EVALUATION OF DIFFERENT KIND OF CIGARETTE FILTERS ABILITY OF TO RETAIN THE TOXIC COMPOUNDS OF THE VAPOR PHASE. A COMPARATIVE GRAPHICAL STUDY

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Abstract

The toxicity of the cigarette smoke can be evaluated on the basis of the content (qualitative and quantitative) of the vapor phase of the main stream smoke. The paper analyses, in a graphical mode, the retention ability of 6 kinds of cigarette filters for 28 volatile compounds found in the vapor phase. The retention ability is a function of the chemical structure of the volatile compound, as expected. The acetate and 50 mg/cigerette charcoal dual filter retained better the highly toxic and very toxic compounds of the vapor phase.

Rezumat

Toxicitatea fumului de ţigară poate fi evaluată prin analiza calitativă şi cantitativă a conţinutului fazei de vapori a curentului primar. Lucrarea prezintă în mod grafic, comparativ, capacitatea a 6 tipuri de filtre de ţigaretă de reţinere a 28 de compuşi volatili din faza de vapori. Abilitatea de a filtra aceşti compuşi depinde, aşa cum era de aşteptat, de structura chimică a compuşilor volatili. Filtrul dual care conţine acetat şi 50 mg/ţigaretă cărbune activ s-a dovedit a fi cel care reţine cel mai bine compuşii cu toxicitate foarte mare şi pe cei foarte toxici.

Keywords: cigarette smoke, vapor phase, filter, toxic volatile compounds

Introduction

Cigarette mainstream smoke (MS) is a complex aerosol of liquid droplets (the particulate phase) suspended within a mixture of gases and semivolatile compounds [5]. The gases and semi-volatiles are termed the vapor phase. By weight, the vapor phase contains approximately 13.5% components from pyrolysis and combustion of tobacco; from that, water and carbon monoxide account for about 90% of the total weight and the remaining 10% of the vapor phase (1.3% of the whole smoke) represents tobacco-derived smoke components. Nearly 4800 tobacco smoke components have been identified [4]. Whole cigarette smoke or cigarette smoke condensate have been associated with a number of pathological states including mild nasopharyngeal and ocular irritation, pulmonary inflammation, atherosclerosis, thrombosis and hemodynamic effects, mutagenicity, cytotoxicity and carcinogenicity, not only to the smoker himself, but also to other people breathing it – the passive smokers [7]. As the MS smoke is a very complex mixture of different toxic compounds, assays conducted using whole smoke most closely approximate the *in vivo* situation experienced by the smoker.

There are many methods to reduce the addiction to nicotine [6], but also to reduce the toxicity associated to the MS smoke. Among them, the most efficient is to use filter cigarettes [2, 9].

The paper aims to compare the ability of different kinds of cigarette filters to filter out the vapor phase of the mainstream smoke components using suggestive graphs.

Materials and Methods

Samples

Twenty standard Kentuky 2R4F [3] cigarettes from Kentucky Tobacco Research & Development Center were smoked for each filter sample using a 20 port rotary Borgwaldt smoking machine. The mainstream smoke was collected according to standard methods (on Cambridge filter pads, in special cuvettes containing liquid trapping solutions, etc.)

A number of 6 kinds of filter were analyzed, as follows: F1= paper filter (reference), F2=mono acetate filter, F3, F4 and F5=dual filters consisting in acetate and charcoal (20 mg, 30 mg, 50 mg per cigarette, respectively), F6= dual filter consisting in paper filter and 30 mg charcoal per cigarette.

Methods

The GC-MS quantitative evaluation was performed for 29 volatile compounds in the vapor phase were collected on the filter pads and analyzed using GC-MS and in-house validated methods, consisting of modified AOAC and ISO modified standard methods [1, 3, 4].

The results of five replicates of a sample collection were expressed as means ± standard deviation per 1 puff count. Graphs were plotted using MSOffice Excel 2010 software.

As the results are rather difficult to be presented and studied as such, we chose to present them on graphs. Therefore, the compounds were split into categories based on their chemical structure (Table I), or on their toxicity (Table II) [8, 10].

