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Chemical and toxicological properties of particles from ironing

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1 Introduction

Particulate matter with aerodynamic diameter lower than 10 µm (PM_{10}) in ambient air is responsible for adverse health effects. Relatively little is known about the concentrations, sources and health effects of PM_{10} in indoor air, although people spend approximately 90% of their time indoors. Indoor particle generation is often short in duration but can increase levels several orders of magnitude above background values for an extended period. Personal exposure can be significantly higher near an active source due to non-instantaneous mixing of emissions (Acevedo-Bolton et al., 2012). One of the domestic activities that most contributes to the rise in PM_{10} levels is ironing. This study aimed at assessing the impact of using different types of irons on indoor PM_{10} levels, and the associated chemical and toxicological characteristics.

2 Materials/Methods

Several PM_{10} samples were collected on quartz fibre filters when ironing different clothes in a room. Two flat irons (steam iron and a steam iron with boiler) were studied. The measurements were performed under minimum ventilation conditions, i.e., all the doors and windows were kept closed due to the cold weather outside. Additionally, the PM_{10} levels generated during steam ironing under normal ventilation conditions, i.e. the room doors were opened, while the windows were kept closed, were also investigated. A high-volume sampler operated at a flow of 30 m^3/h was used. Background air samples from the same room were also obtained. After gravimetric determination, thermo-optical analysis of the PM_{10} filters was performed to obtain the carbonaceous content. After multi-solvent extractions, a detailed organic speciation was conducted by GC-MS (Alves et al., 2011). To evaluate the toxicity of the organic extracts, the human alveolar adenocarcinoma cell line (A549) was cultured and maintained in flasks with Kaighn's Modification of Ham's F-12 Medium, supplemented with 10% (v/v) fetal bovine serum, 1% of penicillin-streptomycin and 1% Fungizone at 37°C in a humidified incubator with 5% CO_2. Subculture was performed when cultures reached approximately 90% confluence. The potential cytotoxic effect of particulate samples was measured with a cell counting kit by using the highly water-soluble tetrazolium salt WST-8, following manufacturer instructions with slight modifications. Particle samples were suspended into dimethyl sulfoxide. Eight different concentrations (0.1-150 µg/mL) of PM_{10} were tested. For each condition, two independent experiments were carried out in triplicate.

3 Results and Discussion

As a result of ironing, particle concentrations increased 4 to 15 times. Total carbon accounted for 26.0±4.14 to 33.3±3.17% of the PM_{10} mass. Particles were composed of hundreds of different organic compounds (Fig. 1).

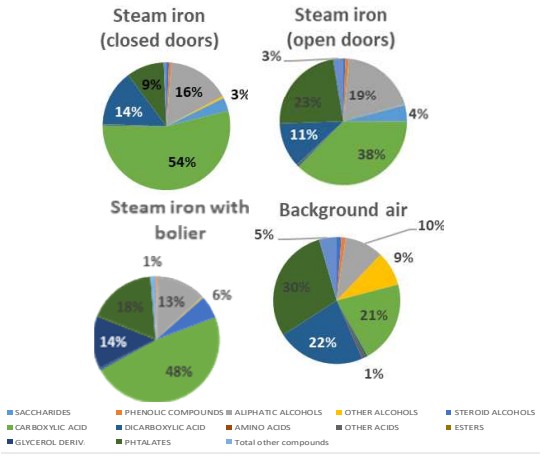

Figure 1: Organic compounds in PM_{10} from ironing.

A decrease in cell viability for all samples at the three highest concentrations (50, 100 and 150 µg/mL) was observed. At the highest concentration (150 µg/mL), samples from steam ironing, under normal and low ventilation conditions, and from boiler steam ironing, presented a decrease of 42±6, 22±12 and 43±2% in cell viability, respectively (Fig. 2). The background air sample also induced a considerable decrease in cell viability (37±3%) at the highest concentration.

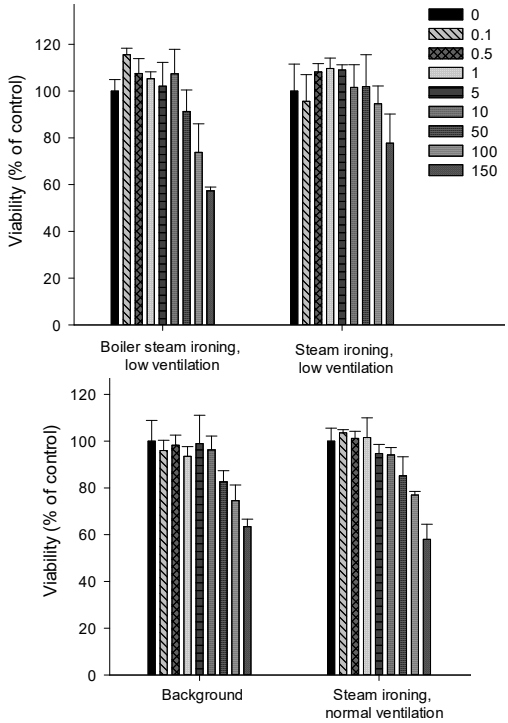

Figure 2: Cell viability after 24 h exposure to increasing concentrations of organic extracts from PM_{10} collected while ironing.

4 Conclusions

Over the last decades, firm steps towards the restriction of emissions into the atmosphere and the control of PM_{10} concentrations in urban areas have been carried out. On the contrary, the predominant idea that indoor environments do not constitute an issue of concern compared with the outdoor air resulted in a delay of research in this topic. In the present study, it was observed that ironing clothes contributes to the emission of particles with a very complex organic composition, significantly enhancing the indoor levels. The organic extracts from these particles were found to have cytotoxic effects. Given the organic compounds detected, it is necessary to evaluate the quantities and quality of detergents and fabric softeners used in washing clothes. In the course of the activity, measures must be taken to promote efficient ventilation. Further investigation is needed, covering various other types of irons and categories of clothing in order to define the safest conditions from the point of view of human health.

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