

Propionic acid decomposition by the multi-decorated TiO₂-based photocatalysts under visible light irradiation

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Introduction. Unpleasant odors are the most disturbing pollutants and the main reason for air quality complaints in urban and industrial areas. Odor emissions consist of various chemical components, some of which can be perceived at very low threshold levels.[1] Volatile organic compounds (VOCs) have been designated as the major odorant group. In particular, volatile fatty acids (VFAs) represent an important source of unpleasant odors that have been considered in many studies. Among them, propionic acid (PA) has attracted much attention as one of the leading compounds responsible for the odors-polluted environment.[2]

In this work, the effect of multi-decorated enhanced photocatalysts, for the PA decomposition, under visible light irradiation, was properly investigated.

Experimental/methodology. Micrometric TiO₂ by Kronos (identified as 1077) was multi-decorated by three noble metals (Ag, Pt, and Au) through a multistep approach. At first, Ag NPs from Ag-enriched wastewater solution were properly prepared by a previously developed method [3] and 8%Ag-TiO₂ photocatalyst was obtained by impregnation method and calcined in the air at 400°C. The final material underwent further decoration by the other metals (Pt and Au). A secondary decoration of Ag-TiO₂ was carried out by Au, Pt, and bimetallic AuPt NPs, prepared by chemical reduction. Also, in this case NPs were prepared from metals-enriched wastewater solution. The secondary decoration of Ag-TiO₂ was done by impregnation as well. All the prepared photocatalysts were characterized by targeted physico-chemical techniques. The PA decomposition tests were performed in a 5.5L Pyrex reactor containing 0.5 ppm of PA in the vapor phase, in the presence of 50 mg of each photocatalyst, under LED light irradiation (P= 2450 LUX) for 190 minutes. The progress of the reaction was monitored by an online GC/FID instrument.

Results and discussion. Figure 1 reports the results obtained in the photodegradation of PA by the prepared photocatalysts. As expected, bare TiO₂ Shows no photoactivity towards PA degradation under visible light irradiation. The first decoration with 8%(wt) Ag NPs leads to a significant increase in photoactivity, reaching a percentage of PA photodecomposition higher than 40% in three hours. The effect of the secondary decoration is strongly related to the type of metal used. If, on the one hand Au@Ag-TiO₂ exhibits poorer activity with respect to Ag-TiO₂, on the other hand Pt@Ag-TiO₂ can decompose about 60% of PA in two hours.

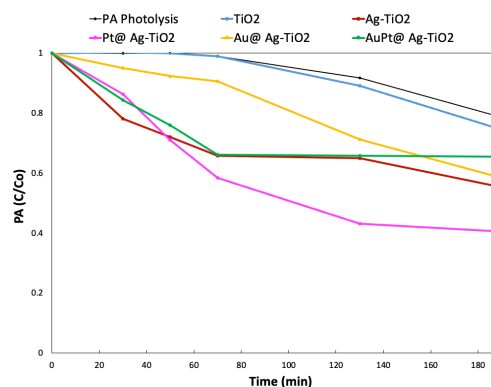


Figure 1. Photoactivity graph of PA

AuPt@Ag-TiO₂ photocatalyst balances the negative aspect of Au NPs with the positive ones of Pt NP, effectively showing the same activity of Ag-TiO₂. The enhanced photoactivity of Pt@Ag-TiO₂ could be ascribed to both the localized surface plasmon resonance (LSPR) effect from Ag NPs and the “Electron sink” effect from Pt NPs. In contrast, the poor performances of Au@Ag-TiO₂ are mainly due to the different transformation products (identified by GC-MS), which negatively affect the Au NPs.

References

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