The way forward for the modification of silver orthophosphate towards better photocatalytic activity

Uyi Sulaeman

Department of Chemistry, Jenderal Soedirman University, Purwokerto 53123, Indonesia
E-mail: uyi_sulaeman@yahoo.com

Abstract

The wastewater treatment technology for organic pollutant degradation is very important to provide the improved environmental health in the future. To support this technology, the highly active photocatalyst for organic pollutant degradation is expected. Recently, the silver phosphate is very promising to be an excellent photocatalyst under visible light irradiation due to its lower band gap energy. Therefore, the improvement of Ag_3PO_4 activity for organic pollutant degradation is essential. This could be achieved by three strategies. The first is the design of particular morphology to generate high reactivity on the surface of Ag_3PO_4 through creating the high surface energy [1] and desired facet formation [2]. These properties could enhance the activity of photocatalyst. The second strategy is the design of heterostructure materials. These designed materials could prevent Ag_3PO_4 photocorrosion during the photocatalytic reaction and can enhance the separation of photogenerated electron and holes. The third strategy is the generation of defect sites in the surface of Ag_3PO_4. These defect sites could be a center of photogenerated electron capture that can effectively inhibit the recombination of photo-induced electron and holes.

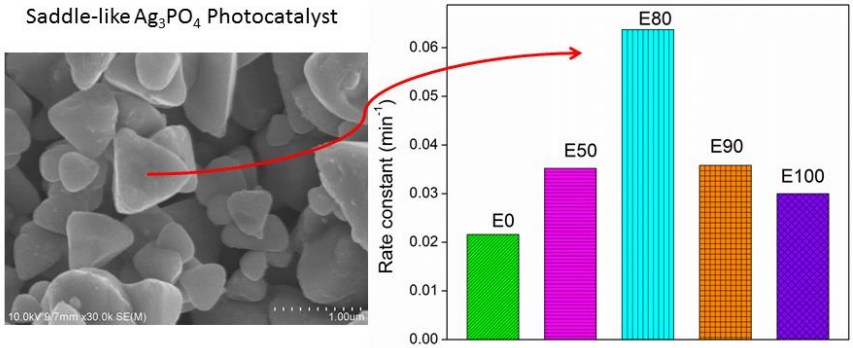

Fig1. Photocatalytic activities of the Ag_3PO_4 synthesized using H_3PO_4 ethanol solution and $AgNO_3$ ethanol-aqueous solution with the ethanol contents (v/v) of 0% (E0), 50% (E50), 80% (E80), 90% (E90) and 100% (E100) [3].

Our report presented that the saddle-like Ag_3PO_4 particles of tetrahedron structure were successfully synthesized using co-precipitation method by mixing H_3PO_4 ethanol solution and $AgNO_3$ ethanol-aqueous solution where the contents of ethanol in $AgNO_3$ ethanol-aqueous solution was varied at 0, 50, 80, 90 and 100 % (v/v) [3]. The photocatalytic performance of the synthesized samples was evaluated by photodegradation of Rhodamine B (RhB) under blue light irradiation (λ=455 nm). The results showed that the morphology of the Ag_3PO_4 particles greatly changed depending on the ethanol content in the reaction solution (Fig.1). Excellent photocatalytic activity was observed at 80 % (v/v) of ethanol, where the Ag_3PO_4 showed saddle-

like morphology derived from the tetrahedron structure. The atomic ratio of Ag/P was increased indicating that the enriched Ag^+ cation in the surface was formed [3].

The native defects of silver vacancy and oxygen vacancy in Ag_3PO_4 could also affect the photocatalytic activity. The oxygen vacancy in Ag_3PO_4 has a relatively high formation energy compared to silver vacancy and silver interstitial because the strong P-O bond must be broken to remove an O atom [4]. Therefore, generating the silver vacancy could be an easy way to improve the activity of Ag_3PO_4. Our report showed that the highly active photocatalyst of silver orthophosphate could be generated by native defects formation (Fig.2) [5]. These catalysts could be synthesized by starting material of $AgNO_3$ and $Na_2HPO_4.12H_2O$. $AgNO_3$ ethanol-aqueous solution with the ethanol contents of 0%, 25%, 50%, 75% and 100% was reacted to Na_2HPO_4 aqueous solution. The products of catalyst were investigated using XRD, DRS, FE-SEM, BET specific surface area and XPS. The increase of ethanol content in the synthesis process decreased the Ag/P atomic ratio in Ag_3PO_4. The-broad absorption in visible region of DRS, the decrement of the Ag4d FWHM and increment of P2p FWHM were observed in XPS due to the silver vacancy formation on the surface of Ag_3PO_4. The native defect of silver vacancy might be generated on the surface of Ag_3PO_4. The photocatalytic activity of silver vacancy Ag_3PO_4 increased 5.8 times higher compared to the pristine Ag_3PO_4. These defect sites might become the centers of photogenerated electron capture which can effectively inhibit the recombination of photo-induced electron and holes, leading to enhancement of photocatalytic activity. The defect sites also might enhance water adsorption on the surface of Ag_3PO_4 and produce much more hydroxyl radical under visible light irradiation.

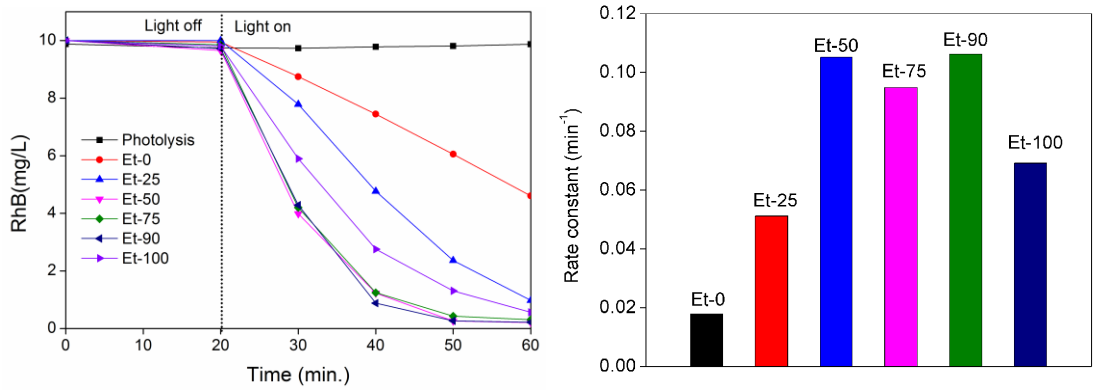

Fig. 2 The photocatalytic activities of Ag_3PO_4 synthesized using Na_2HPO_4 aqueous solution and $AgNO_3$ ethanol-aqueous solution with the ethanol contents of 0% (Et-0), 25% (Et-25), 50% (Et-50), 75% (Et-75), 90% (Et-90) and 100% (Et-100).

References

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