

铜基催化剂用于一氧化碳催化消除研究进展

余强¹, 高飞², 董林^{1,2,*}

¹南京大学化学化工学院, 介观化学教育部重点实验室, 江苏南京 210093; ²南京大学现代分析中心, 江苏省机动车尾气污染控制重点实验室, 江苏南京 210093

YU Qiang¹, GAO Fei², DONG Lin^{1,2,*}

¹School of Chemistry and Chemical Engineering, Key Laboratory of Mesoscopic Chemistry of MOE, Nanjing University, Nanjing 210093, Jiangsu, China;

²Center of Modern Analysis, Jiangsu Key Laboratory of Vehicle Emissions Control, Nanjing University, Nanjing 210093, Jiangsu, China

- 摘要
- 参考文献
- 相关文章

Download: PDF (577KB) [HTML](#) (1KB) Export: BibTeX or EndNote (RIS) Supporting Info

摘要 催化消除 CO 主要包括 CO 的完全氧化 (CO-COOX) 和优先氧化 (CO-PROX)。首先, 结合本课题组的相关研究, 按照催化剂体系介绍了 Cu 基催化剂在 CO-COOX 中的活性物种和组分之间的相互作用。其次, 对用于富氢气氛下 CO-PROX 的 Cu 基催化剂进行了系统的分类总结, 重点阐述了 CuO-CeO₂ 催化剂的制备方法、助剂改性、载体调变以及过渡金属离子掺杂 (CuO/Ce_{1-x}M_xO₂)、反相结构 (CeO₂/CuO) 等方面对 CO-PROX 催化性能的影响。最后, 总结了 Cu 基催化剂在 CO-PROX 中存在的问题, 并展望了未来的研究趋势。

关键词: 一氧化碳 完全氧化 优先氧化 铜基催化剂

Abstract: Catalytic elimination of CO mainly includes complete oxidation (CO-COOX) and preferential oxidation of CO (CO-PROX). First, combined with our group's research, a brief introduction to the active species and the interaction between components in Cu-based catalysts for CO-COOX was presented from the perspective of the catalyst system. Then recent progress in CO-PROX under H₂-rich over Cu-based catalysts was systematically summarized. Influence of the preparation method, promoter, and support of CuO-CeO₂ catalyst as well as transition metal ions doped support (CuO/Ce_{1-x}M_xO₂), and inverse structure (CeO₂/CuO) on the catalytic performance in CO-PROX was elaborated. Finally, the application problems and future research trend of Cu-based catalysts for catalytic removal of CO were discussed and summarized.

Keywords: carbon monoxide, complete oxidation, preferential oxidation, Cu-based catalyst

收稿日期: 2012-04-02; 出版日期: 2012-07-06










引用本文:

余强, 高飞, 董林. 铜基催化剂用于一氧化碳催化消除研究进展[J] 催化学报, 2012,V33(8): 1245-1256

YU Qiang, GAO Fei, DONG Lin. Recent Progress of Cu-Based Catalysts for Catalytic Elimination of CO[J] Chinese Journal of Catalysis, 2012,V33(8): 1245-1256

链接本文:

<http://www.chxb.cn/CN/10.3724/SP.J.1088.2012.20401> 或 <http://www.chxb.cn/CN/Y2012/V33/I8/1245>

