Association of European Candle Makers (AECM)

Executive Summary

June, 2015

Characterization of Substances Released During Burning of Scented Candles: Role of Volatile Aldehydes Produced from Combustion of Fragrance Ingredients

In late April 2015, the highly respected Milan Polytechnic University (Politecnico di Milano) completed a report of a study[1] to examine the relationship between combustion products in glass container scented candles and the characteristics of raw materials. Because of the highly technical and detailed nature of the report, which is over 50 pages in length, the study sponsors, the Association of European Candle Makers and ALAFAVE (Asociacion Lationamericana de Fabricantes de Velas), felt it would be helpful to provide this Executive Summary.

Overall Results

The main goal of this study was to identify and characterize a class of substances, volatile aldehydes,[2] which previous research had suggested was emitted from burning scented candles. The presence of low molecular weight, and hence very volatile, aldehydes in the emissions of burning scented candles is hardly surprising since these are known combustion by-products of organic substances, which would include the fragrance materials used in scented candles.

Nonetheless, this research project had a more specific purpose of defining the relationship between the volatile aldehydes found in combustion products and the raw materials used in scented candles. In fact, previous research has suggested a possible relationship between the fragrances used in candle manufacturing and the aldehyde content of the emissions.

To define the proposed relationship, a series of studies were conducted. The first of these involved measuring the fragrance components of nine test glass jar[3] test candles. The nine candles include one that was unscented (control), one with three levels of fragrance (lavender), one with two levels of fragrance (oriental) and three others, each with one level of fragrance (cinnamon, pomegranate and

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[1] Derudi, M., Giuseppe, N. and Simone, G., Characterization of Aldehydes Produced from Scented Candles Burning, CFALab, Departimento di Chimica, Materiali e Ingegneria Chimica “G. Natta”, Politecnico di Milano, Milan, Italy, April 2015.

[2] Called “light aldehydes” in the report (reference 1). The specific substances are identified further below in footnotes 6 and 7.

[3] Also referred to as glass bottle or glass container candles in the report.

grapefruit). Low molecular weight volatile aldehydes were not identified as components of any fragrance. However, the scented candles included chemical substances, including components of the fragrance materials, which are capable of decomposing on combustion to yield volatile aldehydes.

The second series of studies involved setting up of an experimental test chamber[4] in which the emissions from burning glass candles could be accurately collected.[5] In the first set of studies conducted in the test chamber, the nine glass jar candles were tested using ThermoGravimetric Analysis/Differential Thermal Analysis to detect volatile aldehydes. Only very small amounts of volatile aldehydes were produced during burning of the unscented candle. Moreover, the aldehydes produced were the lowest molecular weight aldehydes, the one carbon and three carbon aldehydes.[6] The scented candles produced larger amounts of volatile aldehydes that include four carbon and seven carbon aldehydes.[7] However, in absolute terms, the amounts produced are still very small, ranging from less than 10 to approximately 150 parts per million (ppm) relative to the weight of the candle burned. This compares to the total fragrance level in the test candles which ranged from 5 to 10% (50,000 to 100,000 ppm) by weight.

Importantly, the analysis shows that the more fragrance present in the scented candles, the greater the amount of volatile aldehydes produced during burning. The amount and type of volatile aldehydes differs depending on the fragrance. This pattern is consistent with the hypothesis advanced in the report that fragrances contain substances[8] which form the volatile aldehydes observed in the emissions from the burning candles. A further conclusion from this study is that fragrance volatility is directly related to the amount of volatile aldehydes that will be formed during combustion, that is the more volatile the fragrance the more aldehydes that will be formed during candle burning.

In the other studies conducted in the test chamber, emissions of various other substances of interest[9] in emissions of the burning candles were also measured. Unscented candles produced similar levels of emissions as scented candles except for emissions of pinene and limonene, which are themselves fragrance ingredients. All of the substances were detected at low concentrations, typically low ppm or less.

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[4] In which glass jar candles have been shown to burn at similar to room rate.

[5] Validation data provided in Report Annex B, pp. 51-53.

[6] Formaldehyde, acetaldehyde, acrolein and propionaldehyde

[7] butyraldehyde, benzaldehyde

[8] Examples of such substances provided in the report included oxygenated solvents, terpenes and higher molecular weight aldehydes, such as cinnamic aldehyde.

[9] These included Volatile Organic Compounds (benzene, toluene, ethylbenzene and xylene), Polycyclic Aromatic Hydrocarbons (only naphthalene found) and Particulate Matter.

Even the maximum level of the air emissions of the pollutant of most concern (formaldehyde) is 20 times less than the health protective standard set by the World Health Organization.[10] This comparison is based on the glass candle with the highest measured emission rate (lavender with 10% fragrance) and standard assumptions for room size and room air exchange rates (one candle, room size 30 cubic meters (room length *width*height = 3.2 m*3.5 m*2.68 m) (1059 cubic feet) and 0.5 /hr air exchange rate).[11] The observation that the maximum level is so much lower than health protective standards even with conservative assumptions such as a standard room size and air exchange rate demonstrates that burning scented candles are not a significant source of hazardous air emissions.

In conclusion, a test chamber study of glass jar candles that were either unscented or contained various levels of five fragrances has shown that the level of volatile aldehydes in emissions of burning candles varies in direct proportion to the concentration of the fragrance in the candles. Fragrance volatility is directly related to the amount of volatile aldehydes formed during combustion. These observations strongly support the hypothesis that certain components of the fragrances used in glass candles are direct precursors of volatile aldehydes found in trace (ppm) levels in emissions of burned candles. Furthermore, volatile aldehydes found in emissions are primarily combustion byproducts of the fragrance compounds used in scented candles. Burning scented candles are not a significant source of hazardous air emissions.

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[10] World Health Organization, WHO Guidelines for Indoor Air Quality: Selected Pollutants, available at: http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf; formaldehyde exposure safety guideline is 100 µg/m^3.

[11] Derudi, M., Gelosa, S., Sliepcevich, A., Catteneo, A, Rota, R., Cavello, D. and Nano, G. , Emissions of air pollutants from scented candles burning in a test chamber, Atmospheric Environment, vol. 55, pp. 257-262, 2012; available at: http://www.sciencedirect.com/science?_ob=ShoppingCartURL&_method=add&_eid=1-s2.0-S1352231012002683&_ts=1433239466&md5=5aa7a1e64a718056f7463185e5fdeaf3; the formula used to calculate the concentration of a substance in a room produced by the burning of a candle is:

C = n*m*EF/V*AER

Where C is the concentration of the substance, n is the number of candles being burned (1), m is the mass burning rate for the candle (1.58 g/hr), EF is the emissions efficiency for the substance (47.05 µg/g), V is the volume of the room (30 m^3) and AER is the air exchange rate for the room (0.5/hr). Therefore, C = 1*1.58*47.05/30/0.5 = 4.96 µg/m^3. 4.96µg/m^3 is 20-fold lower than the safety standard guideline of 100 µg/m^3.