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研究论文

单斜 BiVO4 可见光催化降解甲基橙的形貌效应

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摘要 以硝酸铋和偏钒酸铵为无机源, NaOH 为 pH 值调节剂, 三嵌段共聚物 P123 为表面活性剂, 采用醇-水热法制备了多种形貌的单斜 BiVO4. 利用 X 射线衍射、N2 吸脱附、 扫描电子显微镜、X 射线光电子能谱和紫外可见光漫反射等技术表征了其物化性质, 并考察了这些 BiVO4 样品在可见光照射下降解甲基橙的催化活性. 结果表明, 表面活性剂和溶液 pH 值对所得 BiVO4 产物的粒子形貌影响很大. 在醇-水热温度为 180 °C, pH 值为 2, 7 或 10 时, 可分别制得多孔球状、花状和片状 BiVO4; 而采用 P123 作表面活性剂, 在醇-水热温度为 180 °C 且 pH 为 2 时可制得棒状 BiVO4. BiVO4 样品粒子形貌的不同导致它们的比表面积、表面氧空位密度和 (040) 晶面暴露率不同, 其中以棒状 BiVO4 样品具有最高的比表面积、氧空位密度和 (040) 晶面暴露率以及最低的带隙能, 使其对甲基橙降解表现出最好的光催化活性. 可以认为, BiVO4 样品对甲基橙的光催化降解反应活性存在形貌效应, 棒状形貌有利于提高 BiVO4 的光催化性能.

关键词: 醇-水热法 形貌相依性质 可见光响应催化剂 单斜钒酸铋 甲基橙 降解

Abstract: Monoclinic $BiVO_4$ with multiple morphologies were fabricated using the alcoho-hydrothermal strategy with bismuth nitrate and ammonium metavanadate as inorganic sources, NaOH for pH adjustment, and the triblock copolymer P123 as a surfactant. The materials were characterized by X-ray diffraction, nitrogen adsorption-desorption, scanning electron microscopy, X-ray photoelectron spectroscopy, and ultraviolet-visible diffuse reflectance spectroscopy. The photocatalytic performance of the $BiVO_4$ samples was evaluated for the degradation of methyl orange (MO) under visible-light irradiation condition. The results showed that the surfactant and pH had a significant influence on the particle morphology of the $BiVO_4$ product. Porous spherical, flower-like, and sheet-like $BiVO_4$ were fabricated at an alcoho-hydrothermal temperature of 180 ° C and at a pH of 2, 7, or 10, respectively, whereas rod-like $BiVO_4$ was obtained in the presence of P123 at an alcoho-hydrothermal temperature of 180 ° C and at a pH of 2. The difference in $BiVO_4$ particle morphology led to differences in surface area, surface oxygen vacancy density, and (040) crystal plane exposure. Among the four $BiVO_4$ samples, the rod-like sample had the highest surface area, surface oxygen vacancy density, and (040) crystal plane exposure, and the lowest bandgap energy resulting in it having the best photocatalytic activity for MO photodegradation. It can be concluded that a morphological effect is responsible for the photocatalytic performance and the rod-like morphology seems to favor an enhancement in the photocatalytic performance of the $BiVO_4$ material.

Keywords: alcoho-hydrothermal strategy, morphology-dependent property, visible-light-driven catalyst, monoclinic bismuth vanadate, methyl orange, degradation

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[1] u T, Steele B C H. Solid State Ionics, 1986, 21: 339

[2] irota K, Komatsu G, Yamashita M, Takemura H, Yama-guchi O. Mater Res Bull, 1992, 27: 823

[3] iu W, Yu Y Q, Cao L X, Su G, Liu X Y, Zhang L, Wang Y G. J Hazard Mater, 2010, 181: 1102

[4] hang X, Ai Z H, Jia F L, Zhang L Z, Fan X X, Zou Z G. Mater Chem Phys, 2007, 103: 162

