Investigating the synergistic effect of decoration and doping in silver/strontium titanate for air remediation

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Nitrogen oxides (NOx) and volatile organic compounds (VOCs) are known to have harmful impact on the environment and human health. Over the years several technologies have been optimized for their efficient abatement due to the ever more stringent legislation for air-quality protection. Photocatalysis has emerged for its efficiency and high sustainability: here, the rational design of suitable photocatalytic systems is the crucial point [1]. Strontium titanate (SrTiO3, STO) is a cubic-structure perovskite oxide, showing great potential in different fields, ranging from hydrogen production to water pollutants degradation [2]. It is stable for temperatures higher than 1000°C: this feature confers more interest than titanium dioxide as anatase, which is known to be stable up to 600°C. Unfortunately, it is also characterized by a photocatalytic activity limited to UV irradiation due to its wide energy band bap (ca. 3.2 eV). To overcome this limitation, modification strategies, e.g., metal-doping or metals nanoparticles (NPs) decoration, have emerged [3]. Silver is a very interesting metal for STO modification due to its high melting point (962°C) and antibacterial feature. However, at the present, the scientific literature has not yet discriminated between the effect of the presence of Ag as a dopant inside the structure or in the form of NPs for surface decoration on materials photocatalytic performances. On the other hand, this represents a crucial point both for understanding the physico-chemical properties of materials and for their application in severe conditions (e.g., high temperature). This work aims at studying the synergistic effect of decoration and doping in Ag-modified STO systems to produce highly efficient photocatalysts for NOx abatement. STO was synthesized by a sol gel procedure and modified by two approaches: i) decoration by pre-synthesized Ag NPs (STO + 6 wt.% Ag) and ii) doping and decoration by the addition of Ag precursors during the STO synthesis (Ag6/STO). As shown in Figure 1a, bare STO was able to degrade only 40% NOx. The Ag NPs decoration enhances the photocatalytic performances of the material leading to ca. 80% NOx degradation in 3 h. However, full NOx conversion was achieved only by Ag/STO, where Ag plays the double role for the doping and decoration modification, as confirmed by XRD analyses (Figure 1c) and by the bandgap values (2.6 eV for Ag6/STO, 3.1 eV for STO+ 6 wt.% Ag). Based on these results, a deeper understanding on the effect of the Ag-amount, when used both for doping and decoration, was necessary. Figure 1b shows the effect of the Ag-loading on the photocatalytic performances of STO. The higher was the Ag-loading, the higher was the NOx degradation, according to bandgap values. These evidences suggested that the synergistic effect of decoration and doping in silver/strontium titanate is the key factor that should be modulated for producing highly efficient photocatalysts for NOx degradation. Further investigations related to the discrimination between doping and decoration are ongoing.

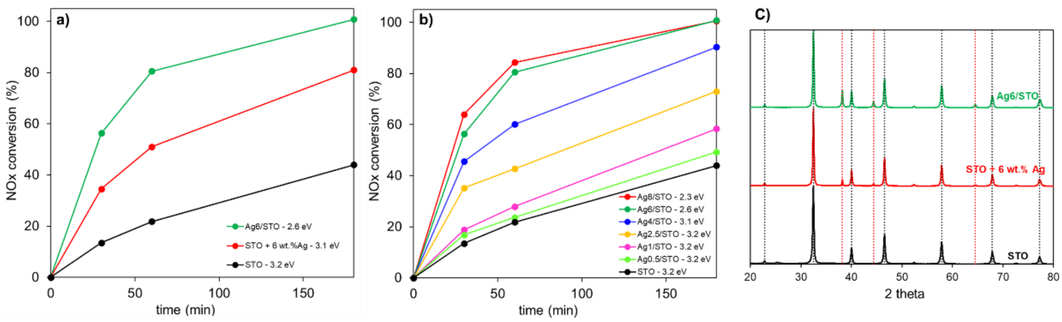

Fig. 1. a,b) NOx degradation results on AgX/STO samples. Experimental conditions: [NOx]= 500 ppb, 25 L batch reactor, LED irradiation (2900 LUX). c) XRD diffractograms compared with references (STO: JCPDS 01-080-4368; Ag: JCPDS 01-071-4613).

References

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