

Double oxidation of austenitic stainless steel foil as a method of the formation of monolithic catalyst for NO, N₂O and carbon particle emission abatement

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Introduction

Monolithic catalysts are commonly used for air pollution abatement [1]. Ceramic or metallic monoliths are used for their manufacturing. To obtain metallic monoliths ferritic steels containing aluminum are always applied as the their oxidation results in the formation of an adhesive alumina layers [1] being the base for the deposition of the oxide supports and active phases.

The use of austenitic stainless steel for metallic monolith production has also been demonstrated [2].

The double oxidation of the monoliths made of commercial 1C18N9T-1.4541 austenitic stainless steel foil (50µm) has recently been proposed a simple and cheap method of the catalyst production for the NO emission abatement from coal power plants [3, 4]. This catalyst can also be used for N₂O emission abatement.

Materials and Methods

The oxidation of the foil chips and the monoliths made of austenitic steel foil was has proceeded during their thermo-programmed heating (3 K/min) up to 1023 K in the air flow, annealing for 4 h at this temperature and slow cooling to room temperature. Next the chips and monoliths were rinsed with the nickel acetate solution and after drying they were re-oxidized first 1023K and then at 773 K. The choice of the synthesis method was based on the previous extensive investigations of the physico-chemical and catalytic properties of the scales formed during foil oxidation at 823K -1113K for 1- 60h. The morphology and the composition of the scales, were studied by SEM/EDX, XPS, TEM/EDX and Raman spectroscopy. A laboratory flow reactor, working in pulse mode, was used to investigate the activity of the double oxidized foil chips in NO and N₂O decomposition. In turn, the activity of the monolithic catalyst in NO and carbon particles' removal was tested in an experimental flow reactor on by-pass of the off-gases' channel in a coal power plant.

Results and Discussion

The layers of the oxide catalyst (Fig. 1) shows high homogeneity and integrity within particular steel grains. They are composed of the crystallites with dimensions not exceeding 500nm. The similar oxygen contents and almost the same relative contents of the cations in the A and B micro-areas (Table 1) suggest that oxide layers on particular steel grains are of the similar thickness and the similar phase composition. Increase of the Ti and

Cr contents in the foil surface micro-layers as a result of the oxidation is caused by relatively high affinities of these elements to oxygen. In turn, the high nickel content originates mainly from its accumulation at the surface of the alloy crystallites during the first oxidation (due to Ni relatively low Tammann temperature and very low affinity to oxygen). Raman spectra of the secondary oxide layers reveal they are composed mainly of nickel ferrite, NiFe₂O₄, and maghemite, γ Fe₂O₃. These oxide layers were found to be highly active in the direct NO and N₂O decomposition and simultaneous NO decomposition and carbon particles combustion.

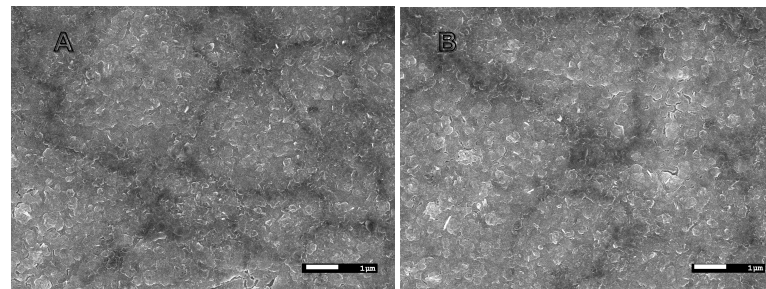


Figure 1. SE image of the foil oxidized at 1023 K, rinsed with the nickel acetate solution, and next secondary oxidized, at 1023K and 773K.

Table 1. Oxygen content and relative Fe, Cr, Ni, Mn and Ti contents in A and B micro-areas

Foil	O [at.%]	(Mx/Fe+Cr+Ni+Mn+Ti)100 [at.%]				
		Fe	Cr	Ni	Mn	Ti
Initial	4	70	20	8	2	0
Oxidized 1013 K/ 4 h (Area A)	20	64	23	9	3	1
Oxidized 1013 K/ 4 h (Area B)	21	63	24	9	1	1

Significance

The new oxide catalyst for N₂O decomposition and NO decomposition and carbon particle oxidation was obtained by double oxidation of the monolith made of austenitic stainless steel foil and it was tested on by-pass of off-gasses channel in a coal power plant.

References

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