



Characterization of the mainstream smoke obtained by smoking different presentation forms of commercial tobacco samples.



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INTRODUCTION

The smoking cigarette process causes the appearance of two streams, the mainstream and the sidestream smoke. The mainstream smoke represents a 25% of the total tobacco smoke, and is the smoke inhaled and exhaled by smokers directly from tobacco products or mixture of gases passing down the tobacco rod and issuing through the filter end. This stream crosses the primary filter and it is exhaled by the smoker. It is a complex mixture of organic and inorganic compounds, many of them toxic and carcinogenic for humans. The sidestream smoke represents a 75% of the total tobacco smoke, and is the smoke released from a smouldering cigarette, cigar, or other smoking device, diluted with ambient air. It is the stream inhaled by passive smokers. These streams present a high hazard for health; the composition of tobacco smoke is very diverse, with volatile agents, with tar, CO, nicotine, PAHs... compounds very toxicity and carcinogenic. The mainstream smoke, including the less volatile compounds which condense in the lung of the smokers are the main responsible of the tobacco toxicity [2]. In this work, three different presentation forms of tobacco, i.e., cigarette, roll tobacco and pipe tobacco, have been selected and smoked in order to obtain the characterization of the respective mainstream smoke.



Figure 1.- Streams of tobacco

EXPERIMENTAL CONDITIONS

The experiments have been carried out with three different presentation forms of tobacco, i.e., cigarette, roll tobacco and pipe tobacco. The cigarettes have been smoked in a smoking machine following specifications of the ISO 3308[1]. Previously, cigarettes previously were kept for 48 hours in air at 23 °C and 60% relative humidity.

The conditions of the smoking machine are:

- five cigarettes were smoked simultaneously
- puff duration 2s
- puff volume 35 ml
- puff frequency 60 s

During the smoking process the mainstream smoke crosses the filter end and the non-condensed products are collected in a Tedlar bag. The condensed products are retained on the cigarette filter and on a trap located after the cigarette. The liquids retained are extracted with isopropanol [3] and analyzed. The determination of non-condensed products has been carried out GC-TCD, for CO₂ and CO, and the rest of components -i.e. the rest non-condensed and condensed products- have been analyzed by GC-FID and GC-MS, respectively.

Figure 2.- Smoking machine



NON-CONDENSED COMPOUNDS

- > The number of chromatographic peaks is very high, 22 compounds have been clearly identified, with probability of assignment higher than 90%.
- > The non-condensed products are mainly composed by hydrocarbons and aldehydes with low number of carbon atoms.
- > The group of others is mainly composed by alkenes, alkadienes and alkanes.
- > Some typical compounds used as indicative of tobacco toxicity have been found (CO, acetaldehyde, benzene).
- > From the point of view of the toxicity of the mainstream smoke, roll tobacco is the worse of the three studied samples.

Table 1.- Gases presents in the mainstream smoke

µg compound /cigarette	Cigarette	Roll tobacco	Pipe tobacco
Propane	62,2627	107,8811	62,9067
Propene	97,8309	123,1931	81,8237
Isobutane	10,3288	14,9135	8,4710
Butane	25,6635	39,0497	20,6785
Chloromethane	59,1052	49,0977	31,5723
2-methyl-1-propene	29,3358	37,4825	23,9965
1,3-butadiene	43,8940	56,0922	36,5781
pentane	11,6008	16,0740	7,0847
H ₂ CN	1,4058	1,6570	1,1010
Furan	17,8360	16,8665	14,3327
Isoprene	3,8385	208,0200	80,7366
1-hexene	11,7560	13,4583	8,5306
Benzene	69,5206	76,0062	66,4781
Acetaldehyde	1207,0929	1431,1457	743,7618
Acrolein	23,0919	21,4949	18,4464
Propionaldehyde	25,4924	30,9580	19,8931
Acetonitrile	33,3673	43,5693	25,8259
Toluene	28,8832	31,7768	27,1996
2,5-dimethylfuran	21,9616	21,9865	30,6857
Crotonaldehyde	7,9037	6,9125	6,9364
Isobutiraldehyde	10,7754	14,6048	8,0765
Acetone	183,2292	238,7818	133,4837

CONDENSED COMPOUNDS

Table 2.- µg/cigarette condensed in filter

µg/cigarette	Cigarette	Roll pipe	Pipe tobacco
2-propanol	334,581	357,179	269,129
Azole	12,595	17,973	3,018
Furfural	27,039	28,142	11,062
1-acetoxi-2-propane	8,077	15,388	5,052
4-ciclopenten-1,3-dione	10,078	9,104	nd
2-methyl-2-cyclopentenone	8,920	14,016	3,423
Phenol	25,947	45,281	14,648
Corylon	13,576	12,577	3,516
Benzeneimethanol	15,618	10,292	11,272
o-cresol	11,145	14,157	5,015
p-cresol	18,597	29,494	10,405
Guaiaicol	9,052	8,744	3,828
Ethylphenol	10,263	9,754	nd
Hydroquinone	16,713	28,453	9,041
Indole	10,960	17,030	5,021
Nicotine	573,176	1167,024	668,088
Skatol	4,019	8,035	2,670
Miscamine	7,503	9,743	nd
Diethyl Phthalate	113,654	77,737	58,080
Neophytadiene	34,699	82,908	23,537

nd: Not Detected

FILTERS

> The condensed products are mainly formed by oxygenated compounds.

> As in the gases case, roll tobacco seems to be the tobacco presentation with higher degree of toxicity.

TRAPS

> These are the compounds which may condense in the respiratory system of active smokers.

> The components are, in some extent, similar to that retained in the filters. However, the nitrogenated compounds tend to appear in higher extent in the traps.



Table 3.- µg/cigarette condensed in traps.

µg/cigarette	Cigarette	Roll tobacco	Pipe tobacco
2-propanol	29,930	77,052	nd
Ethyl N,N dimetilcarbamate	5,411	nd	nd
Phenol	3,606	10,390	5,718
Corylon	1,354	nd	nd
o-cresol	2,465	4,739	2,641
p-cresol	4,187	8,131	4,648
5-hydroxymethylfurfural	5,017	0,000	7,045
Hydroquinone	16,185	29,640	14,018
Indole	3,802	9,119	3,707
Nicotine	573,769	984,276	667,107
Skatol	2,615	3,637	2,333
Miscamine	5,326	14,164	4,449
2,3-Dipicidyl	4,920	4,827	4,440
Diethyl Phthalate	9,078	8,155	4,116
Cotinine	6,962	15,491	8,254
Neophytadiene	28,586	55,119	25,126
Palmitic acid	10,411	19,181	8,251

nd: Not Detected

CONCLUSIONS

Three types of commercial presentation forms of tobacco have been studied.

Gases are mainly composed by hydrocarbons and some aldehydes with low number of carbon atoms, unlike the condensed products retained in the filters which are mainly oxygenated compounds. The results corresponding to the yields and composition of the liquids retained in the traps are very interesting because these are the compounds which condense in the respiratory system of the active smokers.

The results obtained in this work show that the amount of condensed products and gases obtained when roll tobacco is smoked is higher than the corresponding to the cigarette and pipe tobacco. The tobacco pipe shows the least amounts for the compounds analyzed, except in the case of nicotine, cotinine, 5-hydroxymethylfurfural.

ACKNOWLEDGMENTS

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REFERENCES

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