



# Intrinsic AuPt-alloy particles decorated on TiO<sub>2</sub> nanotubes provide enhanced photocatalytic degradation

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## ABSTRACT

In this study we investigate the performance of noble metal co-catalysts on anodic TiO<sub>2</sub> nanotubes for the photocatalytic degradation of a model pollutant. We create the noble metal decoration (nanoparticles of Au, Pt and mixed AuPt) intrinsically and extrinsically. Intrinsic decoration is achieved using a noble metal containing titanium alloy for anodic tube growth. Extrinsic decoration is carried out by physical vapor deposition (PVD) of the same noble elements on pure titania tubes. We find the AuPt intrinsic decoration to provide a significant enhancement for the photocatalytic decomposition of the model pollutant acid orange 7 (AO7) due to a synergistic effect in the formed AuPt alloy. The AuPt alloy provides a photocatalytic activity that is higher than comparable extrinsic decoration or single element (Pt or Au) intrinsic decoration.

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## 1. Introduction

TiO<sub>2</sub> nanotubes (NTs) obtained by electrochemical anodization of a metallic Ti substrate are widely studied in photocatalytic applications due to their unique combination of geometry and functionality [1]. These nanotube arrays are directly grown vertically aligned from a metallic titanium substrate, with an easy control of the geometry during the synthesis via the electrochemical parameters. The large surface area, as well as their unique electronic and ionic properties [1,2], make nanotubular structures suitable for many photoelectrochemical or photocatalytic applications, including pollutant degradation or water purification [3–8].

In photocatalytic applications the TiO<sub>2</sub> photoexcited charge carriers react with the environment without an external applied voltage (in contrast to photoelectrochemical reactions). Under

aerated conditions, conduction band electrons react with O<sub>2</sub> to form O<sub>2</sub><sup>•−</sup> radicals or superoxides, commonly referred to as reactive oxygen species (ROS) while valence band holes may be captured by water to form OH<sup>•</sup> radicals or may directly oxidize organic species to CO<sub>2</sub> and H<sub>2</sub>O. This effect is used for the photocatalytic degradation of unwanted pollutants in air or waste water. Overall, ROS produced at the valence band and at the conduction band may contribute to efficient destruction of organic pollutants. In order to increase the efficiency by accelerating charge transfer reaction rates of the electron transfer to the environment, co-catalysts are frequently used [8–12]. Most commonly used co-catalysts on TiO<sub>2</sub> are noble metals (NM) such as Au, Pt or Pd [13–16], which can lead to a beneficial Schottky junction and thus not only to a significantly improved charge transfer but also may provide catalytic features for the reactions of electrons with electron acceptors (mainly O<sub>2</sub>) [10,17]. Other beneficial effects of some co-catalysts may be that visible light induced surface plasmon resonance effects can occur, enhancing the light absorption region and therefore the catalytic activity in the visible light range [8,18–20]. The overall co-catalyst activity depends not only on the size and distribution of the noble

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