Particulate matter variation for different types of cigarettes in indoor air

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Particulate Matter Variation for Different Types of Cigarettes in Indoor Air

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Abstract. Particulate matter inhalation (PM) in second hand smoke is harmful to smokers and non-smokers. Various additions to cigarettes may affect the amount from PM. Exposure to PM is not only caused lung cancer but also increased risk of stroke breast cancer mortality. Although the main risks may be transferred to the distal lung by particulate matter, A few studies have been interested in studying PM. The present study aims to characterize PM emissions from three different types of cigarettes (Electronic cigarettes, tobacco cigarettes and IQOS cigarettes system). The experiments were carried out in a 65 m^3 lab room with burning the three types of cigarettes separately. PM_1, $PM_{2.5}$ and PM_{10} concentrations were measured simultaneously with aerosol diffusion spectrometer (ADS)[1]. The Electronic cigarettes achieved the highest values of particulate matter with 193, $1*10^3$and $2*10^3$ ($\mu g/m^3$) for PM_1, $PM_{2.5}$ and PM_{10} respectively. The value of surface area ranged from 3460 for IQOS cigarettes to 7482 for Electronic cigarettes. IQOS cigarettes got less particulate matter concentrations in different sizes. This may be due to the way IQOS cigarettes operate, as the tobacco is heated, not burned.

INTRODUCTION

The people spend nearly 80% of their time indoors and often the air within homes, offices, and other buildings may be more sorely contaminated than the outdoor air. Therefore, indoor air contamination represents hazard to human health and deserves attention. Smoking is responsible for severe diseases in financially developed countries and is also ordered the second cause of death globally and the first cause of lung cancer [1,2].

The smoke emitted from burning of tobacco and electronic cigarettes in indoor air releases particulate matter and the combustion leads to the production of a great amount of smoke, which when inhaled poses an enormous health hazards [3]. The observed exposure to wield diminutive variations, from time to time, in surrounding air metal particles concentration leads to the fact that reduction of these particulate and metal pollution to numerous sufficient levels is an essential ecological issue [4]. Among them, fine particles have a higher burden of toxic metals than coarse particles owing to their higher penetration power ability to reach lungs [5]. The major source of particles in the indoor air is mainly derived from the smoking different types of cigarettes, a worldwide custom [5].

Particulate matter (PM) particles have different size, composition and origin a mixture of particles that can be solid, liquid or both, suspended in the air and represent a complex mixture of organic and inorganic substances. The particle size for PM can vary from 0.005 μm to 100 μm in diameter. All ambient PM (diameter from 0.005 μm to 100 μm) are referred to as total suspended particulate matter (TSP). PM less than 10μm is referred to as PM_{10}, that less than 2.5 μm as $PM_{2.5}$ and that less than 1μm as PM_1. Particles less than 0.1 μm are called ultrafine particles (UFP). PM_{10} are inhalable and are referred to as respirable particulate matter (RPM) [6]. The heavy metals in particulate matter which were inhaled in elevated concentration are suggested to impact harsh toxic and carcinogenic effects on humans [5].The size and dynamics of the particles in the respiratory system are shown in Fig. 1.

In the present study, the simultaneous characterization of PM_1, $PM_{2.5}$ and PM_{10} suspended particles for three different types of cigarettes (Electronic cigarettes, tobacco cigarettes and IQOS cigarettes system) in indoor is

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presented. This aims to deepen the knowledge of indoor air quality and present the initial hazard of these cigarettes' types.

