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Photocatalytic degradation of pentachlorophenol (PCP) using TiO_2 thin films prepared by CVD method

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1. Introduction

The aim of this study is to investigate the catalytic behavior of supported TiO_2 catalyst prepared by the CVD method. The change in the photocatalytic activity of thin film, TiO_2, was exemplified by the oxidation of PCP under air saturation and cooling condition. The photocatalytic efficiency of the thin films coated on various supportive surface such as stainless steel cloth(SS), quartz glass tube(QGT), and silica gel(SG) were also investigated.

2. Materials and Methods

2.1 Materials: TiO_2(P25), stainless steel(SS, 37㎛), TIP, PCP and silica-gel(Davisil^{TM}, 40-60 mesh)

2.2 Preparation of TiO_2 thin films by CVD method: Figure 1 shows the hot-wall low-pressure reactor setup(Lu, Shin-Yuan and Chen, Shan-Wei, 2000,).

2.3 Preparation of TiO_2 thin film by sol-gel method: TiO_2 thin film was prepared by a method similar to the one described by Toda(Toda, H. and Honda, H., 1995).

2.4 Thin film characterization: XRD; Rigaku D-Max B, Nd(III) concentration on the surface of the TiO_2/Support; XPS Model ESCA 750, observation of surface morphology; SEM-AMRAY 1810 Model

2.5 Photoreactor and light source: The bench-scale photoreactor system.

2.6 Preparation of PCP-Sample and procedure:

Initial solution containing either 2.5 or 10 ppm of PCP were adjusted to pH 7.5 using 5mM phosphate buffer.

2.7 Analysis: ①HPLC(HP-1100m) equipped with UV detector ②TOC Analyzer(T-D, DC-190 ③ IC(Dionex Bio LC Chromatography) equipped with ECD ④ GC-MS equipped with a HP-5971 mass selective detector

3. Results and discussion

Results show that the PCP degradation follow the order: TiO_2-SS(37㎛) thin film

prepared by CVD>TiO_2-QGT thin film prepared by CVD>TiO_2-SG thin film prepared by CVD》 P25 powder≥TiO_2-SG thin film prepared by sol-gel. Especially, 99% of PCP has been destructed within 80 min when TiO_2-SS thin films prepared by CVD method was used.

Results show that the PCP degradation follow the order: 2%(w/w) TiO_2≥1% TiO_2 >0.5% TiO_2>0.1% TiO_2》 UV alone.

Although the chloride ion emergence lags behind the PCP disappearance, all of the chlorinated intermediates was destroyed within about 240 minutes in the batch mode. The formation of chloride ions is slower than the degradation of PCP. For the example, about 84% of PCP have been degraded, but 48% of chloride ions are observed after 180 minutes. It is also noted that Cl^- ion remains by 210 minutes after the complete degradation of PCP.

4. Conclusion

Chemical vapor deposition(CVD) and sol-gel method were used to prepare thin films, TiO_2 for degradation of hazardous organic compounds exemplified by PCP(pentachlorophenol). The effect of supporting materials and coating methods on the photocatalytic activity of the TiO_2 thin films were also studied. TiO_2 thin films were coated onto various supporting materials including stainless steel cloth(SS), quartz glass tube(QGT), and silica gel(SG). Results indicate that SS(37㎛)-TiO_2 thin film prepared by CVD method improves the photodegradation of PCP. Among all supporting materials studied, SS(37㎛) appears to be the best support. An optimal amount of coating material at 1.0%(w/w) of TiO_2 for support gives the best photodegradation of PCP.

Intermediates and by-products generated during the process were precisely identified and quantified. The major by products are four carboxylic acids: tartaric acid, oxalic acid, malic acid, and hyroximalonic acid. Based on the information concerning the generation of organic acids and other aromatic intermediates, the complete reaction pathways toward mineralization can be proposed.

References

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