

ANALYSIS OF LEAD IN CANDLE PARTICULATE EMISSIONS BY XRF USING UNIQUANT 4

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As part of an extensive program to study the small combustion sources of indoor fine particulate matter (PM), candles with lead-cored wicks were burned in a 46-L glass flow-through chamber. The particulate emissions with aerodynamic diameters $<10\ \mu\text{m}$ (PM_{10}) were captured on quartz filters and analyzed under vacuum in a Philips PW 2404 wavelength-dispersive X-Ray Fluorescence (WDXRF) Spectrometer. UniQuant 4 software was used to calculate the filter lead concentrations. Particulate filter loading masses ranged from 0.1 to 52.1 mg. The lead concentrations ranged from 0.2 to 80% by weight, with carbon comprising the remainder of the matrix. The method was validated by analyzing more than 80 filters, first by XRF and then by EPA Method 12 atomic absorption (AA) analysis. For 84 of 87 filters, weighed on a six-place Sartorius MC-5 balance in a climate-controlled room, the average particle mass recovery after XRF analysis was $99.6 \pm 5.7\%$ (the three outliers were due mainly to small losses of pieces of the brittle quartz filters during handling). For 82 of 83 filters analyzed for lead by both methods, the average recovery of lead by XRF compared to the AA analysis was $108 \pm 9\%$ (one outlier).

Using an Electrical Low Pressure Impactor (ELPI), particulate was distributed into 12 channels by size in the range 30 – 10,000 nm. Analysis by XRF of each aluminum-foil-covered stage of the ELPI using UniQuant 4 showed lead present in the respirable range ($<1\ \mu\text{m}$). Modeling of candle emissions using typical room ventilation scenarios showed that even low-emitting candles can produce a lead concentration above the EPA National Ambient Air Quality Standard (NAAQS) of $1.5\ \mu\text{g}/\text{m}^3$ (quarterly average). Burning more than one heavily emitting candle in a poorly ventilated space can produce concentrations exceeding the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) concentration of $50\ \mu\text{g}/\text{m}^3$ (8-hour time-weighted average). A brief synopsis of the modeling results is presented, and the journal article containing more complete candle lead emission modeling information is referenced.