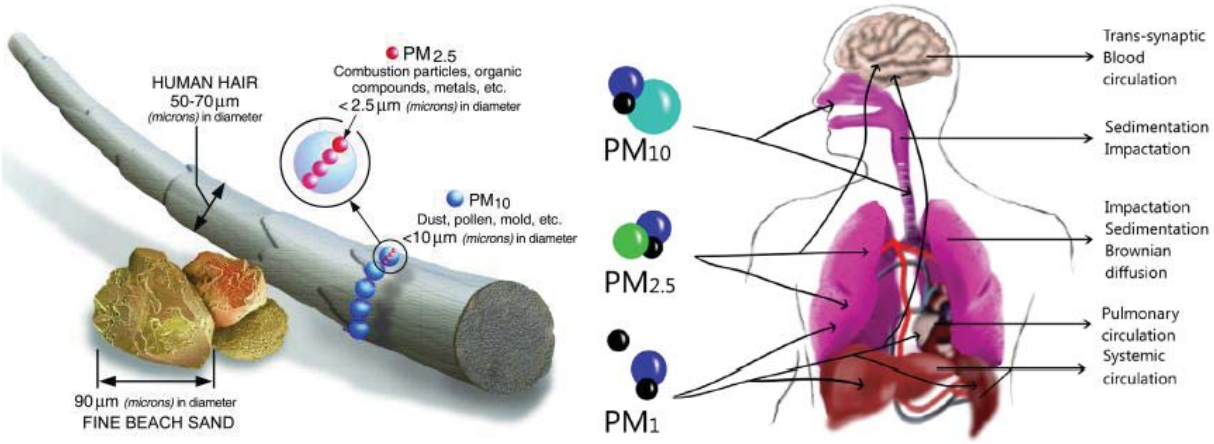

FIGURE 1. The size and dynamics of the particles in the respiratory system (lung and others tissues)

MATERIALS AND METHODS

The experiments were carried in room with volume 65 m^3. Temperature values varied from 23 to 25 ^{0}C with a relative humidity of 40-45%. Particle concentrations were continuously monitored before, during, and after the smoke burning using a diffusion aerosol spectrometer (DAS). The technical design of the DAS (Model 2702 M) is shown in Fig. 2 [7–11]. Aerosol particle parameters like, number concentration, different PM concentration, average particle surface area and metrological parameters (temperature, humidity and pressure) were recorded and automatically saved every ~ 2 minutes. The electronic unit controls spectrometer operations, processing, calculation, the display of measurement results, and the storage and transmission of data to a computer via a USB interface. The output files from the DAS were EXCEL files with the measured data.

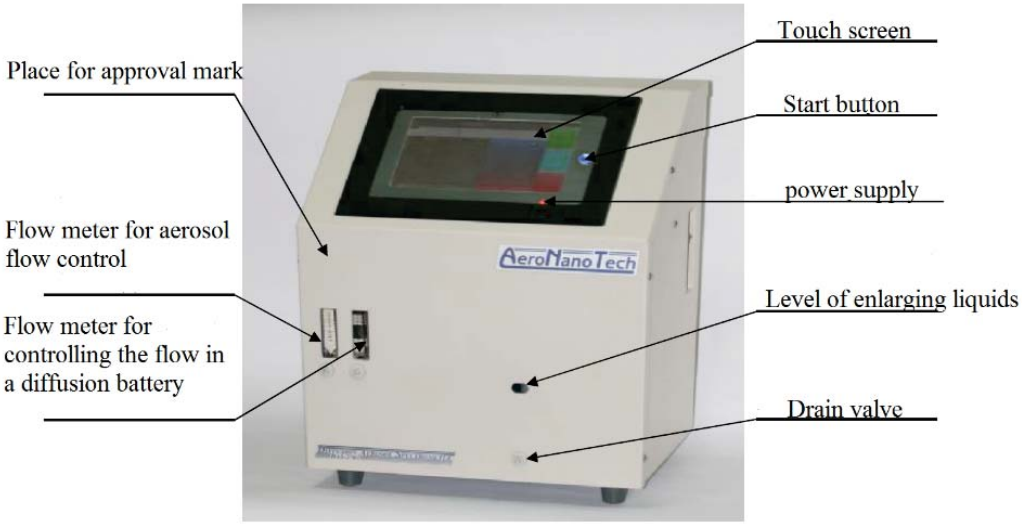

FIGURE 2. Diffusion aerosol spectrometer (DAS) (Model 2702 M)

The smoke source was placed in the center of the room 3 meters from the DAS. *Regular tobacco cigarette*: First, one cigarette was burned for approximately 10 min. A volunteer then smoked the same type of cigarette. There was

no noticeable difference between the two cases. *Electronic cigarette:* Aerosol particles were released from one ordinary e-cigarette (pons) using the same volunteer for approximately 10 min. *IQOS cigarettes:* Aerosol particles were released using the same volunteer for approximately 10 min. Then the source was removed or deactivated: the following changes in the concentration was observed and studied.

