Alternative additives for cigarette filters

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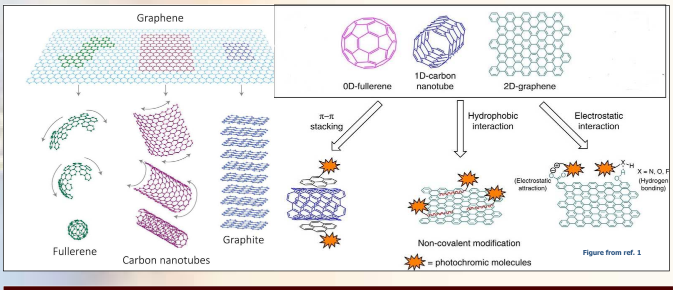
INTRODUCTION

For years, activated carbons have been extensively used for water treatment and gas adsorption because their large surface area. More recently, new generations of carbon structures built at nanoscale with relatively large surface areas and exhibiting novel electronic and chemical properties open new horizons for achieving enhanced adsorption and new and sophisticated applications. Graphene, isolated in 2004 and probably the most important of these new structures, is a flat monolayer (a two dimensions material) made from carbon atoms arranged in a hexagonal pattern. Other morphologies include hexagonal, pentagonal (i.e. fullerenes), heptagonal or higher carbon rings shaping non-planar molecular geometries. Such distortions from the planarity are closely linked to the chemical reactivity that could be attributed to the curvature of the nanosurfaces and the hybridization sp, sp2 or sp3 of the carbon bonds.



OBJECTIVE

In this work we tried to find whether these novel carbon structures were capable of selectively absorb polyaromatic hydrocarbons (PAHs) from cigarette smoke using a device similar to a cigarette filter.

MATERIALS AND METHODS

Additives tested

•Single walled nanotubes size 1-5 nm (SWN)	•Graphene oxide (GOCF)
•Multiwalled nanotubes (MWN) size <10mm	•Graphene high funcionalization C=0 and C-OH size 0.3 - 5 nm (GHF)
•Multiwalled nanotubes (MWN) size 10-30mm	•Graphene medium funcionalization C=0 and C-OH size 0.3 - 5 nm (GMF)
•Multiwalled nanotubes (MWN) size 40-60mm	•Graphene low funcionalization C=0 and C-OH size 0.3 - 5 nm (GLF)
•Multiwalled nanotubes (MWN) size 60-100mm	•Graphene (G) size 1-5 nm
•Fullerene (F)	•Graphene (G) size 6-8nm + size 1-5nm
•Graphene synthesized in the chemistry faculty (GCF)	•Graphene (G) size 6-8nm
•Graphene synthesized in the chemistry faculty + fullerene (GCF+F)	•Graphene (G) size 10-15nm
•Graphene synthesized in the chemistry faculty + nanotubes (GCF+SWN)	

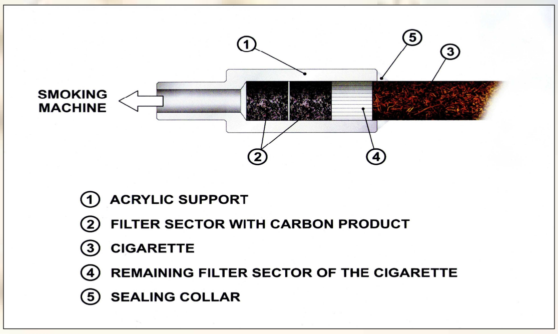
Filter structure

Different filter structures were designed to support the different additives, at first cavities with the additives under cellulose acetate plugs and then cellulose acetate filter with very low-pressure drop that were immersed in an aqueous suspension of the adsorbent with the aid of a surfactant.

- 5 mm sectors of cellulose acetate filter of a rod of 120 mm length, 7 mm diameter, 150 mm Wt pressure drop and 24 K CU plug wrap.
- Surfactants: tween 20, tween 80 and sodium dodecyl sulphate.
- Water.
- Carbon material.

