催化学报 » 2011, Vol. 32 » Issue (7) :1173-1179 DOI: 10.1016/S1872-2067(10)60229-X

研究论文

具有优异热稳定性的磷修饰氧化钛及其对水中污染物的降解

金辰, 邱顺晨, 朱月香*, 谢有畅

北京大学化学与分子工程学院, 分子动态与稳态结构国家重点实验室, 北京分子科学国家实验室, 北京 100871

JIN Chen, QIU Shunchen, ZHU Yuexiang*, XIE Youchang

Beijing National Laboratory for Molecular Science, State Key Laboratory for Structural Chemistry of Unstable and Stable Species, College of Chemistry and Molecular Engineering, Peking University, Beijing 100871, China

摘要 通过水热法制得磷修饰氧化钛, 它在亚甲基蓝和对氯苯酚的降解以及消除大肠杆菌的实验中都表现出高于纯氧化钛的优异活性, 甚至优于商品化催化剂 P25. 在捕获剂中降解亚甲基蓝的实验证实羟基自由基是最主要的活性氧物种, 并且磷修饰氧化钛在光照下拥有较强的产生羟基自由基的能力. 同时, 磷修饰氧化钛具有非常高的热稳定性, 直到 950 ºC 才会发生从锐钛矿到金红石的相变, 这是因为粒子表面的磷酸根阻止了金红石在界面的成核因而抑制了相变发生. 磷修饰氧化钛的这种优异性质使得它即使在 900 oC 焙烧后也能有效地降解水中污染物.

关键词: 磷修饰 氧化钛 光催化 热稳定性 抗菌

Abstract: The phosphorous-modified TiO_2 (P-TiO_2) was synthesized by a hydrothermal method. The as-prepared P-TiO_2 was evaluated for the degradation of methylene blue, the dechlorination of 4-chlorophenol, and the inactivation of *Escherichia coli*. In all these experiments, P-TiO_2 shows superior activity compared with pure TiO_2 and even better activity than the commercially available P25 in most cases. By carrying out methylene blue degradation in the presence of different scavengers, •OH radicals were found to be the dominant reactive oxidizing species. The excellent performance of P-TiO_2 was correlated with its pronounced ability to generate •OH radicals under illumination. We also found that P-TiO_2 is extraordinarily stable against annealing. Its transformation from anatase to rutile does not occur until calcination as high as 950 ºC. This phase transformation is retarded since the phosphate species on the surface of the particles acts as a barrier to grain boundary nucleation. This peculiar feature of P-TiO_2 gives it reliable performance during water decontamination even after calcination at 900 ºC since it retains a 100% anatase phase at this stage.

Keywords: phosphorous modification, titanium dioxide, photocatalysis, thermal stability, antibacterial

收稿日期: 2011-02-21; 出版日期: 2011-06-09

引用本文:

金辰, 邱顺晨, 朱月香等 .具有优异热稳定性的磷修饰氧化钛及其对水中污染物的降解[J] 催化学报, 2011,V32(7): 1173-1179

JIN Chen, QIU Shun-Chen, ZHU Yue-Xiang etc .Phosphorous-Modified TiO2 with Excellent Thermal Stability and Its Application to the Degradation of Pollutants in Water[J] Chinese Journal of Catalysis, 2011,V32(7): 1173-1179

链接本文:

http://www.chxb.cn/CN/10.1016/S1872-2067(10)60229-X 或 http://www.chxb.cn/CN/Y2011/V32/I7/1173

[1] egrini O, Oliveros E, Brauna A M. Chem Rev, 1993, 93: 671

[2] offmann M R, Martin S T, Choi W, Bahnemann D W. Chem Rev, 1995, 95: 69

[3] ndreozzi A R, Caprio V, Insola A, Marotta R. Catal Today, 1999, 53: 51

[4] insebigler A L, Lu G, Yates J T. Chem Rev, 1995, 95: 735

[5] awless D, Serpone N, Meisel D. J Phys Chem, 1991, 95: 5166

[6] ho M, Chung H, Choi W, Yoon J. Water Res, 2004, 38: 1069

[7] andhe A R, Naik S P, Fernandes J B. Microporous Mesoporous Mater, 2005, 87: 103

