

REFERENCES

- [1] Vedrine, J. C.; Coudurier, G.; Millet, J. M. "Molecular design of active sites in partial oxidation reactions on metallic oxides", *Catal. Today*, **1997**, *33*, 3.
- [2] Xiao, F.; Sun, J.; Meng, X.; Yu, Ranbo, Yuan, H.; Jiang, D.; Qiu, S.; Xu, R. "Heat of adsorption of carbon monoxide on a Ru/Al₂O₃ catalyst using adsorption equilibrium conditions at high temperatures", *Appl. Catal. A*, **2001**, *201*, 267.
- [3] Cavany, F.; and Trifiro, F. "Classification of industrial catalysts and catalysis for the petrochemical industry", *Catal. Today*, **1997**, *34*, 269.
- [4] Clerici, M.; and Ingallina, P. "Oxidation reactions with in situ generated oxidants", *Catal. Today*, **1998**, *41*, 351.
- [5] Yokoi, T.; Wu, P., Tatsumi, T. "Para-selectivity enhancement by coexistent molecules in phenol hydroxylation over TS-1/H₂O₂ system", *Catal. Commun.*, **2003**, *4*, 11.
- [6] Taramasso, M.; Perego, G.; Notari, B. *U.S. Patent.*, **1983**, 4,410,501.
- [7] Serrano, D. P.; Uguina, M. A.; Ovejero, G.; Van Grieken, R. ; Camacho, M. "Synthesis of TS-1 by wetness impregnation of amorphous SiO₂-TiO₂ solids prepared by the sol-gel method", *Micropor. Mater.*, **1995**, *4*, 273.
- [8] Tuel, A.; Moussa-Khouzami, S.; Ben Taarit, Y.; Naccache, C. "Hydroxylation of phenol over TS-1: Surface and solvent effects", *J. Mol. Catal.*, **1991**, *68*, 45.
- [9] Wu, P.; Tatsumi, T.; Komatsu, T.; Yashima, T. "A Novel Titanosilicate with MWW Structure: I. Hydrothermal Synthesis, Elimination of Extraframework Titanium, and Characterizations", *J. Phys. Chem. B.*, **2001**, *105*, 2897.
- [10] Thangaraj, A.; Kumar, R.; Mirajkar, S.P.; Ratnasamy, P. "Catalytic properties of crystalline titanium silicalites I. Synthesis and characterization of titanium-rich zeolites with MFI structure", *J. Catal.*, **1991**, *130*, 1.
- [11] Van der Pol, A. J. H. P.; Verduyn, A. J.; Van Hooff, J. H. C. "Why are some titanium silicalite-1 samples active and others not?", *Appl. Catal. A*, **1992**, *92*, 113.

- [12] Davis, R. J.; Liu, Z. "Titania-Silica: a model binary oxide catalyst system", *Chem. Mater.*, **1997**, *9*, 2311.
- [13] Grieneisen, J. L.; Kessler, H.; Fache, E.; Le Govic, A. M. "Synthesis of TS-1 in fluoride medium. A new way to a cheap and efficient catalyst for phenol hydroxylation", *Microporous Mesoporous Mater.*, **2000**, *37*, 379.
- [14] Khomane, R. B.; Kulkarni, B. D.; Paraskar, A.; Sainkar, S. R. "Synthesis , characterization and catalytic performance of titanium silicate-1 prepared in micellar media", *Meter. Chem. Phys.*, **2002**, *76*, 99.
- [15] Lee, Y. M.; Porter, J. F. "The synthesis and characterization of titanium silicalite-1", *J. Mater. Sci.*, **2002**, *37*, 1959.
- [16] Ramakrishna Prasad, M.; Kamalakar, G.; Kulkarni, S. J.; Raghavan, K. V.; Narasimha Rao, K.; Sai Prasad, P. S.; Madhavendra, S. S. "An improved process for the synthesis of titanium-rich titanium silicates (TS-1) under microwave irradiation", *Catal. Commun.*, **2002**, *3*, 399.
- [17] Xia, Q. H.; Gao, Z. "Crystallization kinetic of pure TS-1 zeolite using quaternary ammonium halides as templates", *Meter. Chem. Phys.*, **1997**, *47*, 225.
- [18] Wang, X.; Guo, X. "Synthesis characterization and catalytic properties of low cost titanium silicate", *Catal. Today.*, **1999**, *51*, 177.
- [19] Li, G.; Guo, X.; Wang, X.; Zhao, Q.; Bao, X.; Han, X.; Lin, L. "Synthesis of titanium silicalites in different template systems and their catalytic performance", *Appl. Catal. A.*, **1999**, *185*, 11.
- [20] Xiang-sheng, W.; Xin-wen,G.; Gang, L. "Synthesis of Titanium Silicalite (TS-1) From the TPABr System and Its Catalytic Properties for Epoxidation of Propylene", *Catal. Today.*, **2002**, *74*, 65.
- [21] Tuel A. "Crystallization of titanium silicalite-1 (TS-1) from gels containing hexanediamine and tetrapropylammonium bromide", *Zeolites.*, **1996**, *16*, 108.
- [22] Esposito, A.; Taramasso, M.; Neri, C. *U.S. Patent.*, **1983**, 4,396,783.
- [23] Esposito, A.; Neri, C.; Bounomo, F. *U.S. Patent.*, **1983**, 4,480,135.
- [24] Reddy, J. S.; Kumar, R.; Ratnasamy, P. "Titanium silicalite-2: Synthesis, characterization and catalytic properties", *Appl. Catal.*, **1990**, *58*, L1.

