

Solid particle investigation in the mainstream of 3R4F reference combustible cigarettes and the Tobacco Heating System THS2.2

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Introduction & Objectives

Smoke is a mixture containing liquid droplets and solid carbon particles suspended within a gas whereas an aerosol may contain only suspended droplets (K. M. Butler and G. W. Mulholland). In particular, suspension of carbon in air are typically emitted from a burning substance. In particular, the combustion process is likely to produce solid carbon particles whereas their production is kinetically much less favored when an organic substrate like tobacco material is heated (K. C. Oha et al.) instead of being burnt.

The objective of the current work was to evaluate whether carbon solid particles are released in the mainstream aerosol from the heat-not-burn product Tobacco Heating System THS2.2 in comparison with the smoke produced from the 3R4F combustible reference cigarette. For this purpose, a methodology using a Dekati commercial Thermo-denuder operating at 300°C associated with chemical characterization was developed.

Methods & Equipment

When the aerosol (THS2.2) or the smoke (3R4F) reach the entrance of a thermo-denuder maintained at 300°C, it is transported to a second section consisting of a gas stripper used to remove the gas vapor phase from evaporated droplets. Any remaining suspended matter should be composed only of solid particles or high boiling point droplets.

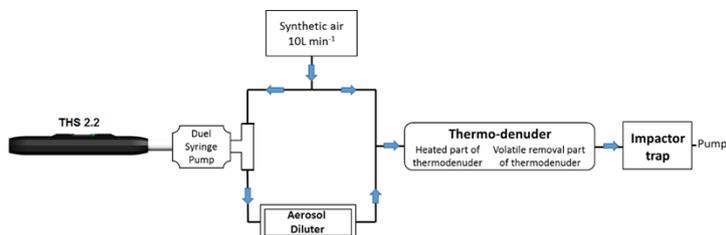


Figure 1: Experiment design for mainstream aerosol collection.

- the efficiency of the thermo-denuder was evaluated using glycerin model aerosols and a TSI Scanning Mobility Particle Sizer (SMPS).
- a TSI Condensation Particles Counter (CPC) was used to quantify particles potentially released from 3R4F smoke and THS2.2 aerosol.
- a two-stage impactor trap (T. Jalanti and P. Henchoz) was used to deposit the thermo-denuder treated aerosols on a collection substrate.
- Scanning Electron Microscope (SEM) and Energy Dispersive X-ray (EDX) analyses were performed at the collection substrate surface.

From the method validation it was demonstrated that:

- 86% of the glycerin droplets were removed from the thermo-denuder at 300°C.
- At 300°C wall losses were approximately 20% from the use of a dry NaCl aerosol.
- the number concentration removal yield of the particulate matter needed to be from 80 to 14% to achieve quantification.

Results & Discussions

3R4F experiments: (20 puffs accumulated/two cigarettes smoked)

- Approximately 80% in number of the total particulate matter was neither evaporated nor removed in the thermo-denuder representing $\sim 10^{12}$ particles per 3R4F, attributed to solid particles/low volatile liquid droplets.
- The Count Median Diameter was found to be approximately 75 nm.
- Mainly carbon-based material with oxygen was found. To a lesser extent, traces of potassium, chlorine, aluminum, sulphur and silicon matter were detected, most likely coming from the environment.

THS2.2 experiments: (22 puffs accumulated/two tobacco sticks heated)

- The removal of the particulate matter from the mainstream aerosol was slightly larger than the determined glycerin effective removal efficiency.
- No solid particle were quantified.
- Compared to the blank, no additional particles were observed.

Figure 2 shows the SEM images from the collection experiments for 3R4F combustible cigarette smoke and THS2.2 aerosol.

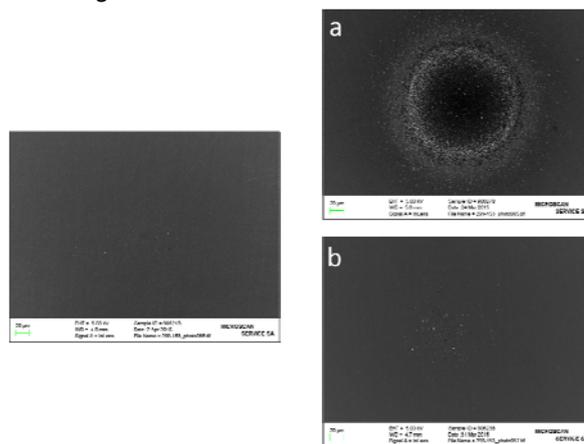


Figure 2: pictures showing accumulated submicron particles from the thermo-denuder treated mainstream of a) 3R4F smoke and b) THS2.2 aerosol. The picture on the left side is the related blank prior aerosol collection started. We would like to thank Microscan Service SA (Rue de la Blancherie 17, 1022 Chavannes-près-Renens, Suisse) to have performed the SEM/EDX analyses, provided scientific expertise and SEM pictures.

Conclusions

- Smoke generated from combustion in 3R4F was found to contain high levels of solid particles, mostly carbon-based, consistent with the combustion processes known to occur in this product.
- The aerosol produced from THS2.2, in contrast, was identified to be made up of liquid droplets, with no increase over background levels of solid particles. This finding confirms the absence of combustion in the Tobacco Heating System THS2.2.

References

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