- [1] 毕玉水, 吕功煊. 分子催化 (Bi Y Sh, Lü G X. J Mol Catal (China)), 2003, 17: 313
- [2] 梁飞雪, 朱华青, 秦张峰, 王国富, 王建国. 化学进展 (Liang F X, Zhu H Q, Qing Zh F, Wang G F, Wang J G. Progr Chem), 2008, 20: 1453
- [3] Hasegawa Y, Fukumoto K, Ishima T, Yamamoto H, Sano M, Miyake T. Appl Catal B, 2009, 89: 420 
- [4] Ayastuy J L, Gurbani A, González-Marcos M P, Gutiérrez-Ortiz M A. Appl Catal A, 2010, 387: 119 
- [5] Monyanon S, Luengnaruemitchai A, Pongstabodee S. Int J Hydrogen Energy, 2010, 35: 3234 
- [6] Ayastuy J L, Gamboa N K, González-Marcos M P, Gutiérrez-Ortiz M A. Chem Eng J, 2011, 171: 224 
- [7] Song C. Catal Today, 2002, 77: 17 
- [8] Choudhary T, Goodman D W. Catal Today, 2002, 77: 65 
- [9] Goerke O, Pfeifer P, Schubert K. Appl Catal A, 2004, 263: 11 
- [10] Caputo T, Lisi L, Pirone R, Russo G. Ind Eng Chem Res, 2007, 46: 6793 
- [11] Park E D, Lee D, Lee H C. Catal Today, 2009, 139: 280 
- [12] Pozdnyakova O, Teschner D, Wootsch A, Kröhnert J, Steinhauer B, Sauer H, Toth L, Jentoft F C, Knop-Gericke A, Paál Z, Schlögl R. J Catal,