- [25] Thangaraj, A.; Kumar, R.; Mirajkar, S. P.; Ratnasamy, P. "Catalytic properties of crystalline titanium silicalites I. Synthesis and characterization of titanium-rich zeolites with MFI structure", *J. Catal.*, **1991**, *130*, 1.
- [26] Reddy, J. S.; Sivasanker, S.; Ratnasamy, P. "Hydroxylation of phenol over TS-2, a titanium silicate molecular sieve", *J. Mol. Catal.*, **1992**, *71*, 373.
- [27] Reddy, J. S.; Kumar R. "Synthesis, characterization, and catalytic properties of a titanium silicate, TS-2, with MEL structure", *J. Catal.*, **1991**, *130*, 440.
- [28] van der Pol, A. J. H. P.; Verduyn, A. J.; van Hooff, J. H. C. "Comparison between gas chromatography and high-performance liquid chromatography analysis of the reaction products formed by the hydroxylation of phenol", *Appl. Catal. A.*, **1993**, *96*, L13.
- [29] Kraushaar, B.; Hooff, J. H. C. "A new method for the preparation of titanium-silicalite (TS-1)", *Catal. Lett.*, **1988**, *1*, 81.
- [30] Kraushaar-Czarnetzki, B.; Hooff, J. H. C. "A test reaction for titanium silicalite catalysts", *Catal. Lett.*, **1989**, *2*, 43.
- [31] Huybrechts, D. R. C.; Vaesen, I.; Li, H. X.; Jacobs, P. A. "Factors influencing the catalytic activity of titanium silicalites in selective oxidations", *Catal. Lett.*, **1991**, *8*, 237.
- [32] Kooyman, P. J.; Waal, P.; Verdaasdonk, P. A. J.; Jansen, K. C.; Bekkum, H. "Titanium deposited from TiCl₄ on amorphous silica and silicalite-1 as catalyst in aromatic hydroxylation reactions", *Catal. Lett.*, **1992**, *13*, 229.
- [33] Tuel, A.; Ben Taarit, Y. "Comparison between TS-1 and TS-2 in the hydroxylation of phenol with hydrogen peroxide", *Appl. Catal. A.*, **1993**, *102*, 69.
- [34] Martens, J. A.; Buskens, Ph.; Jacobs, P. A.; van der Pol, A. J. H. P.; van Hooff, J. H. C.; Ferrini, C.; Kouwenhoven, H. W.; Kooyman, P. J.; van Bekkum. "Hydroxylation of phenol with hydrogen peroxide on EURO TS-1 catalyst", *Appl. Catal. A.*, **1993**, *99*, 71.
- [35] Notari, B. "Synthesis and catalytic properties of titanium containing zeolites", *Surf. Sci. Catal.*, **1988**, *37*, 413.
- [36] Yokoi, T.; Wu, P.; Tatsumi, T. "Para-selectivity enhancement by coexistent molecules in phenol hydroxylation over TS-1/H₂O₂ system", *Catal. Commun.*, **2003**, *4*, 11.

