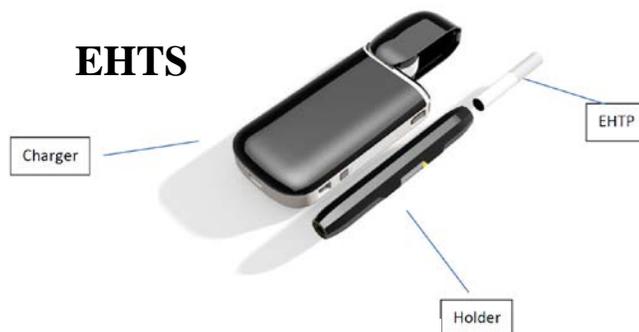


Philip Morris International (PMI) has developed a patented Electrically Heated Tobacco System (EHTS) that heats a specifically designed tobacco product (Electrically Heated Tobacco Product or EHTP). The EHTP contains tobacco<sup>1</sup> material in the form of a plug that undergoes a controlled heating process to produce a vapor (aerosol). The tobacco is only heated and is not burnt as happens in a lit cigarette.



PMI retained Professor Osamu Fujita to review and analyze scientific data on the thermal processes taking place in EHTS during aerosol generation. Professor Fujita is a faculty member in the Division of Mechanical and Space Engineering at Hokkaido University, Japan. He is an expert in the field of combustion and an international leader in microgravity combustion research. His work covers a wide area of combustion research including: ignition and flame spreading, catalytic combustion, soot formation, high temperature combustion, combustion in microgravity, electric and magnetic field effects on combustion, biofuels, and combustion diagnostics. He is Vice President of the Combustion Society of Japan and committee member of the International Combustion Institute.

Professor Fujita performed a literature search of scientific definitions for combustion and smoke. He then reviewed the operation of the EHTS, analyzed experimental data on the EHTS provided by PMI (that included data generated by an independent analytical laboratory), and carried out numerical ignition calculations to assess whether any combustion processes occur in the EHTP and if the aerosol formed should be classified as smoke.

Based on the above, Professor Fujita issued an expert opinion that includes:

1. Scientific definition of combustion for cigarettes.
2. Analyses as to whether any combustion processes occur when the Holder heats the tobacco material in the EHTP.
3. Numerical ignition calculations
4. Analyses as to whether the aerosol generated from heating the tobacco in the EHTP is smoke

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<sup>1</sup> The EHTP does not contain tobacco cut-filler (tobacco leaf cut in small pieces found in cigarettes) or pipe tobacco. All of the tobacco in the EHTP is reconstituted (cast-leaf) tobacco made from tobacco powder, water, glycerin, guar gum and cellulose fibers.

From his review of the scientific literature, Professor Fujita concludes that the most appropriate definition for cigarette combustion is:

*"Combustion is the phenomenon which happens after ignition."*<sup>2</sup>

He opines that without ignition, no combustion exists.

Prof. Fujita used well established classical ignition theory calculations together with the experimentally measured temperature and thermal properties of the tobacco material in the EHTP to assess if ignition occurs.

He concludes that no ignition, and therefore no combustion, of the tobacco in the EHTP takes place when the EHTP is used as intended with the Holder.

Professor Fujita's expert opinion is based on the following findings from his assessment:

- Combustion can be defined as the phenomenon that takes place after ignition. To satisfy the conditions needed for ignition to occur, both the change in temperature (T) and the rate of change in temperature of the tobacco material, as a function of time (t), must be greater than zero (at temperatures greater than 400 K). This can be expressed mathematically as:

$$\frac{dT}{dt} > 0 \text{ and } \frac{d^2T}{dt^2} > 0$$

- Based on the results of the numerical ignition calculations, the threshold for ignition is not reached (i.e. the temperature of the tobacco material in the EHTP is below the ignition temperature) and therefore no combustion occurs.

From his review of the scientific literature, Professor Fujita concludes that the most appropriate definition for smoke is:

*"a kind of aerosol formed by condensation process of chemical compounds which are generated by combustion process (include pyrolysis process)."*<sup>2</sup>

He concludes that the EHTP generates no smoke but just aerosol as long as the EHTP is used as intended and heated in the Holder.

Professor Fujita's expert opinion is based on the following findings from his assessment:

- Results from aerosol formation simulations performed by PMI show that aerosol droplets are formed only in the presence of an aerosol former being mainly glycerol, but also nicotine and water. Minor compounds of the gas mixture were shown not to be able to reach supersaturation alone and therefore could not generate aerosol droplets from the multicomponent gas mixture at the operating conditions simulated.
- According to the definition of smoke, liquid or solid particulate material in smoke should be formed by condensation process of chemical compounds which are generated by combustion process (including pyrolysis process). As glycerin, water and nicotine are evaporated from the tobacco it can be concluded that EHTP generates no smoke.

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<sup>2</sup> O. Fujita and H. Yan. November 6, 2015. Verification of the absence of combustion processes in the electrically heated tobacco system, EHTS, pages 1 - 14.