

REFERENCES

- Adam, F., Andas, J., Rahman, I.A. (2010) A study on the oxidation of phenol by heterogeneous iron silica catalyst. Chemical Engineering Journal, 165, 658–667.
- Adam, F., Wong, J.-T., Ng, E.-P. (2013) Fast catalytic oxidation of phenol over iron modified zeolite L nanocrystals. Chemical Engineering Journal, 214, 63–67.
- Agency for Toxic Substances and Disease Registry (ATSDR). (1998) Toxicological profile for phenol (update). Atlanta: Public Health Service, U.S. Department of Health and Human Services.
- Allian, M., Germain, A., Figueras, F. (1994) The formation of para-benzoquinone and the mechanism of the hydroxylation of phenol by hydrogen peroxide over solid acids. Catalysis Letters, 28, 409-415.
- Angevine, P.J., Gaffney, A.M., Shan, Z., Koegler, J.H., Yeh, C.Y. "TUD-1: A generalized mesoporous catalyst family for industrial applications." Digital Refining, Dec 2008, 10 May 2013 <www.digitalrefining.com/article/1000209>
- Charoenpinijkarn, W., Sawankruhasn, M., Kesapabutr, B., Wongkasemjit, S., Jamieson, A.M. (2001) Sol-gel processing of silatranes. European Polymer Journal, 37, 1441-1448.
- Choi, J.-S., Yoon, S.-S., Jang, S.-H., Ahn, W.-S. (2006) Phenol hydroxylation using Fe-MCM-41 catalysts. Catalysis Today, 111, 280-287.
- Chumee, J., Grisdanurak, N., Neramittagapong, A., Wittayakun, J. (2009) Characterization of platinum–iron catalysts supported on MCM-41 synthesized with rice husk silica and their performance for phenol hydroxylation. Science and Technology of Advanced Materials, 10, 015006.
- Crowther, N., Larachi, F. (2003) Iron-containing silicalites for phenol catalytic wet peroxidation. Applied Catalysis B: Environmental, 46, 293–305.

- Haddoum, S., Fechete, I., Donnio, B., Garin, F., Lutic, D., Chitour, C. E. (2012) Fe-TUD-1 for the preferential rupture of the substituted C-C bond of methylcyclopentane (MCP). Catalysis Communications, 27, 141–147.
- Hu, X., Lam, F.L.Y., Cheung, L.M., Chan, K.F., Zhao, X.S., Lu, G.Q. (2001) Copper/MCM-41 as catalyst for photochemically enhanced oxidation of phenol by hydrogen peroxide. Catalysis Today, 68, 129–133.
- IARC (1977) Some Fumigants, the Herbicides 2,4-D and 2,4,5-T, Chlorinated Dibenzodioxins and Miscellaneous Industrial Chemicals. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, 15, 255–264.
- Jansen, J. C., Shan, Z., Marchese, L., Zhou, W., Puil, N. v. d., Maschmeyer, T. (2001) A new templating method for three-dimensional mesopore networks. Chemical Communications, 713–714.
- Kannan, S., Dubey, A., Knozinger, H. (2005) Synthesis and characterization of CuMgAl ternary hydrotalcites as catalysts for the hydroxylation of phenol. Journal of Catalysis, 231, 381–392.
- Klaewkla, R., Rirksomboon, T., Kulprathipanja, S., Nemeth, L., Rangsunvigit, P. (2006) Light sensitivity of phenol hydroxylation with TS-1. Catalysis Communications, 7, 260–263.
- Kumar, A., Srinivas, D. (2013) Hydroxylation of phenol with hydrogen peroxide catalyzed by Ti-SBA-12 and Ti-SBA-16. Journal of Molecular Catalysis A: Chemical, 368–369, 112–118.
- Kustrowski, P., Chmielarz, L., Dziembaj, R., Cool, P., Vansant, E.F. (2005) Modification of MCM-48-, SBA-15-, MCF-, and MSU-type mesoporous silicas with transition metal oxides using the molecular designed dispersion method. The Journal of Physical Chemistry B, 109, 11552–11558.
- Liu, H., Lu, G., Guo, Y., Guo, Y., Wang, J. (2008) Study on the synthesis and the catalytic properties of Fe-HMS materials in the hydroxylation of phenol. Microporous and Mesoporous Materials, 108, 56–64.
- Longloilert, R., Chaisuwan, T., Luengnaruemitchai, A., Wongkasemjit, S. (2011) Synthesis of MCM-48 from silatrane via sol–gel process. Journal of sol-gel science and technology, 58, 427–435.

