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Hygroscopic effects on the mobility and mass of cigarette smoke particles

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Shorten Running Title: Hygroscopicity of cigarette smoke particles

Abstract

The hygroscopic growth of particles, produced from a University of Kentucky 3R4F reference cigarette smoked following Health Canada Intense (HCI) puffing parameters (55 mL puff of 2 s duration, every 30 s), was measured in terms of the electrical mobility diameter and particle mass, using a Hygroscopic Tandem Differential Mobility Analyzer (HTDMA) and Centrifugal Particle Mass Analyzer (CPMA) system. Both the particle mobility diameter and mass growth factors were found to agree with previously determined values and hygroscopicity models. The mobility diameter growth factor of the particles produced from either a University of Kentucky 3R4F or 1R5F reference cigarette, following HCI puffing parameters, were found to be very similar. As the relative humidity (RH) approached saturation, the effects of the initial particle size on the mobility growth factor became more dominant, with larger particles growing proportionally larger than smaller particles. From the measured mobility diameter and mass growth factors, the density growth factor was calculated. This parameter showed that the particle density increased as the sample relative humidity increased. This case is only possible, given that the dried smoke particle density (1109 ± 118 kg/m^3) was determined to be greater than the density of water, if the water condensation on the smoke particle dissolves at least a portion of it, resulting in a significant increase in mass with only a small increase volume.

1. Introduction

Tobacco smoking is a recognised dose-related health risk (Doll et al., 2004; International Agency for Research on Cancer, 2004; U.S. Department of Health and Human Services, 2010) resulting from the chronic exposure to tobacco smoke toxicants (Fowles & Dybing, 2003; U.S. Department of Health and Human Services, 2012). These substances affect the body via mechanisms of inflammation or oxidative stress, or more specific toxic mechanisms depending on the exposure (Stratton et al., 2001).

Smoke dosimetry is an important part of any toxicological assessment, and deposition and retention mechanisms will vary with the physical and chemical form of each compound, but also with the bulk aerosol properties of the particle phase (International Commission for Radiological Protection, 1994; Baker & Dixon, 2006; St. Charles et al., 2013). Tobacco smoke is a dynamic mixture of particulate and vapour phases consisting of more than six thousand individual substances (Rodgman & Perfetti, 2013). It contains both hydrophilic and hydrophobic species and therefore the potential hygroscopic growth of the smoke droplets may be a significant parameter in modelling particle behaviour on inhalation.