

# EFFECT OF SBA-15 MORPHOLOGY IN THE COMPOSITION OF THE MAINSTREAM TOBACCO SMOKE

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## ABSTRACT

Different SBA-15 have been synthesized with different morphology, fiber-like particles [2], spherical particles [3], rods [4] and platelets [5]. All these materials have been added to 3R4F tobacco and mixed thoroughly. The conditioned mixtures have been rolled in cigarettes and smoked according to the ISO 3308 standard [1]. The mainstream tobacco smoke has been collected in two fractions, i.e.: the gas and the condensed particulate matter and analyzed by GC/FID and GC/MS [2]. The results have been compared with samples prepared in a similar way but not including any catalysts, in order to study the effect that the structure of the different SBA-15 on the reduction of the compounds generated in the mainstream tobacco smoke.

## EXPERIMENTAL PROCEDURE

All samples used have been synthesized in our laboratory, following different procedures reported in the bibliography [2,3,4,5]. Cigarettes were prepared by manually mixing 3R4F tobacco with around 4 wt% of each powder material. After conditioned, cigarettes were smoked in a smoking machine [2,6], under the ISO 3308 [1] conditions. All the experiments were triplicated. Samples without catalyst have been prepared and smoked. The results obtained have been compared, in order to evaluate the effectiveness of the addition of this material to tobacco. Figure 1 shows the smoking machine where the experiments have been performed.

After performing experiments, global yields were obtained by weight difference of the Cambridge filter pads (TPM) before and after smoking. The non-condensed products were collected in a Tedlar bag and analysed by gas chromatography with a flame ionization detector (GC/FID) in a Porapak Q column, for the CO and CO<sub>2</sub> analysis, GC/FID is coupled to a metalizer (Nickel catalyst). The other components of the gas stream were analysed by GC/FID in a GAS-PRO column. The condensed particulate matter were analysed by GC/MS using a HP-5MS column, being nicotine the main and majority component of this fraction.



Figure 1.- Smoking machine

## INTRODUCTION

Mesoporous silica materials, such as SBA-15, are attracting increasing interest in the last years. Our research group has focused in their capability for reducing the toxic compounds generated in the smoking process when mixed with tobacco, previous studies have already revealed that this material is capable of reducing large amount of the compounds present in the mainstream tobacco smoke [2].

By tuning the mixing time and intensity, temperature and other variables, SBA-15 may be prepared with different morphologies, fiber-like, spherical, platelets and rods. These different structures could affect in a different way the effect they cause when they are added to tobacco, and therefore in the reductions achieved in the main compounds analyzed in the mainstream of tobacco smoke.

## RESULTS and CONCLUSIONS

- Different structures synthesized of SBA-15 are shown in the Figure 2.
- Images obtained by SEM demonstrate that changes in the synthesis process causes differences in the structure obtained.
- Figure 3 and 4 show the adsorption isotherm N<sub>2</sub> and X-Ray diffraction.

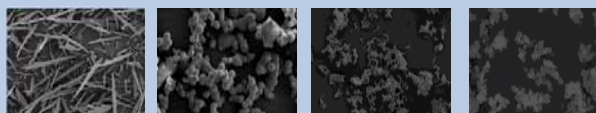


Figure 2.- Structures obtained of SBA-15, fiber-like particles, spherical particles, rods and platelets

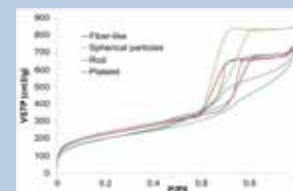


Figure 3.- Adsorption N<sub>2</sub> isotherm

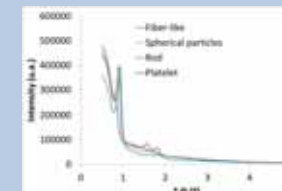


Figure 4.- DRX

Results of CO<sub>2</sub>, CO and TPM reduction are shown in Table 1, Table 2 show yield of some compounds of the gas fraction and Figure 5 and 6 the reduction achieved in the TPM fraction, Nicotine and the some compounds analyzed in the condensed fraction.