[5] okunaga S, Kato H, Kudo A. Chem Mater, 2001, 13: 4624

[6] leight A W, Chen H Y, Ferretti A, Cox D E. Mater Res Bull, 1979, 14: 1571
[7] u J Q, Zhang Y, Kudo A. J Solid State Chem, 2009, 182: 223
[8] eves M C, Trindade T. Thin Solid Films, 2002, 406: 93
[9] ayama K, Nomura A, Zou Z G, Abe R, Abe Y, Arakawa H. Chem Commun, 2003: 2908
[10] Zhou L, Wang W Z, Liu S W, Zhang L S, Xu H L, Zhu W. J Mol Catal A, 2006, 252: 120
[11] Yu J Q, Kudo A. Adv Funct Mater, 2006, 16: 2163
[12] Sun S M, Wang W Z, Zhou L, Xu H L. Ind Eng Chem Res, 2009, 48: 1735
[13] Zhang L, Chen D R, Jiao X L. J Phys Chem B, 2006, 110: 2668
[14] Li G R, Hu T, Pan G L, Yan T Y, Gao X P, Zhu H Y. J Phys Chem C, 2008, 112: 11859
[15] Mclaren A, Valdes-Solis T, Li G Q, Tsang S C. J Am Chem Soc, 2009, 131: 12540
[16] Xi G C, Ye J H. Chem Commun, 2010, 46: 1893
[17] Wang D E, Jiang H F, Zong X, Xu Q, Ma Y, Li G L, Li C. Chem Eur J, 2011, 17: 1275
[18] 张妍, 于建强, 工藤昭彦, 赵修松. 催化学报 (Zhang Y, Yu J Q, Kudo A, Zhao X S. Chin J Catal), 2008, 29: 624
[19] Ge L. Mater Chem Phys, 2008, 107: 465
[20] 索静, 柳丽芬, 杨凤林. 催化学报 (Suo J, Liu L F, Yang F L. Chin J Catal), 2009, 30: 323
[21] Meng X, Zhang L, Dai H X, Zhao Z X, Zhang R Z, Liu Y X. Mater Chem Phys, 2011, 125: 59
[22] Ke D N, Peng T Y, Ma L, Cai P, Dai K. Inorg Chem, 2009, 48: 4685
[23] Kudo A, Omori K, Kato H. J Am Chem Soc, 1999, 121: 11459
[24] Zhang A P, Zhang J Z, Cui N Y, Tie X Y, An Y W, Li L J. J Mol Catal A, 2009, 304: 28
[25] Li L Z, Yan B. J Alloys Compd, 2009, 476: 624.
[26] Zhou L, Wang W Z, Xu H L. Cryst Growth Des, 2008, 8: 728
[27] Xu A W, Antonietti M, Cölfen H, Fang Y P. Adv Funct Mater, 2006, 16: 903
[28] Chen L M, Liu Y N, Lu Z G, Zeng D M. J Colloid Interface Sci, 2006, 295: 440
[29] Gong Q, Qian X F, Ma X D, Zhu Z K. Cryst Growth Des, 2006, 6: 1821
[30] Xu H, Li H M, Wu C D, Chu J Y, Yan Y S, Shu H M, Gu Z. J Hazard Mater, 2008, 153: 877
[31] Liu W, Lai S Y, Dai H X, Wang S J, Sun H Z, Au C T. Catal Lett, 2007, 113: 147
[32] Yamazoe N, Teraoka Y, Seiyama T. Chem Lett, 1981: 1767
[33] Zhang C, Zhu Y F. Chem Mater, 2005, 17: 3537
[34] Li H B, Liu G C, Duan X C. Mater Chem Phys, 2009, 115: 9
[35] Zhang A P, Zhang J Z. Appl Surf Sci, 2010, 256: 3224
[36] Yu J G, Xiong J F, Cheng B, Liu S W. Appl Catal B, 2005, 60: 211
[37] Mohajerani M S, Lak A, Simchi A. J Alloys Compd, 2009, 485: 616
[38] Lucky R A, Charpentier P A. Appl Catal B, 2010, 96: 516
[39] Wang Y X, Li X Y, Wang N, Quan X, Chen Y Y. Sep Purif Technol, 2008, 62: 727

[1] 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
[2] 万密密, 朱建华.沸石对亚硝胺吸附及降解的研究进展[J]. 催化学报, 2012,33(1): 60-69
[3] 李京京, 刘兴海, 石雷, 孙琪, 周永刚, 徐健峰, 单作刚, 王福冬.担载 CuO 基催化剂上 2,4-二氯酚的有效氧化降解[J]. 催化学报, 2011,32(8): 1387-1392
[4] 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
[5] 张静, 阎松, 付鹿, 王飞, 原梦琼, 罗根祥, 徐倩, 王翔, 李灿.锐钛矿、金红石和板钛矿降解罗丹明 B 光催化活性的比较研究[J]. 催化学报, 2011,32(6): 983-991
[6] 潘浩, 周丽娜, 朱艺, 彭娜, 龚茂初, 陈耀强.尿素水解法制备降解地表臭氧的 $Pd-MnO_x/Al_2O_3$ 催化剂[J]. 催化学报, 2011,32(6): 1040-1045
[7] 蔡陈灵, 王金果, 曹锋雷, 李和兴, 朱建*.非水溶剂热法制备 (001) 面暴露的 F/TiO_2纳米晶及其光催化活性[J]. 催化学报, 2011,32(5): 862-871
[8] 县涛 1,2, 杨华 1,2, 戴剑锋 1,2, 魏智强 1,2, 马金元 2, 冯旺军 2.粒径可控的纳米铁酸铋的制备及其光催化性能[J]. 催化学报, 2011,32(4): 618-623
[9] 向全军, 余家国.暴露{001}面 TiO_2 纳米片分等级花状结构的制备及其光催化活性[J]. 催化学报, 2011,32(4): 525-531
[10] 崔华楠, 赵振华, 梁业如, 石建英, 吴丁财, 刘鸿, 符若文.炭气凝胶孔结构对其负载的 TiO_2 光催化降解甲基橙性能的影响[J]. 催化学报, 2011,32(2): 321-324

[11] 陈渊, 刘国聪, 李志友, 黄苏萍, 周科朝.柠檬酸辅助水热法制备可见光高效去除甲基橙的 Bi_2WO_6 纳米片[J]. 催化学报, 2011,32(10): 1631-1638
[12] 郑华荣, 崔言娟, 张金水, 丁正新, 王心晨.Pt 助剂对 N 掺杂 TiO_2 可见光光催化性能的影响[J]. 催化学报, 2011,32(1): 100-105
[13] 刘红旗, 顾晓娜, 陈锋, 张金龙.BiOCl 纳米片微球的制备及其形成机理[J]. 催化学报, 2011,32(1): 129-134
[14] 仝长水 1,2, 仝晓霞 1, 靳孟贵 1, 叶念军 3.Cu 对 MnCeOx 催化苯酚水相氧化的促进作用[J]. 催化学报, 2010,31(9): 1185-1188
[15] 徐爱华 1, 邵科杰 1, 吴文利 1, 范兢 2, 崔金久 2, 尹国川 1.碳酸氢钠溶液中微量 Mn2+离子催化氧化降解有机污染物[J]. 催化学报, 2010,26(8): 1031-1036