- Mahoney, L.M. (2010) Photocatalysis studies using mesoporous modified V-MCM-48 Stober synthesis. PhD thesis, Kansas State University, Kansas, USA.
- Noreña-Franco, L., Hernandez-Perez, I., Aguilar-Pliego, J., Maubert-Franco, A. (2002) Selective hydroxylation of phenol employing Cu-MCM-41 catalysts. Catalysis Today, 75, 189–195.
- Perego, C., Carati, A., Ingallina, P., Mantegazza, M. A., Bellussi, G. (2001) Production of titanium containing molecular sieves and their application in catalysis. Applied Catalysis A: General, 221, 63-72.
- Qiao, J.-Q., Yuan, N., Tang, C.-J., Yang, J., Zhou, J., Lian, H.-Z., Dong, L. (2012) Determination of catalytic oxidation products of phenol by RP-HPLC. Research on Chemical Intermediates, 38, 549–558.
- Rahmat, N., Abdullah, A. Z., Mohamed, A. R. (2010) A review: Mesoporous Santa Barbara amorphous-15, types, synthesis and its applications towards biorefinery production. American Journal of Applied Sciences, 7, 1579-1586.
- Ramanathan, A., Villalobos, M. C. C., Kwakernaak, C., Telalovic, S., Hanefeld, U. (2008) Zr-TUD-1: a Lewis acidic, three-dimensional, mesoporous, zirconium-containing catalyst. Chemistry- A European Journal, 14, 961-72.
- Ray, S., Mapolie, S.F., Darkwa, J. (2007) Catalytic hydroxylation of phenol using immobilized late transition metal salicylaldimine complexes. Journal of Molecular Catalysis A: Chemical, 267, 143–148.
- Rives, V., Prieto, O., Dubey, A., Kannan, S. (2003) Synergistic effect in the hydroxylation of phenol over CoNiAl ternary hydrotalcites. Journal of Catalysis, 220, 161–171.
- Rokhina, E.V., Virkute, J. (2011) Environmental application of catalytic processes: heterogeneous liquid phase oxidation of phenol with hydrogen peroxide. Critical Reviews in Environmental Science and Technology, 41, 125–167.
- Rouquerol, J., Avnir, D., Fairbridge, C.W., Everett, D.H., Haynes, J.H., Pernicone, N., Ramsay, J.D.F., Sing, K.S.W., Unger, K.K. (1994) Recommendations for the characterization of porous solids. Pure and Applied Chemistry, 66, 1739-1758.