Table I

The volatile compounds ranged by their chemical structure

Aliphatic hydrocarbons (saturated)	methane, ethane, propane, 2-methylpropane
Aliphatic hydrocarbons (unsaturated)	ethene, acetylene, 1-butene, 1,3-butadiene, 2-butene, cis-2-butene, 2-methyl-2-butene
Homocyclic hydrocarbons	benzene, toluene
Heterocyclic hydrocarbons	furan, 2-methylfuran, 2,5-dimethylfuran
Aldehydes	acetaldehyde, acrolein, propionaldehyde, 2-methylpropanal, crotonaldehyde
Ketone	acetone, methyl vinyl ketone, methyl ethyl ketone
Nitroalkanes	acetonitrile, propionitrile
Ester	methyl acrylate
Alcohols	methanol
Haloalkanes	chloromethane

Table II

The volatile compounds ranged by their toxicity

Highly toxic	acrolein, furan, propionitrile, methyl vinyl ketone, methyl ethyl ketone, crotonaldehyde, benzene, 2,5-dimethylfuran, toluene
Very toxic	methanol, acetaldehyde, propionaldehyde, acetone, 2-methylfuran
Toxic	chloromethane, 1,3-butadiene, acetonitrile, methyl acrylate
Low toxicity	ethene, 1-butene, 2-methylpropanal
Non-toxic	methane, acetylene, ethane, propane, 2-methylpropane, 2-butene, cis-2-butene, 2-methyl-2-butene

Results and Discussion

The first analysis of the graphs representing the studied compounds shows, as expected, that the less retained compounds by the filter were those having a lower molecular weight (Figure 1).