Service

- ▶ 把本文推荐给朋友
- ▶ 加入我的书架
- ▶ 加入引用管理器
- ▶ Email Alert
- ▶ RSS

作者相关文章

- ▶ 余强
- ▶ 高飞
- ▶ 董林

- [13] Wang H, Zhu H Q, Qin Z F, Wang G F, Liang F X, Wang J G. *Catal Commun*, 2008, 9: 1487 
- [14] Moretti E, Lenarda M, Storaro L, Talon, A, Frattini R, Polizzi S, Rodriguez-Castellón E, Jiménez-López A. *Appl Catal B*, 2007, 72: 149 
- [15] Luo M F, Fang P, He M, Xie Y L. *J Mol Catal A*, 2005, 239: 243 
- [16] Chen C S, You J H, Lin J H, Chen Y Y. *Catal Commun*, 2008, 9: 2381 
- [17] Wu G J, Guan N J, Li L D. *Catal Sci Technol*, 2011, 1: 601 
- [18] Luo M F, Ma J M, Lu J Q, Song Y P, Wang Y J. *J Catal*, 2007, 246: 52 
- [19] Luo J Y, Meng M, Zha Y Q, Guo L H. *J Phys Chem C*, 2008, 112: 8694 
- [20] Sundar R S, Deevi S. *J Nanopart Res*, 2006, 8: 497 
- [21] Moreno M, Bergamini L, Baronetti G T, Laborde M A, Marino F J. *Int J Hydrogen Energy*, 2010, 35: 5918 
- [22] Qi L, Yu Q, Dai Y, Tang C J, Liu L J, Zhang H L, Gao F, Dong L, Chen Y. *Appl Catal B*, 2012, 119-120: 308 
- [23] Jia A P, Hu G S, Meng L, Xie L Y, Lu J Q, Luo M F. *J Catal*, 2012, 289: 199 
- [24] 单文娟, 刘畅, 郭红娟, 杨利华, 王晓楠, 冯兆池. 催化学报 (Shan W J, Liu Ch, Guo H J, Yang L H, Wang X N, Feng Zh Ch. *Chin J Catal*), 2011, 32: 1336 
- [25] Qin J W, Lu J F, Cao M H, Hu C W. *Nanoscale*, 2010, 2: 2739 
- [26] Song C Y, Wang C L, Zhu H Y, Wu X C, Dong L, Chen Y. *Catal Lett*, 2008, 120: 215 
- [27] Wang J B, Shih W H, Huang T J. *Appl Catal A*, 2000, 203: 191 
- [28] Huang T J, Kung Y C. *Catal Lett*, 2003, 85: 49 
- [29] Ma S M, Lu G Z, Shen Y X, Guo Y, Wang Y Q, Guo Y L. *Catal Sci Technol*, 2011, 1: 669 
- [30] Zhang T Y, Wang S P, Yu Y, Su Y, Guo X Z, Wang S R, Zhang S M, Wu S H. *Catal Commun*, 2008, 9: 1259 
- [31] Zou Z Q, Meng M, Guo L H, Zha Y Q. *J Hazard Mater*, 2009, 163: 835 
- [32] Hornés A, Bera P, Cámara A L, Gamarra D, Munuera G, Martínez-Arias A. *J Catal*, 2009, 268: 367 
- [33] Martínez-Arias A, Hungria A B, Fernández-García M, Iglesias-Juez A, Soria J, Conesa J C, Anderson J A, Munuera G. *Phys Chem Chem Phys*, 2012, 14: 2144
- [34] Chen H L, Zhu H Y, Wu Y, Gao F, Dong L, Zhu J J. *J Mol Catal A*, 2006, 255: 254 
- [35] Li X W, Wan H Q, Liu B, Yang L J, Zhu H Y, Chen H L, Zhao X, Sun K Q, Dong L, Chen Y. *Catal Commun*, 2009, 10: 741 
- [36] Zhu J, Zhang L L, Deng Y, Liu B, Dong L H, Gao F, Sun K Q, Dong L, Chen Y. *Appl Catal B*, 2010, 96: 449 
- [37] 董林. 催化学报 (Dong L. *Chin J Catal*), 2009, 30: 1150
- [38] 张丽萍, 万海勤, 朱捷, 宋春燕, 刘斌, 李丹, 董林. 无机化学学报 (Zhang L P, Wan H Q, Zhu J, Song Ch Y, Liu B, Li D, Dong L. *Chin J Inorg Chem*), 2007, 23: 427
- [39] 杨立娟, 李晓伟, 刘斌, 万海勤, 胡玉海, 董林. 无机化学学报 (Yang L J, Li X W, Liu B, Wan H Q, Hu Y H, Dong L. *Chin J Inorg Chem*), 2007, 23: 1717
- [40] 王哲, 赵曦, 万海勤, 朱捷, 刘斌, 董林. 无机材料学报 (Wang Zh, Zhao X, Wan H Q, Zhu J, Liu B, Dong L. *J Inorg Mater*), 2008, 23: 454 
- [41] Wan H Q, Wang Z, Zhu J, Li X W, Liu B, Gao F, Dong L, Chen Y. *Appl Catal B*, 2008, 79: 254 
- [42] Wan H Q, Li D, Dai Y, Hu Y H, Zhang Y H, Liu L J, Zhao B, Liu B, Sun K Q, Dong L, Chen Y. *Appl Catal A*, 2009, 360: 26 
- [43] 万海勤. [博士学位论文]. 南京: 南京大学 (Wan H Q. [PhD Dissertation]. Nanjing: Nanjing Univ), 2008 
- [44] Wang Z, Wan H Q, Liu B, Zhao X, Li X W, Zhu H Y, Xu X, Ji F Y, Sun K Q, Dong L, Chen Y. *J Colloid Interface Sci*, 2008, 320: 520 
- [45] Yu Q, Wu X X, Tang C J, Qi L, Liu B, Gao F, Sun K Q, Dong L, Chen Y. *J Colloid Interface Sci*, 2011, 354: 341 
- [46] Yang Z X, He B L, Lu Z S, Hermansson K. *J Phys Chem C*, 2010, 114: 4486 
- [47] Song E H, Wen Z, Jiang Q. *J Phys Chem C*, 2011, 115: 3678 
- [48] Wang K, Zeng Q H, Yu A B. *Chem Eng J*, 2011, 174: 408 
- [49] Gamarra D, Belver C, Fernández-García M, Martínez-Arias A. *J Am Chem Soc*, 2007, 129: 12064 
- [50] Kim D H, Cha J E. *Catal Lett*, 2003, 86: 107 
- [51] Marino F, Descorme C, Duprez D. *Appl Catal B*, 2005, 58: 175 