- Samran, B., White, T. J., Wongkasemjit, S. (2011) A novel room temperature synthesis of mesoporous SBA-15 from silatrane. Journal of Porous Materials, 18, 167-175.
- Shan, Z., Jansen, J.C., Marchese, L., Maschmeyer, Th. (2001) Synthesis, characterization and catalytic testing of a 3D mesoporous titanosilica, Ti-TUD-1. Microporous and Mesoporous Materials, 48, 181-187.
- Song S., Zhao, W., Wang, L., Chu, J., Qu, J., Li, S., Wang, L., Qi, T. (2011) One-step synthesis of Ti-MSU and its catalytic performance on phenol hydroxylation. Journal of Colloid and Interface Science, 354, 686–690.
- Sun, J., Meng, X., Shi, Y., Wang, R., Feng, S., Jiang, D., Xu, R., Xiao, F.-S. (2000) A Novel Catalyst of Cu–Bi–V–O Complex in Phenol Hydroxylation with Hydrogen Peroxide. Journal of Catalysis, 193, 199–206.
- Tanglumlert, W., Imae, T., White, T. J., Wongkasemjit, S. (2007) Structural aspects of SBA-1 cubic mesoporous silica synthesized via a sol-gel process using silatrane precursor. Journal of the American Ceramic Society, 90(12), 3992–3997.
- Tanglumlert, W., Yang, S.-T., Jeong, K.-E., Jeong, S.-Y., Ahn, W.-S. (2011) Facile synthesis of Ti-TUD-1 for catalytic oxidative desulfurization of model sulfur compounds. Research on Chemical Intermediates, 37, 1267–1273.
- Telalović, S., Ramanathan, A., Mul, G., Hanefeld, U. (2009). TUD-1: synthesis and application of a versatile catalyst, carrier, material. Journal of Materials Chemistry, 20, 642–658.
- Thanabodeekij, N., Sathupunya, M., Jamieson, A.M., Wongkasemjit, S. (2003) Correlation of sol-gel processing parameters with microstructure and properties of a ceramic product. Materials Characterization, 50, 325-337.
- Thanabodeekij, N., Tanglumlert, W., Gulari, E., Wongkasemjit, S. (2005) Synthesis of Ti-MCM-41 directly from silatrane and titanium glycolate and its catalytic activity. Applied Organometallic Chemistry, 19, 1047-1054.
- Timofeeva, M.N., Malyshev, M.E., Panchenko, V.N., Shmakov, A.N., Potapov, A.G., Mel'gunov, M.S. (2010) FeAl₁₂-Keggin type cation as an active site source for Fe,Al-silica mesoporous catalysts. Applied Catalysis B: Environmental, 95, 110–119.

- Timofeeva, M.N., Mel'gunov, M.S., Kholdeeva, O.A., Malyshev, M.E., Shmakov, A.N., Fenelonov, V.B. (2007) Full phenol peroxide oxidation over Fe-MMM-2 catalysts with enhanced hydrothermal stability. Applied Catalysis B: Environmental, 75, 290–297.
- U.S. Environmental Protection Agency. (1999) Integrated Risk Information System (IRIS) on Phenol. Washington,DC: National Center for Environmental Assessment. Office of Research and Development.
- Wilkenhoner, U., Langhendries, G., van Laar, F., Baron, G.V., Gammon, D.W., Jacobs, P.A., van Steen, E. (2001) Influence of pore and crystal size of crystalline titanosilicates on phenol hydroxylation in different solvents. Journal of Catalysis, 203, 201–212.
- Wu, C., Kong, Y., Gao, F., Wu, Y., Lu, Y., Wang, J., Dong, L. (2008) Synthesis, characterization and catalytic performance for phenol hydroxylation of Fe-MCM41 with high iron content. Microporous and Mesoporous Materials, 113, 163–170.
- Wu, Y., Zhang, Y., Cheng, J., Li, Z., Wang, H., Sun, Q., Han, B., Kong, Y. (2012) Synthesis, characterization and catalytic activity of binary metallic titanium and iron containing mesoporous silica. Microporous and Mesoporous Materials, 162, 51–59.
- Yang, G., Hu, X., Wu, Y., Liu, C., Zhang, Z. (2012) Phenol oxidation catalyzed by a simple water-soluble copper catalyst with an imidazole salt tag. Catalysis Communications, 26, 132–135.
- Zhang, Y., Gao, F., Wan, H., Wu, C., Kong, Y., Wu, X., Zhao, B., Dong, L., Chen, Y. (2008) Synthesis, characterization of bimetallic Ce–Fe-SBA-15 and its catalytic performance in the phenol hydroxylation. Microporous and Mesoporous Materials, 113, 393–401.
- Zhang, Z.-X., Bai, P., Xu, B., Yan, Z.-F. (2006) Synthesis of mesoporous alumina TUD-1 with high thermostability. Journal of Porous Materials, 13, 245–250.
- Zhao, S., Su, D., Che, J., Jiang, B., Orlov, A. (2011) Photocatalytic properties of TiO₂ supported on SBA-15 mesoporous materials with large pores and short channels. Materials Letters, 65, 3354–3357.