Figure 3 presents the scheme of electronic cigarettes, tobacco cigarette and IQOS cigarettes system that used as aerosol sources. The experiments were repeated several times for the three cigarettes as indoor aerosol sources for significant statistics.

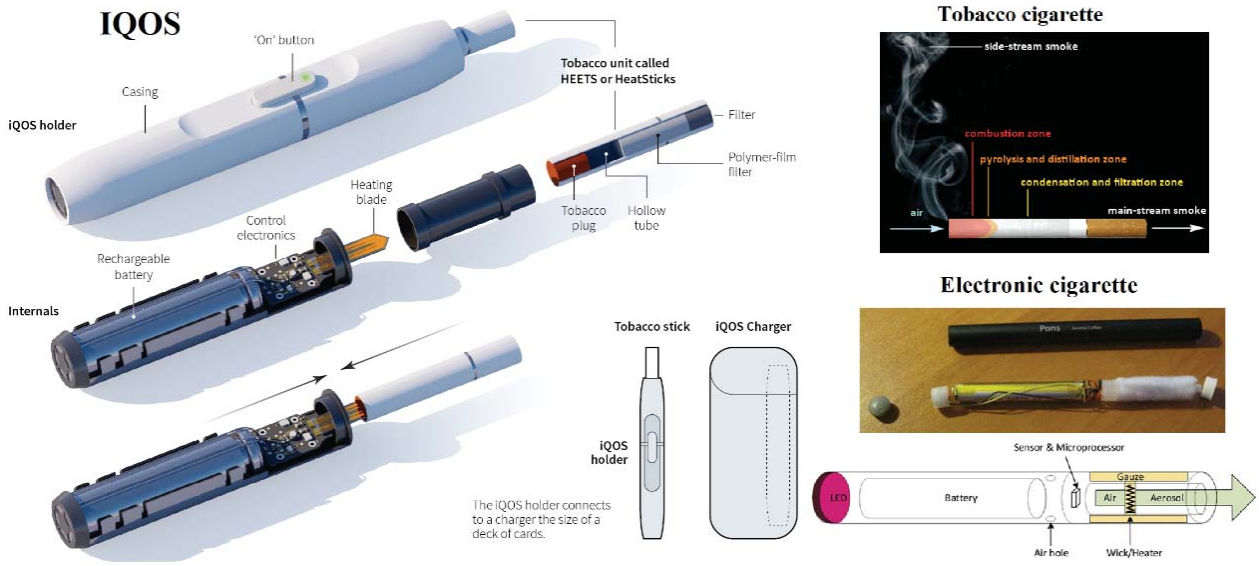

FIGURE 3. Scheme of electronic cigarettes [10], tobacco cigarette and IQOS cigarettes system

RESULTS AND DISCUSSION

The particulate matter concentration (PM_1, $PM_{2.5}$, and PM_{10}) was obtained for the three different cigarettes (Electronic cigarettes, tobacco cigarettes and IQOS cigarettes system) as indoor aerosol sources. These results are shown in Fig. 4. The results in Fig. 4 with times intervals (before, during source turning on and after turning source off in indoor air 5, 10, 15 min). The clear effect is during source turned on and after 5 min source turned off. The concentrations of particulate matter backs to background at ten/fifteen minutes source turned off. Its not mean the hazed disappeared because it needs a critical chemical analysis to understand the composition of air before and after smoking. The question, Are the air completely back to the fresh case or not after smoking? is under investigation. Now, there is no doubt that during 15 min of smoking (including burn and 5/10 minutes after end) not only smoker but also companions with him expose to high level of particulate matter.

Electronic cigarettes have the highest mass concentration for the three-particulate matter sizes (PM_1, $PM_{2.5}$ and PM_{10}) compared to other two types (tobacco cigarettes and IQOS cigarettes system). Particulate matter concentrations of the sources after the first five minutes from the turning off are presented in Fig. 5.