Table 1.- CO<sub>2</sub>, CO and TPM reduction

	CO <sub>2</sub> reduction	CO reduction	TPM reduction
3R4F+fiber like SBA-15	30.09	32.85	62.46
3R4F+spherical SBA-15	15.95	14.83	51.77
3R4F+rod SBA-15	5.69	13.24	37.63
3R4F+platelet SBA-15	27.81	33.08	76.34

Table 2.- Reduction of the compounds in the gas fraction

		3R4F+fiber like SBA-15	3R4F+spherical SBA-15	3R4F+rod SBA-15	3R4F+platelet SBA-15
Chloromethane	Others	2.76	19.82	-13.31	33.65
1,3-Butadiene	Olefins	-2.10	23.12	-14.59	28.74
Pentane	Paraffins	-2.45	26.85	-12.50	37.13
Methanethiol	Others	31.22	-4.85	15.38	41.36
Benzene	Aromatics	28.09	-1.92	18.87	52.28
Acetaldehyde	Aldehydes	-0.13	-4.46	-37.56	25.81
Acrolein	Aldehydes	7.70	-34.82	-25.84	22.67
Propionaldehyde	Aldehydes	22.10	7.51	0.00	45.52
Toluene	Aromatics	20.76	3.50	21.98	62.63
Crotonaldehyde	Aldehydes	65.35	24.29	50.00	25.85
Acetylaldehyde	Aldehydes	-5.44	-19.85	-16.90	43.06
Total gases		7.54	21.62	-12.94	32.63

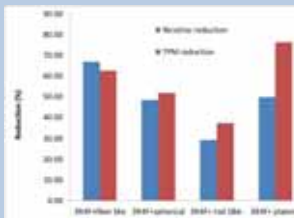


Figure 5.- Reduction obtained in TPM and Nicotine.

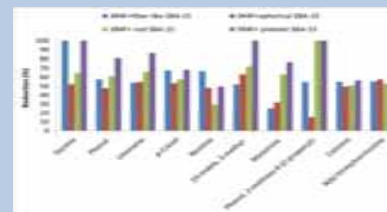


Figure 5.- Reduction obtained in some compounds of the condensed fraction.

- Adsorption N<sub>2</sub> isotherm and DRX obtained show that the four samples synthesized present the SBA structure.
- The best reductions are obtained when the structures employed are the fiber-like and platelet SBA-15.
- Platelets show the best results in the gas fraction, and Rods are the worst structure for this fraction.
- In condensed fraction the reductions obtained are very interested for the four structures.
- In general, the SBA-15 material is of great interest to be added to tobacco, since it achieves significant reductions in most of the compounds present in the mainstream of tobacco smoke, especially with fibers and platelets.

## REFERENCES

- [1]- ISO 3308:2000, Routine analytical cigarette-smoking machine – definitions and standard conditions.
- [2]- A. Marcilla, M.I. Beltrán, A. Gómez-Siurana, I. Martínez, D. Berenguer, Effect of the concentration of siliceous materials added to tobacco cigarettes on the composition of the smoke generated during smoking. Ind. Eng. Chem. Res. 54 (2015) 1916–1929.
- [3]- K. Kosuge, N. Kikukawa, and M. Takemori, One-Step Preparation of Porous Silica Spheres from Sodium Silicate Using Triblock Copolymer Templating. Chem. Mater. 2004, 16, 4181–4186
- [4]- H. Dan, L. Chen, Q. Xian, F. Yi and Y. Ding, Tailored synthesis of SBA-15 rods using different types of acids and its application in adsorption of uranium. Separation and Purification Technology 210 (2019) 491–496
- [5]- H. Long, W. Wang, W. Yang, Y. Wang, H. Ru, Facile and controllable preparation of different SBA-15 platelets and their regulated drug release behaviours. Microporous and Mesoporous Materials 263 (2018) 34–41
- [6]- A. Marcilla, I. Martínez, D. Berenguer, A. Gómez-Siurana, M.I. Beltrán, Comparative study of the main characteristics and composition of the mainstream smoke of ten cigarette brands sold in Spain. Food and Chemical Toxicology 50 (2012) 1317–1333

## ACKNOWLEDGEMENT

Financial support for this investigation has been provided by the Spanish "Secretaría de Estado de Investigación" del Ministerio de Ciencia e Innovación (CTQ2015-70726-P) and Generalitat Valenciana (PROMETEO/2016/056) ) and Conselleria d'Educació, Investigació, Cultura i Esport (IDIFEDER 2018/009).