[8] umar K N P, Keizer K, Burggraaf A J, Okubo T, Nagamoto H, Morooka S. Nature, 1992, 358: 48

[9] hannon R D, Pask J A. J Am Ceram Soc, 1965, 48: 391

[10] Gouma P I, Dutta P K, Mills M J. Nano Mat, 1999, 11: 1231
[11] Machida M, Norimoto K, Kimura T. J Am Ceram Soc, 2005, 88: 95
[12] Hirano M, Ota K, Iwata H. Chem Mater, 2004, 16: 3725
[13] Periyat P, Pillai S C, Mccormack D E, Colreavy J, Hinder S J. J Phys Chem C, 2008, 112: 7644
[14] Choi H, Kim Y J, Varma R S, Dionysiou D D. Chem Mater, 2006, 18: 5377
[15] Colon G, Hidalgo M C, Munuera G, Ferino I, Cutrufello M G, Navio J A. Appl Catal B, 2006, 63: 45
[16] 卢晗锋, 周瑛, 徐柏庆, 陈银飞, 刘化章. 分子催化 (Lu H F, Zhou Y, Xu B Q, Chen Y F, Liu H Zh. J Mol Catal(China)), 2008, 22: 54
[17] Li H X, Zhang X Y, Huo Y N, Zhu J. Environ Sci Tech, 2007, 41: 4410
[18] 张敬畅, 高玲玲, 曹维良. 无机化学学报 (Zhang J Ch, Gao L L, Cao W L. Chin J Inor Chem), 2003, 19: 934
[19] 陈艳敏, 钟晶, 陈锋, 张金龙. 催化学报 (Chen Y M, Zhong J, Chen F, Zhang J L. Chin J Catal), 2010, 31: 120
[20] 魏凤玉, 桑蕾. 催化学报 (Wei F Y, Sang L, Chin J Catal), 2009, 30: 335
[21] 郑华荣, 崔言娟, 张金水, 丁正新, 王心晨. 催化学报 (Zheng H R, Cui Y J, Zhang J S, Ding Zh X, Wang X Ch. Chin J Catal), 2011, 32: 100
[22] Zhao D, Chen C C, Wang Y F, Ji H W, Ma W H, Zang L, Zhao J C. J Phys Chem C, 2008, 112: 5993
[23] Yu J C, Zhang L Z, Zheng Z, Zhao J C. Chem Mater, 2003, 15: 2280
[24] Korosi L, Papp S, Bertoti I, Dekany I. Chem Mater, 2007, 19: 4811
[25] Li F F, Jiang Y S, Xia M S, Sun M M, Xue B, Liu D R, Zhang X G. J Phys Chem C, 2009, 113: 18134
[26] Zheng R Y, Lin L, Xie J L, Zhu Y X, Xie Y C. J Phys Chem C, 2008, 112: 15502
[27] Yang H G, Liu G, Qiao S Z, Sun C H, Jin Y G, Smith S C, Zou J, Cheng H M, Lu G Q. J Am Chem Soc, 2009, 131: 4078
[28] Jin C, Zheng R Y, Guo Y, Xie J L, Zhu Y X, Xie Y C. J Mol Catal A, 2009, 313: 44
[29] Korosi L, Oszko A, Galbacs G, Richardt A, Zollmer V, Dekany I. Appl Catal B, 2007, 77: 175
[30] Zhang H Z, Banfield J F. J Mater Chem, 1998, 8: 2073
[31] Reidy D J, Holmes J D, Morris M A. J Eur Ceram Soc, 2006, 26: 1527
[32] Zhang J, Li M J, Feng Z C, Chen J, Li C. J Phys Chem B, 2005, 110: 927
[33] Mendive C B, Bahnemann D W, Blesa M A. Catal Today, 2005, 101: 237
[34] Joo J, Kwon S G, Yu T, Cho M, Lee J, Yoon J, Hyeon T. J Phys Chem B, 2005, 109: 15297
[35] Irmak S, Kusvuran E, Erbatur O. Appl Catal B, 2004, 54: 85