- [37] Wilkenhöner, U.; Langhendries, G.; Laar, F. V.; Baron, G, V.; Gammon, D. W.; Jacobs, P. A.; Steen, E. V. "Influence of Pore and Crystal Size of Crystalline Titanosilicates on Phenol Hydroxylation in Different Solvents", *J. Catal.*, **2001**, *203*, 201.
- [38] Wu, P.; Tatsumi, T. "Unique *trans*-Selectivity of Ti-MWW in Epoxidation of *cis/trans*-Alkenes with Hydrogen Peroxide", *J. Phys. Chem. B.*, **2002**, *106*, 748.
- [39] Wu, P.; Tatsumi, T. "A Novel Titanosilicate with MWW Structure: III. Highly Efficient and Selective Production of Glycidol Through Epoxidation of Allyl Alcohol with H₂O₂", *J. Catal.*, **2003**, *214*, 317.
- [40] Wu, P.; Tatsumi, T. "Unique *trans*-Selectivity of Ti-MWW in Epoxidation of *cis/trans*-Alkenes with Hydrogen Peroxide", *J. Phys. Chem. B.*, **2002**, *106*, 748.
- [41] Trawczynski, J. "Noble metals supported on carbon black composites as catalysts for the wet-air oxidation of phenol", *Carbon.*, **2003**, *41*, 1515.
- [42] Hamoudi, S.; Sayari, A.; Belkacemi, K.; Bonneviot, L.; Larachi, F. "Catalytic wet oxidation of phenol over Pt_xAg_{1-x}MnO₂/CeO₂ catalysis", *Catal. Today.*, **2000**, *62*, 379.
- [43] Szostak, R. Molecular Sieves: Principles of Synthesis and Identification. New York : Van Nostrand Reinhold, **1989**.
- [44] Breck, D. Zeolite Molecular Sieves: Structure, Chemistry, and Use. New York: John Wiley & Sons, **1974**.
- [45] Oliviero, L.; Barbier Jr., J.; Duprez, D. Guerrero-Ruiz, A.; Bachiller-Baeza, B. Rodriguez-Ramos, I. "Catalytic wet air oxidation of phenol and acrylic acid over Ru/C and Ru-CeO₂/C catalysts", *Appl. Catal. B.*, **2000**, *25*, 267.
- [46] Vaidya, P. D.; Mahajani, V. V. "Insight into heterogeneous catalytic wet oxidation of phenol over a Ru/TiO₂ catalyst", *Chem Eng J.*, **2000**, *87*, 403.
- [47] Smart, L.; Moore, E. Solid State Chemistry. London: Chapman & Hall University, **1992**.
- [48] Derouane, E. G. "New Aspects of Molecular Shape-Selectivity: Catalysis by Zeolite ZSM-5", *Studies Surface Science Catal.*, **1980**, *5*, 5.
- [49] Gates, B. C. Catalytic Chemistry. New York: Wiley, **1992**.

