2013

1 Introduction

Ozone initiated indoor chemistry products can potentially cause health and comfort problems to building occupants (Kleno and Wolkoff 2004; Weschler et al. 2006; Strom-Tejsen et al. 2008; Apte et al. 2008). Secondary organic aerosols (SOA) which is one of the products of ozone initiated chemistry has been receiving considerable attention in the literature (Weschler and Shields 1999; Wainman et al. 2000; Long et al. 2000; Rohr et al. 2003; Sarwar et al. 2003, 2004; Liu et al. 2004; Tamas et al. 2006; Singer et al. 2006; Destaillats et al. 2006; Sarwar and Corsi 2007; Lamorena et al. 2007; Toftum et al. 2008; Langer et al. 2008; Youssefi and Waring 2012; Amin et al. 2013). However, there are fewer studies examining SOA in air-conditioned buildings recirculating larger proportion of its air (Zuraimi et al. 2007; Fadeyi et al. 2009). Recirculation of larger proportion of indoor air is a common practice in tropical climates due to the need to reduce energy required to reduce sensible and latent heat.

Zuraimi et al. (2007) studied the impacts of four recirculation rates on SOA derived from indoor chemistry. Their study was done with ozone generated from indoor environment. Studying the impacts of outdoor to indoor transport of ozone is important as outdoor ozone is a major source of indoor ozone (Weschler 2000). To address this, Fadeyi et al. (2009) studied the effects of recirculation, ventilation and filtration on SOA generated from ozone (of outdoor source) initiated chemistry. However, recirculation rates studied by Fadeyi et al. (2009) were limited to two recirculation rates (7 and 14 h^{-1}). Although, the study clearly showed that doubling recirculation rate from 7 to 14 h^{-1} would reduce steady-state indoor ozone concentration (transported from outdoor to indoor) and SOA derived from the chemistry. It was not documented whether the same will apply to "small" increase in recirculation rate. This present study aims to bridge this knowledge gap by using mass balance model. Using high end recirculation rate to reduce ozone and its chemistry products will result in higher

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