[1] 王卫, 陆春华, 苏明星, 倪亚茹, 许仲梓.N 掺杂富含 (001) 晶面 TiO_2 纳米片的制备及 N 掺杂浓度对可见光催化活性的影响[J]. 催化学报, 2012,33(4): 629-636
[2] 杨祝红, 李力成, 王艳芳, 刘金龙, 冯新, 陆小华.磷化镍/介孔 TiO_2 催化剂的制备及其催化加氢脱硫性能[J]. 催化学报, 2012,33(3): 508-517
[3] 景明俊, 王岩, 钱俊杰, 张敏, 杨建军.水热法制备铂掺杂二氧化钛及其可见光催化性能[J]. 催化学报, 2012,33(3): 550-556
[4] 黄燕, 李可心, 颜流水, 戴玉华, 黄智敏, 薛昆鹏, 郭会琴, 熊晶晶.二维六方 *p6mm* 有序介孔 WO_3-TiO_2 复合材料的制备及其可见光光催化性能[J]. 催化学报, 2012,33(2): 308-316
[5] 李伟, 赵莹, 刘守新.以纳米微晶纤维素为模板的酸催化水解法制备球形介孔 TiO_2[J]. 催化学报, 2012,33(2): 342-347
[6] 王伟鹏, 杨华, 县涛, 魏智强, 马金元, 李瑞山, 冯旺军.$BaTiO_3$ 纳米颗粒的聚丙烯酰胺凝胶法合成及光催化降解甲基红性能[J]. 催化学报, 2012,33(2): 354-359
[7] 宋明娟, 邹成龙, 牛国兴, 赵东元.$(NH_4)_2SiF_6$ 预处理改善 SBA-15 介孔材料的水热稳定性[J]. 催化学报, 2012,33(1): 140-151
[8] 任远航, 辜敏, 胡怡晨, 岳斌, 江磊, 孔祖萍, 贺鹤勇b.稀土负载钛-硅沸石 ETS-10 的制备及其光催化性质[J]. 催化学报, 2012,33(1): 123-128
[9] 汪青, 尚静, 宋寒.影响 TiO_2 纳米管光电催化还原 Cr(VI) 的因素探讨[J]. 催化学报, 2011,32(9): 1525-1530
[10] 王晟, 高艳龙, 王骉, 王栋良, 丁源维, 许学飞, 张晓龙, 江国华.紫外光还原法制备铂填充硅钛复合纳米管及其光催化性能[J]. 催化学报, 2011,32(9): 1513-1518
[11] 冯建, 熊伟, 贾云, 王金波, 刘德蓉, 陈华, 李贤均.Ru/TiO_2 催化剂上甘油氢解制 1,2-丙二醇[J]. 催化学报, 2011,32(9): 1545-1549
[12] 罗海英, 聂信, 李桂英, 刘冀锴, 安太成 .水热法合成的介孔二氧化钛的结构表征及其对水中 2,4,6-三溴苯酚的光催化降解活性[J]. 催化学报, 2011,32(8): 1349-1356
[13] 马鹏举, 闫国田, 钱俊杰, 张敏, 杨建军.新型 N-TiO_2 的固相法制备及其光催化性能[J]. 催化学报, 2011,32(8): 1430-1435
[14] 郑青, 李金花, 陈红冲, 陈全鹏, 周保学, 尚树川, 蔡伟民.基于薄层反应器的有机污染物光电催化氧化反应性能与机理[J]. 催化学报, 2011,32(8): 1357-1363
[15] 王仕发, 杨华, 县涛.新型半导体可见光催化剂纳米锰酸钇[J]. 催化学报, 2011,32(7): 1199-1203