After the immersion period of 30 min the filter sectors were dried a 100 ºC during one hour. In some cases a second period of immersion and drying was applied to the filter sectors.

Reference cellulose acetate filter sectors were chose to obtain the similar pressure drop of the samples

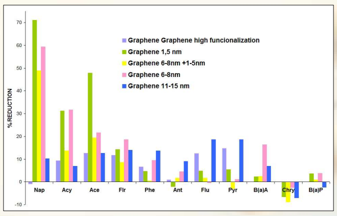


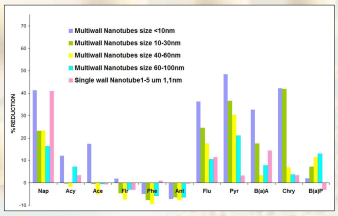
Cigarettes were prepared with the aid of a specially designed acrylic nozzle support. The filter plugs with the different additives and the reference filters were placed inside the support and attached to the same cigarette tobacco column, a vinyl collar is applied to improve the sealing. The physical characteristics of the simulated filters were maintained as close as possible to those of the normal cigarette filters.

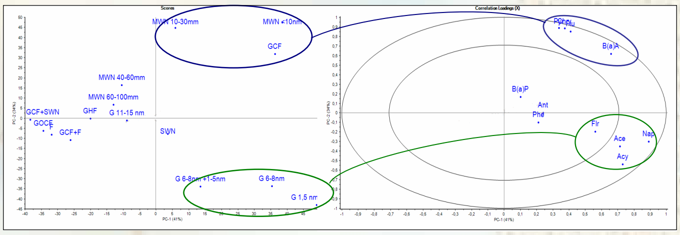
Smoke analysis

Cigarettes were smoked following the ISO regime with the puff time modification to 4 seconds to increase the residence time of the smoke in the filter. PHAs were analyzed by extracting them from the cambridge filters with 20ml of hexane:dicloromethane (85:15) by agitation and ultrasonicating for 1 h. The samples were injected directly in a GC/MS Varian Saturn 2100 and quantified with GC-EI-MS-MS. Phenantrene D10 and Benzo(a)pyrene D12 were used as internal standards. Retention efficiency against the reference cigarettes was tested for eleven PAHs: Naphtalene (Nap), Acenaphthylene (Acy), Acenaphthene (Ace), Fluorene (Flr), Phenantrene (Phe), Anthracene (Ant), Fluoranthene (Flu), Pyrene (Pyr), Benzo(a)anthracene (BaA), Chrysene (Chry), and Benzo(a)pyrene (BaP).

RESULTS







CONCLUSIONS

- All tests with graphene, fullerene and graphene oxide indicate some degree of reduction for PAHs.
- Low and medium functionalized graphenes retain better the PAHs than high functionalized graphenes.
- The reduction is very dependent of the load of adsorbent.
- Graphene could selectively retain PAHs and also depending on the particle size retain selectively the lower or higher molecular weight compounds.
- The small nanopowder particles seem to be more efficient adsorbents for the lighter PAHs molecules, these molecules have in general higher vapor pressures that could increase their concentration in the gas phase of the smoke and facilitate the contact with the adsorbent.
- Multiwall nanotubes of small size seem to retain better high weight PAHs.

We evaluated the capacity of some novel carbon nanostructures for reducing PAHs in the cigarette smoke compared to a reference cigarette prepared exactly in the same way than the test sample and both conditioned and smoked at the same time in same conditions. The immersion procedure for introducing the adsorbent in the cellulose acetate fibers has limitations concerning the load capacity of the adsorbent in the filter. In fact, the results of this study must be analyzed in the perspective of an improved application of the adsorbent over a suitable matrix support that could allow a bigger load of it but that could also maintain a range of normal pressure drop in the cigarettes.

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