This result is refusing the postulate by some studies which indicated that the aerosol particle size and mass concentration generated from e-cigs may be similar to that of conventional tobacco cigarette [6]. Electronic cigarettes are an effective source for $PM_{2.5}$ and PM_{10} but PM_{10} is two times higher than $PM_{2.5}$. Also, the different between tobacco cigarettes and IQOS cigarettes system is presented in small figure. The difference in PM_1 is clear for IQOS cigarettes system with two time higher than tobacco cigarettes also the total number concentrations of tobacco cigarettes in tin minutes three/four times higher than IQOS cigarettes system. It means that IQOS cigarettes system nearly don't have ultra-fine particles fraction which is the highest harmful fraction on the respiratory system. This is Because the tobacco in IQOS cigarettes system is heated (~350 ºC) and not burned (≥600 ºC) likes tobacco cigarettes. In this case, the levels of UFP and harmful chemicals are significantly reduced.

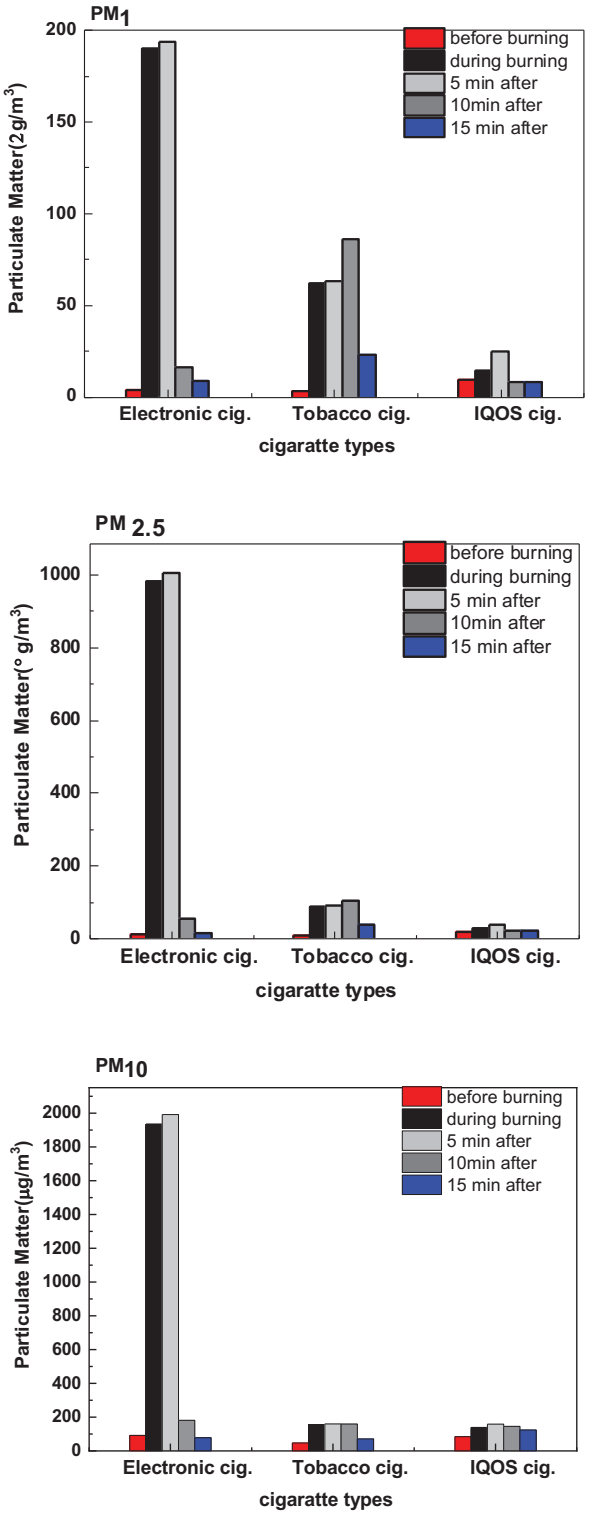

FIGURE 4. The particulate matter concentration (PM_1, $PM_{2.5}$, and PM_{10}) for the three different cigarettes (Electronic cigarettes, tobacco cigarettes and IQOS cigarettes system) as indoor aerosol sources with times intervals (before, during source turning on and after turning source off in indoor air 5,10,15 min)

The total surface area of the three different cigarettes (Electronic cigarettes, tobacco cigarettes and IQOS cigarettes system) is shown in Fig. 6 with the same time intervals. Since the electronic cigarette were the highest sources of particle number concentration and particulate matter concentration, it also achieved the highest value for surface area, especially in the first five/ten minutes after stopping smoking. Although tobacco cigarettes surface area nearly two times smaller than electronic cigarette but have a high resident time in air. This result one of the hazards of these types of cigarettes regarding to large surface area allows for a greater proportion of absorbed or condensed particles in tissues and bloodstream [12].