- [52] Sedmak G, Hocevar S, Levec J. *J Catal*, 2003, 213: 135 [crossref](#)
- [53] Avgouropoulos G, Ioannides T, Matralis H. *Appl Catal B*, 2005, 56: 87 [crossref](#)
- [54] Marban G, Fuertes A B. *Appl Catal B*, 2005, 57: 43 [crossref](#)
- [55] Liu Y, Fu Q, Stephanopoulos M F. *Catal Today*, 2004, 93-95: 241 [crossref](#)
- [56] Avgouropoulos G, Ioannides T. *Appl Catal B*, 2006, 67: 1 [crossref](#)
- [57] Gamarra D, Munuera G, Hungria A B, Fernández-García M, Conesa J C, Midgley P A, Wang X Q, Hanson J C, Rodríguez J A, Martínez-Arias A. *J Phys Chem C*, 2007, 111: 11026 [crossref](#)
- [58] Tada M, Bal R, Mu X D, Coquet R, Namba S, Iwasawa Y. *Chem Commun*, 2007: 4689 [crossref](#)
- [59] Jobbágy M, Mariño F, Schönbrod B, Baronetti G, Laborde M. *Chem Mater*, 2006, 18: 1945 [crossref](#)
- [60] Mariño F, Schönbrod B, Moreno M, Jobbágy M, Baronetti G, Laborde M. *Catal Today*, 2008, 133-135: 735 [crossref](#)
- [61] Kydd R, Teoh W Y, Wong K, Wang Y, Scott J, Zeng Q H, Yu A B, Zou J, Amal R. *Adv Funct Mater*, 2009, 19: 369 [crossref](#)
- [62] Kydd R, Ferri D, Hug P, Scott J, Teoh W Y, Amal R. *J Catal*, 2011, 277: 64 [crossref](#)
- [63] Martínez-Arias A, Hungria A B, Munuera G, Gamarra D. *Appl Catal B*, 2006, 65: 207 [crossref](#)
- [64] Polster C S, Nair H, Baertsch C D. *J Catal*, 2009, 266: 308 [crossref](#)
- [65] Zou H B, Chen S Z, Liu Z L, Lin W M. *Powder Technol*, 2011, 207: 238 [crossref](#)
- [66] Zou H B, Chen S Z, Liu Z L, Lin W M. *Int J Hydrogen Energy*, 2009, 34: 9324 [crossref](#)
- [67] Ko E Y, Park E D, Seo K W, Lee H C, Lee D, Kim S. *Catal Today*, 2006, 116: 377 [crossref](#)
- [68] Park J W, Jeong J H, Yoon W L, Jung H, Lee H T, Lee D K, Park Y K, Rhee Y W. *Appl Catal A*, 2004, 274: 25 [crossref](#)
- [69] Sirichaiprasert K, Luengnaruemitchai A, Pongstabodee S. *Int J Hydrogen Energy*, 2007, 32: 915 [crossref](#)
- [70] Li J, Zhu P F, Zhou R X. *J Power Sources*, 2011, 196: 9590 [crossref](#)
- [71] Fonseca J S L, Ferreira H S, Bion N, Pirault-Roy L, Rangel M C, Duprez D, Epron F. *Catal Today*, 2012, 180: 34 [crossref](#)
- [72] Pakharukova V P, Moroz E M, Kriventsov V V, Zyuzin D A, Kosmambetova G R, Strizhak P E. *Appl Catal A*, 2009, 365: 159 [crossref](#)