- [50] Song, C.; Garcés, J. M.; Sugi, Y. Shape-Selective Catalysis Chemicals Synthesis and Hydrocarbon Processing, Washington, DC: American Chemical Society, **2000**.
- [51] Notari, B. "Synthesis and catalytic properties of titanium containing zeolites". *Surf. Sci. Catal.*, **1989**, *37*, 413.
- [52] Lewis, D. W.; Catlow, C. R. A.; Sankar, G. "Structure of Iron-Substituted ZSM-5", *J. Phys. Chem.*, **1995**, *99*, 2377.
- [53] Tuel, A.; Ben Taarit, Y. "Comparison between TS-1 and TS-2 in the hydroxylation of phenol with hydrogen peroxide", *Chem. Soc., Chem commun.*, **1994**, 1667.
- [54] <http://www.iza-structure.org/database/>
- [55] Xiao, F-S.; Sun, J.; Meng, X.; Yu, R.; Yuan, H.; Xu, J.; Song, T.; Jiang, D.; Xu, R. "Synthesis and Structure of Copper Hydroxyphosphate and Its High Catalytic Activity in Hydroxylation of Phenol by H_2O_2 ", *J. Catal.*, **2001**, *199*, 273.
- [56] Rocha, G.M.; Joohnstone, R. A. W.; Neves, M. G. "Catalytic effects of metal(IV) phosphates on the oxidation of phenol and 2-naphthol", *J. Mol. Catal. A: Chem.* **2002**, *187*, 95.
- [57] Khouw, C. B.; Dartt, C. B.; Labinger, J. A.; Davi, M. E. "Studies on the Catalytic-Oxidation of Alkanes and Alkenes by Titanium Silicates", *J. Catal.*, **1994**, *149*, 195.
- [58] Reddy, J. S.; Kumar, R.; Csicsery S. M. "Synthesis, Characterization, and Catalytic Properties of Metallo-Titanium Silicate Molecular Sieves with MEL Topology", *J. Catal.*, **1994**, *145*, 73.
- [59] Reddy, J. S.; Sayari, A. "Oxidation of primary amines over vanadium silicalite molecular sieve, VS-1", *Catal. Lett.*, **1994**, *28*, 263.
- [60] van der Pol, A. J. H. P.; van Hooff, J. H. C. "Parameters affecting the synthesis of titanium silicalite 1", *Appl. Catal. A: General*, **1992**, *92*, 93.
- [61] Liu, Z. F.; Tabora, J.; Davis, R. J. "Relationships between Microstructure and Surface Acidity of Ti-Si Mixed Oxide Catalysts", *J. Catal.*, **1994**, *149*, 117.
- [62] Conte, V.; Di Furia, F.; Modena, G. Organic peroxides (Ando, W. Ed), New York: Wiley, **1992**.

- [63] Huybrechts, D. R. C.; Vaesen, I.; Li, H. X.; Jacobs, P. A. "Factors influencing the catalytic activity of titanium silicalites in selective oxidations", *Catal. Lett.*, **1991**, *8*, 237.
- [64] Clerici, M. G.; Ingallina, P. "Epoxidation of Lower Olefins with Hydrogen Peroxide and Titanium Silicalite", *J. Catal.*, **1993**, *140*, 71.
- [65] Mimoun, H. "Oxygen Transfer from Inorganic and Organic Peroxides to Organic Substrates: A Common Mechanism?", *Angew. Chem. Int. Ed. in Engl.*, **1982**, *21*, 734.
- [66] Bellussi, G.; Carati, A.; Clerici, M. G.; Maddinelli, G.; Millini, R. "Reactions of titanium silicalite with protic molecules and hydrogen peroxide", *J. Catal.*, **1992**, *133*, 220.
- [67] Khouw, C. B.; Davis, M. E. "Catalytic Activity of Titanium Silicates Synthesized in the Presence of Alkali-Metal and Alkaline-Earth Ions", *J. Catal.*, **1995**, *151*, 77.
- [68] Amato, G.; Arcoria, A.; Ballistreri, F. P.; Tomaselli, G. A.; Bortolini, O.; Conte, V.; Di Furia, F.; Modena, G.; Valle, G. "Oxidations with peroxotungsten complexes: rates and mechanism of stoichiometric olefin epoxidations", *J. Mol. Catal.*, **1986**, *37*, 165.
- [69] Sandler, S. I. Chemical and Engineering Thermodynamics, 2nd Ed, Amsterdam: Elsevier, **1992**.
- [70] Langhendries, G.; De Vos, D. E.; Baron, G. V.; Jacobs, P. A. "Quantitative Sorption Experiments on Ti-Zeolites and Relation with α -Olefin Oxidation by H_2O_2 ", *J. Catal.*, **1999**, *187*, 453.
- [71] Xiao, F-S.; Sun, J.; Meng, X.; Yu, Ranbo.; Yuan, H.; Xu, J.; Song, T.; Jiang, D.; Xu, Ruren. "Synthesis and Structure of Copper Hydroxyphosphate and Its High Catalytic Activity in Hydroxylation of Phenol by H_2O_2 ", *J. Catal.*, **2001**, *199*, 273.

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