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Household products and indoor air quality: emission, reactivity and by-products in both gaseous and particulate phases

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SUMMARY

The present work investigates Secondary Organic Aerosols (SOA) formation in indoor environment from VOCs ozonolysis emitted by housecleaning products. For each of the 54 housecleaning products tested physical characterisation of particles has been investigated. Cleaning products, containing high level of terpenes and derivatives, have been extensively studied in the occupational house MARIA (Maison Automatisée pour des Recherches Innovantes sur l'Air) allowing simulation of realistic use conditions and exposure. Important formation of AOS and strong increment of particle number was observed upon their use for at least 1 hour, on-line chemical composition were followed using an AMS-c-TOF (Aerosol Mass Spectrometer Compact Time-of-Flight). Chemical speciation of both gas and particulate phases were additionally carried out by simultaneous sampling on sorbent tubes and filters has been performed. The molecular composition of oxygenated species was investigated using derivatisation prior to thermal-desorption coupled with gas chromatography and mass spectrometry (TD-GC-MS) analysis.

PRACTICAL IMPLICATIONS

This work provides a clear and realistic evidence of the potential of housecleaning products to largely contribute to the formation of new particle in indoor environments and additionally provides a complete identification of major products both in the gas and particle phase.

KEYWORDS

Household cleaning products, VOCs, new particle formation, pollutants exposure, emission factors.

1 INTRODUCTION

In western countries, where people spend most of their time in confined areas, indoor air quality is recognized as a public health issue. Among multiple indoor air pollution sources (building materials, furniture, heating) the use of housecleaning products is still poorly characterized. It is well known that limonene, and many other terpenes, are good Secondary Organic Aerosols (SOAs) precursor towards ozonolysis (Chen and Hopke, 2010). Limonene and other terpenes are widely employed in scented products such as freshener and household cleaners (Nazaroff and Weschler, 2004). Besides, indoor ozone levels can be high enough to initiate gas phase chemistry (Weschler, 2000) and possibly lead to the formation of indoor secondary products which may be of health concern. Investigations are therefore necessary to

characterize chemical composition of particles and gases formed during housecleaning use and to evaluate real population exposure.

2 MATERIALS/METHODS

First emission factor of 54 housecleaning products were evaluated using emission chamber under controlled conditions of temperature, relative humidity and ventilation, according to ISO 16000-9 standard (ISO 160009, 2006). The household product was deposited on a glass plate and introduced in the emission chamber. For those products showing higher terpenes emissions further work was undertaken on MARIA to evaluate realistic concentration in an indoor environment and their potential to form AOS. This second set of experiment were followed with a complete set of instrumentation (allowing on-line and off-line monitoring of particle evolution and chemical composition of both gas and particle phase).

3 RESULTS

Major results from this work indicates that housecleaning products as bathroom foam or surface cream contained high level of terpenes and some amino compounds. Both products contributed to high increase of particle number (above 50000p/cm³), they showed fast growth with diameter going from 10 to 70nm in less than one hour and simultaneous coagulation onto pre-existing particles. Major oxygenated products identified are 4-oxopentanal, limoneladehyde, methylglyoxal, butanal in the gas phase, and levulinic acid, methylglyoxal and nonanal in the particle phase respectively.

4 DISCUSSION

Use of certain housecleaning products can lead to the formation of a high level of new particles (10-70nm size range) and a wide range of oxygenated polyfunctional secondary products in gaseous and particulate phases. Based on a new analytical approach, this work provides certainly a comprehensive list of detected and quantified oxygenated compounds.

5 CONCLUSIONS

These results, obtained under real household product use conditions, are a very useful source of information in order to qualitatively and quantitatively assess the population exposure to both ultrafine particles and oxygenated compounds in indoor environments. These still limited results of exposure study emphasize the need to evaluate which phase, gaseous or particulate or a synergy of both, may cause health effects and therefore the need to assess the physical and chemical properties of the secondary gaseous or particulate products potentially responsible of these effects. From this perspective, the present study is a realist set of data of indoor chemical pollutants observed in both gaseous and particulate phases, that can be used to carry out toxicological profiling by means of toxicological experimental data available in the literature and structure-toxicity modeling analysis.

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