- [73] Kosmambetova G R, Moroz E M, Gural'sky A V, Pakharukova V P, Boronin A I, Ivashchenko T S, Gritsenko V I, Strizhak P E. *Int J Hydrogen Energy*, 2011, 36: 1271 [crossref](#)
- [74] Ramaswamy V, Malwadkar S, Chilukuri S. *Appl Catal B*, 2008, 84: 21 [crossref](#)
- [75] Reyes-Carmona A, Arango-Diaz A, Moretti E, Talon A, Storaro L, Lenarda M, Jiménez-López A, Rodríguez- Castellón. *J Power Sources*, 2011, 196: 4382 [crossref](#)
- [76] 邵一凡, 伍艳辉. *工业催化* (Shao Y F, Wu Y H. *Ind Catal*), 2010, 18(6): 40
- [77] Han J, Kim H J, Yoon S, Lee H. *J Mol Catal A*, 2011, 335: 82 [crossref](#)
- [78] Gómez-Cortés A, Márquez Y, Arenas-Alatorre J, Díaz G. *Catal Today*, 2008, 133-135: 743 [crossref](#)
- [79] Zeng S H, Liu Y. *Appl Surf Sci*, 2008, 254: 4879 [crossref](#)
- [80] Ayastuy J L, Gurbani A, González-Marcos M P, Gutiérrez-Ortiz M A. *Int J Hydrogen Energy*, 2012, 37: 1993 [crossref](#)
- [81] Chen Y Z, Liaw B J, Huang C W. *Appl Catal A*, 2006, 302: 168 [crossref](#)
- [82] Wu Z W, Zhu H Q, Qin Z F, Wang H, Huang L C, Wang J G. *Appl Catal B*, 2010, 98: 204 [crossref](#)
- [83] Peng C T, Lia H K, Liaw B J, Chen Y Z. *Chem Eng J*, 2011, 172: 452 [crossref](#)
- [84] Chen Y Z, Liaw B J, Chang W C, Huang C T. *Int J Hydrogen Energy*, 2007, 32: 4550 [crossref](#)
- [85] Martínez-Arias A, Hungria A B, Fernández-García M, Conesa J C, Munuera G. *J Power Sources*, 2005, 151: 32 [crossref](#)
- [86] Liu Z G, Zhou R X, Zheng X M. *J Nat Gas Chem*, 2008, 17: 283 [crossref](#)
- [87] Wang J B, Lin S C, Huang T J. *Appl Catal A*, 2002, 232: 107 [crossref](#)
- [88] Hornés A, Hungria A B, Bera P, López-Cámara A, Fernández-García M, Martínez-Arias A, Barrio L, Estrella M, Zhou G, Fonseca J J, Hanson J C, Rodríguez J A. *J Am Chem Soc*, 2010, 132: 34 [crossref](#)
- [89] Barrio L, Estrella M, Zhou G, Wen W, Hanson J C, Hungria A B, Hornés A, Fernández-García M, Martínez-Arias A, Rodríguez J A. *J Phys Chem C*, 2010, 114: 3580 [crossref](#)
- [90] Rodríguez J A, Graciani J, Evans J, Park J B, Yang F, Stacchiola D, Senanayake S D, Ma S G, Pérez M, Liu P, Sanz J F, Hrbek J. *Angew Chem*,