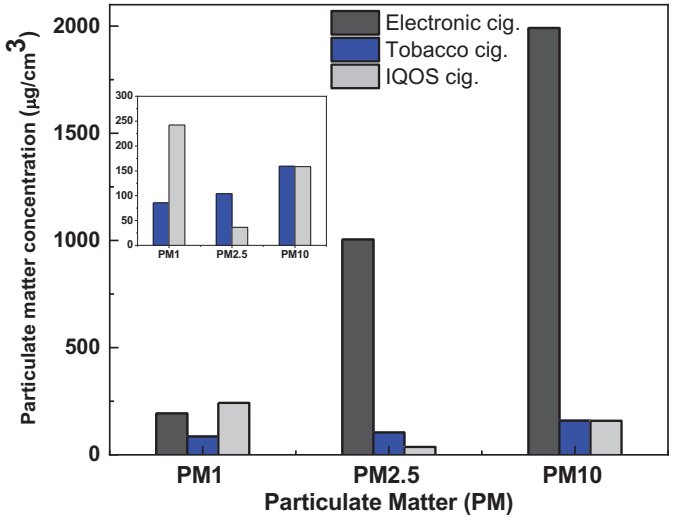

FIGURE 5. The particulate matter concentration (PM_1, $PM_{2.5}$, and PM_{10}) for the three different cigarettes (Electronic cigarettes, tobacco cigarettes and IQOS cigarettes system) as indoor aerosol sources after the first five minutes from the source turned off

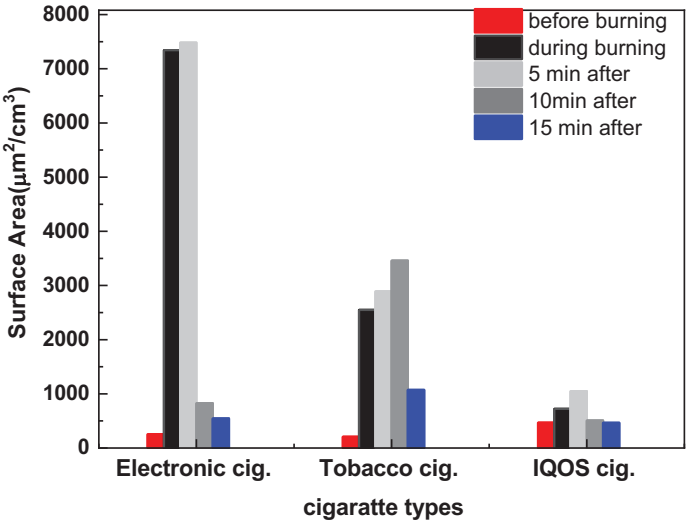

FIGURE 6. The total surface area of the three different cigarettes (Electronic cigarettes, tobacco cigarettes and IQOS cigarettes system) as indoor aerosol sources

CONCLUSIONS

1. The higher concentrations of $PM_{1.0}$, $PM_{2.5}$, and PM_{10} were recorded for the electronic cigarette source.
2. Fifteen minutes of smoking (including burn and 5/10 minutes after end), not only smoker but also companions with him expose to high level of particulate matter.
3. The obtained results is refusing the postulate by some recent studies which indicated that the aerosol particle size and mass concentration generated from e-cigs may be similar to that of conventional tobacco cigarette.
4. Because the tobacco in IQOS cigarettes system is heated and not burned as tobacco cigarettes, the levels of inhaled PM and harmful chemicals are significantly reduced.
5. The large surface area with high resident time in air for tobacco cigarettes allows for a greater proportion of absorbed or condensed particles in tissues and bloodstream with high inhalation chance.
6. As recommendation, chemical analysis gradient for these PM should be test to understand the total hazards.

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