

# Co,Ba,K/ZrO<sub>2</sub> coating stainless steel foam for the catalytic combustion of soot

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## Introduction

Diesel vehicles are very popular nowadays due to their economy and efficiency, but they produce two contaminants which are dangerous for humans and for the environment: soot and NO<sub>x</sub> [1]. Soot consists of particles of carbon that have adsorbed unburned hydrocarbons, water and sulfur and they are dangerous for health due to their small size [2]. NO<sub>x</sub> is produced either by the oxidation of the nitrogen of the air or by the oxidation of nitrogen compounds present in the fuel. It contributes to the formation of acid rain and smog in the environment. One way of reducing these contaminants is using catalytic filters that should exhibit mechanical, chemical and physical properties to resist the conditions present in an exhaust pipe.

In this work, stainless steel foam is used as a structured support and the Co,Ba,K/ZrO<sub>2</sub> catalyst (previously tested as a good powder catalyst [3]) is coated on it.

## Materials and Methods

Stainless steel foam (SS314, 50 ppi) in the form of cylinders of 1.5 cm diameter and 2.5 cm height was used. The foam was calcined at 900°C during 20h. Then, a ZrO<sub>2</sub> layer was deposited by dipping the foam into a ZrO<sub>2</sub> nanoparticle suspension (Nyacol, 20wt%), eliminating the excess of suspension with airflow, drying it at 130°C during 12h and calcining it at 700°C for 2h. The active components of the catalyst (Co, Ba and K) were deposited by dipping the ZrO<sub>2</sub>-containing foam into a solution with K: 35.9%, Co: 40.7 and Ba: 23.4 (the same atomic percentages as those used in the preparation of the powder catalyst), repeating the cycle followed during the ZrO<sub>2</sub> layer formation, the only difference being the final calcination temperature, which was 500°C in this case. This cycle was repeated 10 times.

Soot was obtained by burning diesel fuel (Repsol-YPF - Argentina) and it was incorporated to the structured catalyst by dipping it in a suspension of 600 ppm of soot in n-hexane. The soot/catalyst mixtures were heated at 5 °C/min from room temperature up to 600°C in O<sub>2</sub> (18%) + NO stream, He balance (total flow 20 ml/min), in a flow equipment. The exhaust gases were analyzed with a Shimadzu GC-2014 chromatograph (with TCD detector). Both the presence of NO and the amount of loaded soot were studied.

## Results and Discussion

Table 1 shows the weight changes observed during each stage of the preparation of the structured catalyst. Several batches of the SS314 foam were calcined at 900°C for 20h and the increase in weight (related to the formation of a surface Cr<sub>2</sub>O<sub>3</sub> layer) is 4.23±0.71%. Two of these samples were submitted to the whole catalyst preparation procedure and after the ZrO<sub>2</sub> coating and the Co, Ba and K deposition, the increments observed were similar, which implies reproducibility in the coating process.

The XRD characterization of the calcined SS314 foam indicated the segregation of Cr<sub>2</sub>O<sub>3</sub> and also traces of FeCr<sub>2</sub>O<sub>4</sub> [4]; whereas, after the ZrO<sub>2</sub> coating, only the tetragonal phase of ZrO<sub>2</sub> (*t*-ZrO<sub>2</sub>) is observed, according to Štefanić et al [5], who found that Cr<sub>2</sub>O<sub>3</sub> stabilized *t*-ZrO<sub>2</sub> at low temperature. The ZrO<sub>2</sub> layer obtained was not continuous, as observed by SEM; cracks and flakes appeared. After deposition of the catalyst, signals of both K<sub>2</sub>CrO<sub>4</sub> and BaCrO<sub>4</sub> were observed by FTIR, which indicates the reaction of the cracks (rich in Cr<sub>2</sub>O<sub>3</sub>) and the added metals (K and Ba).

**Table 1. Weight changes during the preparation of the structured catalysts**

Foam (batch)	Weight gained after ZrO <sub>2</sub> coating, % (referred to the calcined SS314 foam)	Weight gained after Co,Ba and K deposition, % (referred to ZrO <sub>2</sub> -coated SS314)
1	11.17	11.23
2	10.14	10.88

The catalytic activity of the Co,Ba,K/ZrO<sub>2</sub>-SS314 system is shown in Figure 1, in addition to the support activity (SS314). The temperature of maximum combustion rate of soot for the structured catalyst is between 370-380°C, ca. 150 °C less than that corresponding to the structured support (Table 2). This value is very similar to that obtained for the Co,Ba,K/ZrO<sub>2</sub> powder catalysts [3], which highlights the potentiality of the system under study.

## Conclusions

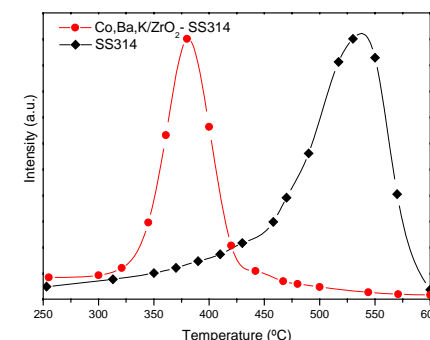
Cobalt, barium and potassium deposited on ZrO<sub>2</sub>-coated stainless steel foam (Co,Ba,K/ZrO<sub>2</sub>-SS314) showed to be a very attractive catalyst for the catalytic combustion of soot. The fact of being a structured catalyst highlights its potentiality for technological applications.

## References

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**Table 2. Soot combustion activity**

Concentration of the soot suspension (ppm)	Average temperature of maximum combustion rate (°C) (standard deviation)	
	NO+O <sub>2</sub> +He	O <sub>2</sub> +He
600	370.9 (9.38)	428 (17.88)
1500	376.6 (9.37)	461 (4.67)



**Figure 1.** Catalytic activity when feeding 18% O<sub>2</sub> and 0.1% NO. The soot was impregnated with a suspension of 600 ppm of soot in n-hexane.