- [91] Yang F, Graciani J, Evans J, Liu P, Hrbek J, Sanz J F, Rodriguez J A. *J Am Chem Soc*, 2011, 133: 3444 
- [92] Jia A P, Jiang S Y, Lu J Q, Luo M F. *J Phys Chem C*, 2010, 114: 21605 
- [93] Qiao B T, Wang A Q, Lin J, Li L, Su D S, Zhang T. *Appl Catal B*, 2011, 105: 103 
- [94] Kugai J, Kitagawa R, Seino S, Nakagawa T, Ohkubo Y, Nitani H, Daimon H, Yamamoto T A. *Appl Catal A*, 2011, 406: 43 
- [95] Moretti E, Storaro L, Talon A, Patrono P, Pinzari F, Montanari T, Ramis G, Lenarda M. *Appl Catal A*, 2008, 344: 165 
- [1] 石川, 徐力, 朱爱民, 张玉卓, 区泽棠. 氧化铈稳定的 CuO 簇在 CO, C₃H₆ 和 NO 消除中的催化性能[J]. 催化学报, 2012,33(9): 1455-1462
- [2] 曹昌燕, 窦智峰, 刘华, 宋卫国. 三维花状 Co₃O₄ 的低成本制备及其在催化 CO 氧化中的应用[J]. 催化学报, 2012,33(8): 1334-1339
- [3] 赵兰兰, 陈吉祥. P 对 Cu/Al₂O₃ 催化剂结构及其催化甘油氢解反应性能的影响[J]. 催化学报, 2012,33(8): 1410-1416
- [4] 张晓静, 李华举, 李勇, 申文杰. Sr 取代 LaFeO₃ 钙钛矿的结构性质和催化性能[J]. 催化学报, 2012,33(7): 1109-1114
- [5] 张慧丽, 任丽会, 陆安慧, 李文翠. Au/CeO₂/SiO₂ 催化 CO 低温氧化反应过程中 CeO₂ 的作用[J]. 催化学报, 2012,33(7): 1125-1132
- [6] 崔亚娟, 何胜楠, 方瑞梅, 史忠华, 龚茂初, 陈耀强. 整体式 Pd/La₂O₃-Al₂O₃ 和 Pd/CeO₂-ZrO₂-Y₂O₃ 催化剂上汽油车尾气净化性能的比较[J]. 催化学报, 2012,33(6): 1020-1026
- [7] 邱文革, 王昱, 李传强, 展宗城, 瞿学红, 张桂臻, 王锐, 何洪. 活化温度对 CuBTC 催化 CO 氧化反应性能的影响[J]. 催化学报, 2012,33(6): 986-992
- [8] 陈维苗, 丁云杰, 宋宪根, 朱何俊, 严丽, 王涛. 助剂促进的 Rh-Fe/Al₂O₃ 催化剂上 CO 加氢制乙醇反应性能[J]. 催化学报, 2012,33(6): 1007-1013
- [9] 王瑞雪, 吴宝山, 李永旺. 单相碳化铁的制备及其表面吸附性质[J]. 催化学报, 2012,33(5): 863-869
- [10] 张新, 冯秀娟, 刘鹤松, 秦余虎, 戴耀. 钌催化苜基氯衍生物、三丁基烯丙基锡和一氧化碳三组分偶联反应: α,β -不饱和酮的有效合成[J]. 催化学报, 2012,33(3): 523-529
- [11] 赵德志, 丁天英, 李小松, 刘景林, 石川, 朱爱民. 室温 MnO_x 上 O₃ 氧化脱除空气中甲醛[J]. 催化学报, 2012,33(3): 396-401
- [12] 单文娟, 刘畅, 郭红娟, 杨利华, 王晓楠, 冯兆池. O₂, 1, 3 维 CeO₂ 的可控制备及 CuO/CeO₂ 催化剂上 CO 氧化反应[J]. 催化学报, 2011,32(8): 1336-1341
- [13] 王家宁, 戴洪兴, 何洪. 负载型 Pt 模型催化剂中 Pt 纳米粒子的形貌对 CO 氧化活性的影响[J]. 催化学报, 2011,32(8): 1329-1335
- [14] 余育生, 孙伟华, 詹瑛瑛, 林性贻, 郑起. Au/Cu_xMn_yO_z 催化剂的制备、表征及其 CO 消除性能[J]. 催化学报, 2011,32(7): 1220-1226
- [15] 陈明英¹, 翁维正^{1,a}, 华卫琦², 伊晓东¹, 万惠霖^{1,b}. 合成气制 C₂ 含氧化合物 Rh-Mn/SiO₂ 催化剂上 CO 吸附的红外光谱研究[J]. 催化学报, 2011,32(4): 672-681