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The Removal of CO_2, CO, NO_x and Nicotine from Tobacco Smoke Using Non-Thermal Plasma System

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Abstract

Environmental tobacco smoke is a highly diluted combination of mainstream smoke (MS) exhaled by smokers and sidestream smoke (SS) released directly from the burning tips of cigarettes. In this article the possibility to decrease the unwanted compounds from tobacco smoke i.e. CO_2, CO, NO_X, tar components, PAH and nicotine is shown.

Experiments

The measurements were made for both polarities of spontaneously pulsing transition discharge. The smoke was introduced into gas-cell discharge tube, where the discharge was repeatedly applied. The IR absorption spectra were scanned between discharge applications each 30 s up to 7 minutes (step-by-step kinetic measurements). The decrease of all gaseous oxides namely CO, CO_2, NO, NO_2 are indicated from the IR spectra on Fig.1. The decrease of benzene ring containing tar components and PAH is seen from Kekule band at 1580-1600 cm^{-1} as well as deformation vibrations between 700-200 cm^{-1}. Nicotine appears as C-N-C group in pyrrolle or pyrimidine rings at 1000-1300 cm^{-1}. For the detailed study of nicotine decomposition the solution of one cigarette in a 60 ml of boiled water was made.

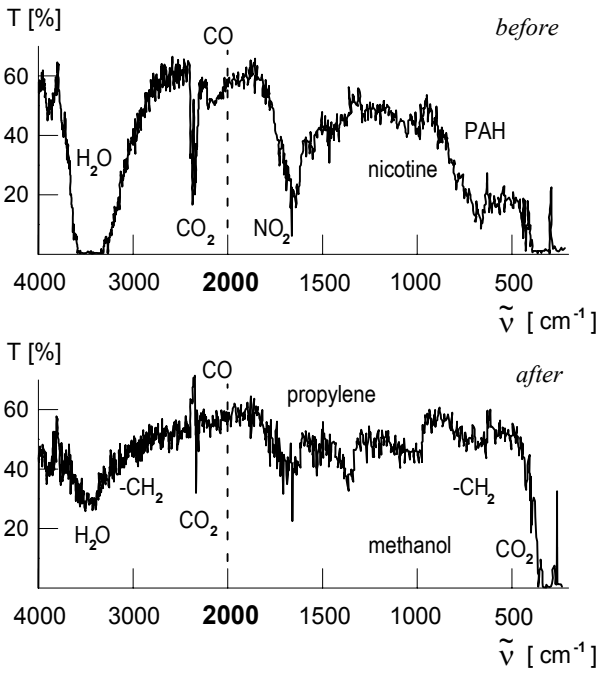

Figure 1. IR absorption spectra of the smoke before / after transition discharge action (up to 7 minutes).

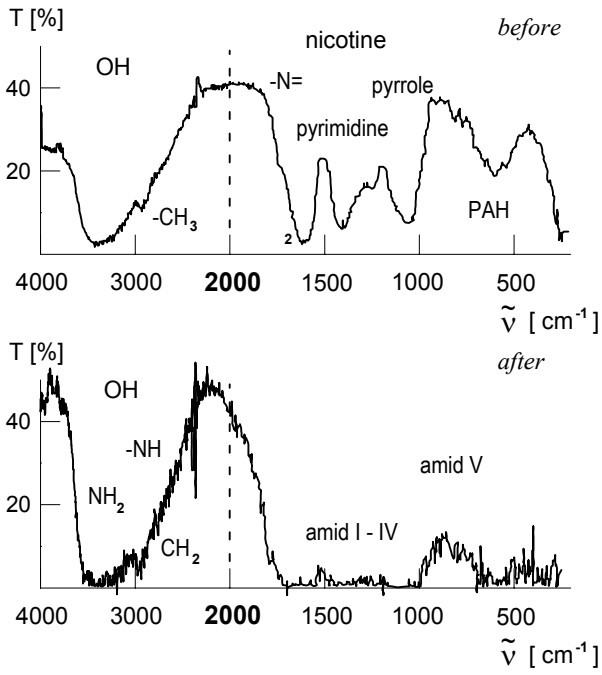

Figure 2. IR spectra from KBr tablet of nicotine compound sediments before / after transition discharge action.

The discharge with plate electrode immersed in the solution and HV electrode situated over the fluid level was applied. The sediment in the case with and without discharge was separated. After drying the KBr pellet technique was used for analysis. The gained spectra are in Fig.2.

Conclusions

In cigarette smoke the concentration of CO_2 reach 25%, CO 2%, NO_X due to high combustion temperature reach 0,3%. In spite of this the removal efficiency is very high, CO_2 decreases under the background level (350 ppm), CO and NO_X decrease to values non-measurable with IR method. The removal efficiency for tar components and PAH differs each other, but in general lies between 65-98% depending on compound type. Very interesting are the result for nicotine especially in comparison with the way, how the human body deals with it. The nicotine after penetration into body is in liver converted into water-soluble cotidine (Fig.3) and later urinated.

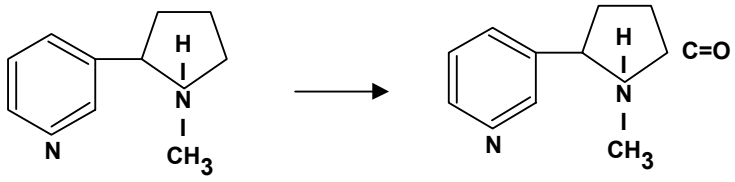

Figure 3. Decomposition of nicotine in liver

From the figure is seen that the structural change in human body is made in a position trans. After transition discharge acts on nicotine solution (or aerosol) the main end product is nicotine amid acid (white powder detected from KBr pellet IR spectrum, Fig.2), which sediments on the non-stressed electrode and can be separated. The gas phase by-products are propylene and methanol as it is very good seen from IR spectrum after discharge action, Fig.1. From the step-by-step kinetic measurements is seen that process of nicotine reconfiguration undergo in two levels. The first phase is oxidation-reduction step connected with deformation by electric field causing the change into position cis. The second phase is decomposition step connected with the formation of terminative =CO and -NH_2 groups (the formation of this group is connected with CO_2 and N_2 fixation published earlier) and release of residual propylene and methanol. The overview of final solid product formation is in Fig.4.

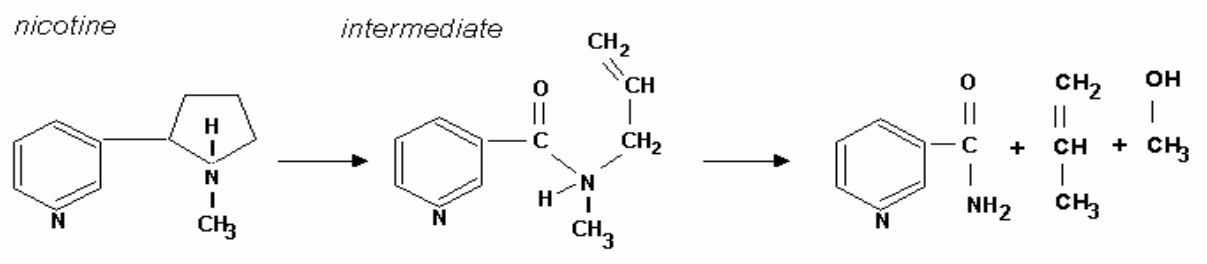

Figure 4. Decomposition of nicotine in transition discharge

Acknowledgement

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