The aerosol generated from the Tobacco Heating System is not smoke

Introduction

A new opportunity to reduce the harm from combusted tobacco products (generating smoke) has emerged, based on switching consumers to potentially less harmful smokeless products that deliver significantly reduced levels of harmful chemical compounds when compared to continued cigarette smoking.1

These new and innovative products have the potential to significantly reduce the individual risk for smokers when compared to the continued smoking of cigarettes. One of these new and innovative non-combustible products is the Tobacco Heating System (THS), which heats rather than burns a specially formulated tobacco substrate.

Smoke versus non-smoke aerosols

An aerosol is a mixture of dispersed solid particles and / or liquid droplets suspended in a gas.2,3 Aerosols are naturally present in nature and are generated by various natural and industrial processes.

Smoke is defined by Gross et al.4 as “the gaseous products of burning organic materials in which small solid and liquid particles are also dispersed” and by Mulholland5 as “the smoke aerosol or condensed phase component of the products of combustion.” It is apparent from these scientific definitions, that smoke is an aerosol that is generated from combustion products. Tobacco smoke is generated when tobacco leaves burn (combust).

While smoke is an aerosol, not all aerosols are smoke, as shown in Figure 1. The aerosols formed from the condensation of water vapor or vaporized liquids are very different in terms of origin, chemical and physical composition compared to smoke aerosols formed from the combustion and associated high temperature pyrolysis products generated from the burning of wood or tobacco.

Non-smoke Aerosols

Smoke Aerosols

Figure 1. Examples of different aerosols.

Cigarette smoke formation

When the tobacco in a cigarette is set on fire, a self-sustaining smoldering combustion process is established. During the smoldering combustion, the tobacco in the burning cone of the cigarette reaches temperatures up to 1652°F (900°C). The large amount of energy released by the combustion process breaks down tobacco components generating a complex smoke aerosol (composed of gases, liquid droplets and solid particles suspended in air) and ash. Cigarette smoke is a complex mixture in which over 6,000 chemicals have been identified.6 A smaller number of these chemicals have been classified by public health authorities as likely causes of smoking-related diseases, such as lung cancer, heart disease and emphysema. The majority of these chemicals are generated by processes occurring when tobacco is burnt.

The smoke particulates are formed when combustion and high temperature pyrolysis products (e.g. hydrocarbons) reach supersaturation and condense to form droplets, react, or by the nucleation and growth of positively charged hydrocarbon ions resulting in the formation of soot particles.7

THS aerosol generation

Unlike burning cigarettes, the THS heats a specially formulated tobacco substrate using an electronically controlled heater to temperatures below that necessary to initiate combustion. The controlled heating of the tobacco substrate vaporizes water, glycerol (an aerosol former added to the tobacco substrate), nicotine and flavors generating an aerosol that is not smoke, and that is fundamentally different in origin, chemical and physical composition to cigarette smoke. As the tobacco substrate in the Tobacco Stick is heated and not burned, the aerosol generated contains on average 90 to 95% lower levels of harmful and potentially harmful constituents compared to the mainstream smoke of a standard reference cigarette (3R4F).8

The liquid droplets of the THS aerosol are generated when the vaporized glycerol (having a low vapor pressure) reaches supersaturation and condenses forming nuclei, onto which more glycerol, water, nicotine and other constituents can condense forming droplets.9,10 The resulting non-smoke, nicotine containing aerosol, is therefore generated by glycerol (which is specifically added to the tobacco substrate during processing to act as an aerosol former and is vaporized when the tobacco substrate is heated).9,10

Scientific assessments

A series of robust scientific experiments have confirmed that the THS aerosol is not smoke: temperature measurements and experiments performed under nitrogen and air confirm the absence of combustion occurring in the tobacco substrate when used as intended and heated in the THS device;11,12 chemical characterization of the THS aerosol shows that it is profoundly different compared to mainstream cigarette smoke in terms of
chemical composition\textsuperscript{13} (see Figure 2), and that in contrast to cigarette smoke, the THS aerosol does not contain solid particles.\textsuperscript{14} The absence of combustion and no smoke formation has been verified by scientific experts in numerous countries including the U.S., U.K., Italy, Japan, and Poland.\textsuperscript{15}

Evidence that the THS aerosol does not contain solid particles is shown in Figure 3, which is a comparison of scanning electron microscope (SEM) images determined for the THS aerosol and for the mainstream smoke of a 3R4F reference cigarette. The SEM image of a blank run performed prior to cigarette smoke and THS aerosol generation is also shown. X-ray data analysis of the SEM images confirmed that both the blank and the THS aerosol samples are similar, i.e. the observed small amount of particles are due to unavoidable system contamination from the experimental setup (metal joints/fixtures).

In stark contrast, the SEM image obtained for the mainstream smoke of the 3R4F reference cigarette shows a significant number of solid particles/high boiling point droplets which are not present in the blank or THS aerosol samples. X-ray analyses showed that these particles were composed mainly of carbonaceous solid particles.

To learn more about the science behind PMI’s heat-not-burn tobacco products, visit PMIScienceUSA.com.

\textbf{References}