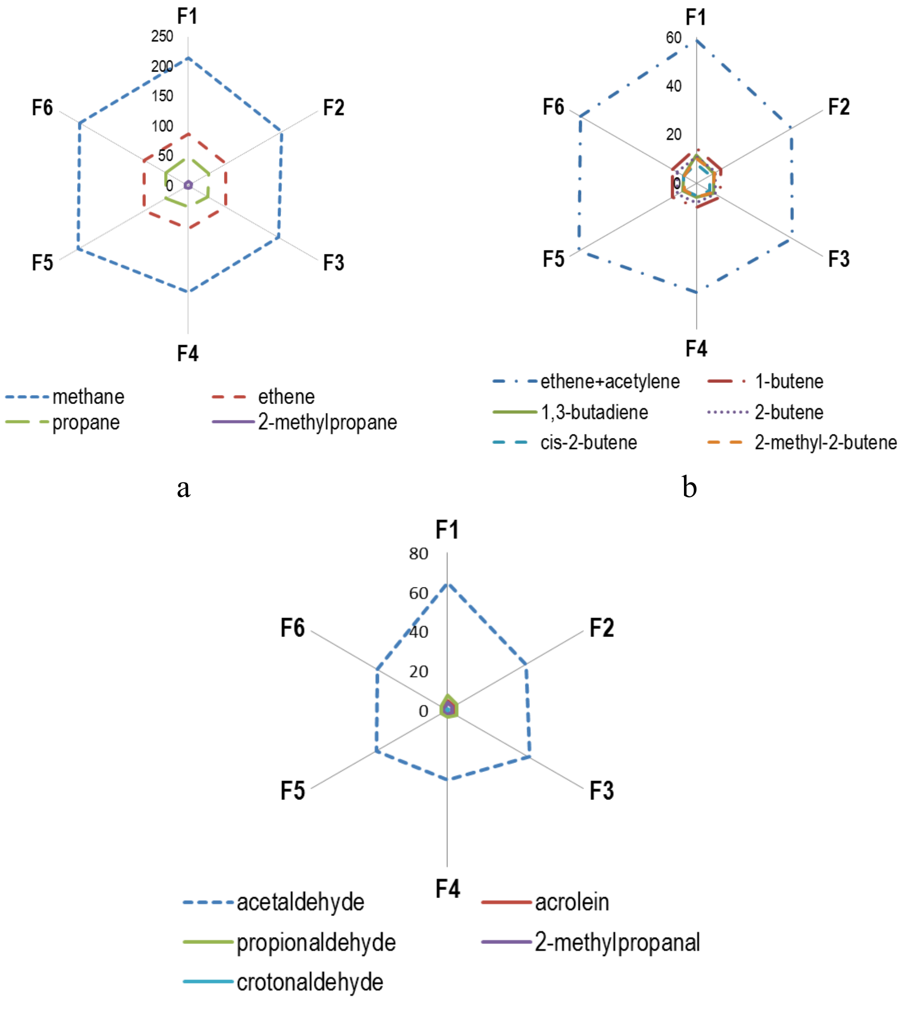


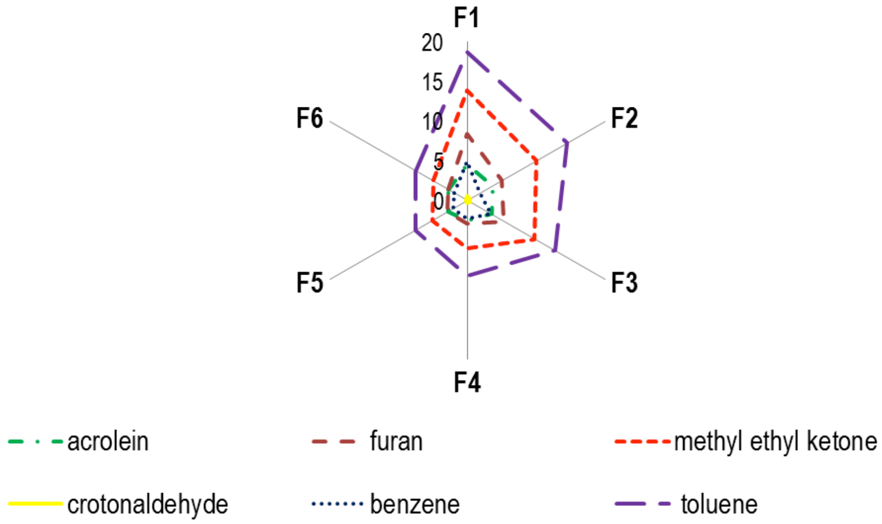
Figure 1

Amounts of compounds (ng/puff) detected in the vapor phase: a) aliphatic hydrocarbons (saturated), b) aliphatic hydrocarbons (unsaturated), c) aldehydes

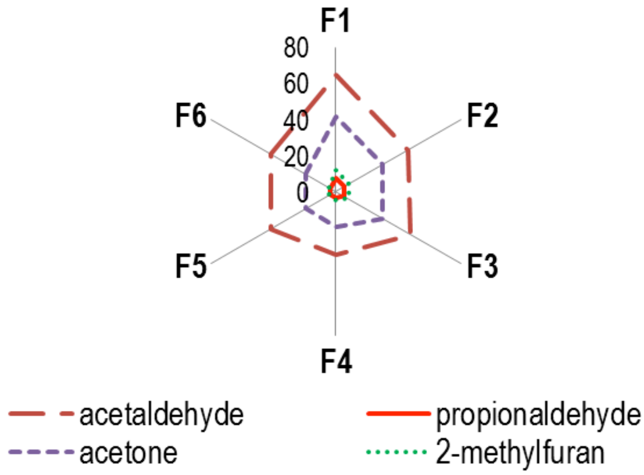
However, only the criteria of the molecular weight is not relevant to classify the ability of cigarette filters to retain the compounds in the main stream smoke, as obviously the chemical structure and molecular volume also play an important role in filtering the vapor phase.

From all the compounds, methane and ethene were the less retained, however at a large difference between them (i.e., methane found was about 200 ng/puf and ethene at about 80 ng/puff). Acetaldehyde, propane and ethene plus acetylene are in the same order of magnitude (about 40 ng/puff count), followed by chloromethane and acetone (around 20 ng/puff).

The toxic compounds (Figure 2) are less retained by the reference filter (F1) than all the other tested filters. Filter F5 (acetate and 50 mg/cigarette charcoal dual filter) seems to be the best of all tested filters, as it retains a greater amount of highly toxic and very toxic compounds.



a)



b)

Figure 2

Amounts of toxic compounds (ng/puff) detected in the vapor phase:
a) highly toxic, b) very toxic

This kind of analysis can be further developed in a pattern recognition type analysis, provided that a proper algorithm of quantifying the effects of the cigarette smoke is established.

Conclusions

As much as 29 volatile compounds in the vapor phase were analysed having in view the ability of retaining these compounds by 6 kinds of cigarette filters. The analysis was performed in a graphical mode, having in view the comparison between different kinds of filters. The compounds were classified on the basis of their molecular structure and their toxicity. The retention ability is a function of the chemical structure of the volatile compound, as expected. The acetate and 50 mg/cigerette charcoal dual filter retained better the higly toxic and very toxic compounds of the vapor phase.

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Manuscript received: August 12th 2012