Zhao, W., Luo, Y., Deng, P., Li, Q. (2010) Synthesis of Fe-MCM-48 and its catalytic performance in phenol hydroxylation. Cataysis Letters, 73, 2-4.

APPENDICES

Appendix A Structure of Silatrane Precursor

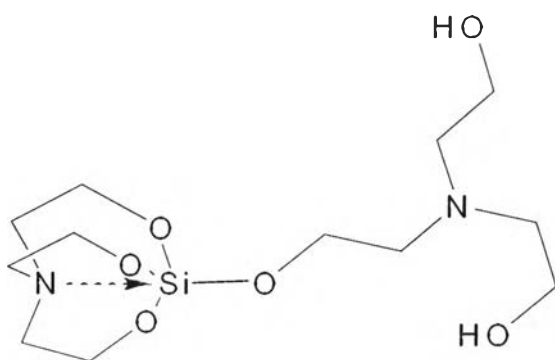


Figure A1 Structure of silatrane precursor.

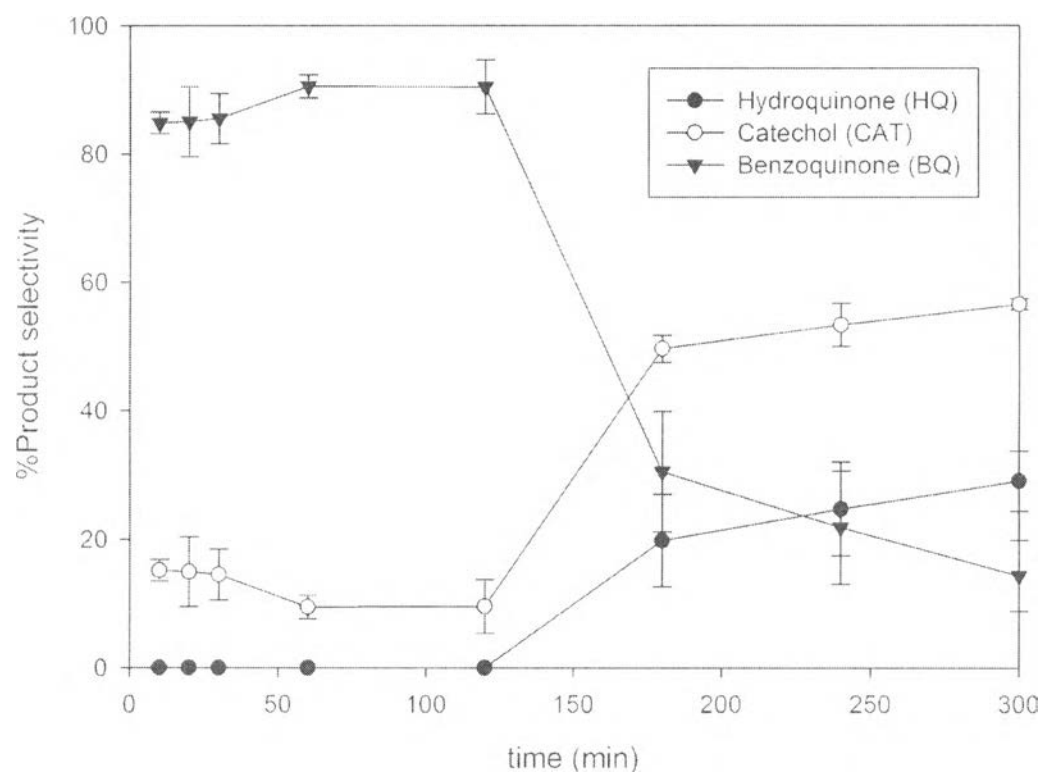
Appendix B Change of Catalytic Performance

Figure B1 Effect of reaction time and reaction temperature for phenol hydroxylation at 30 °C.

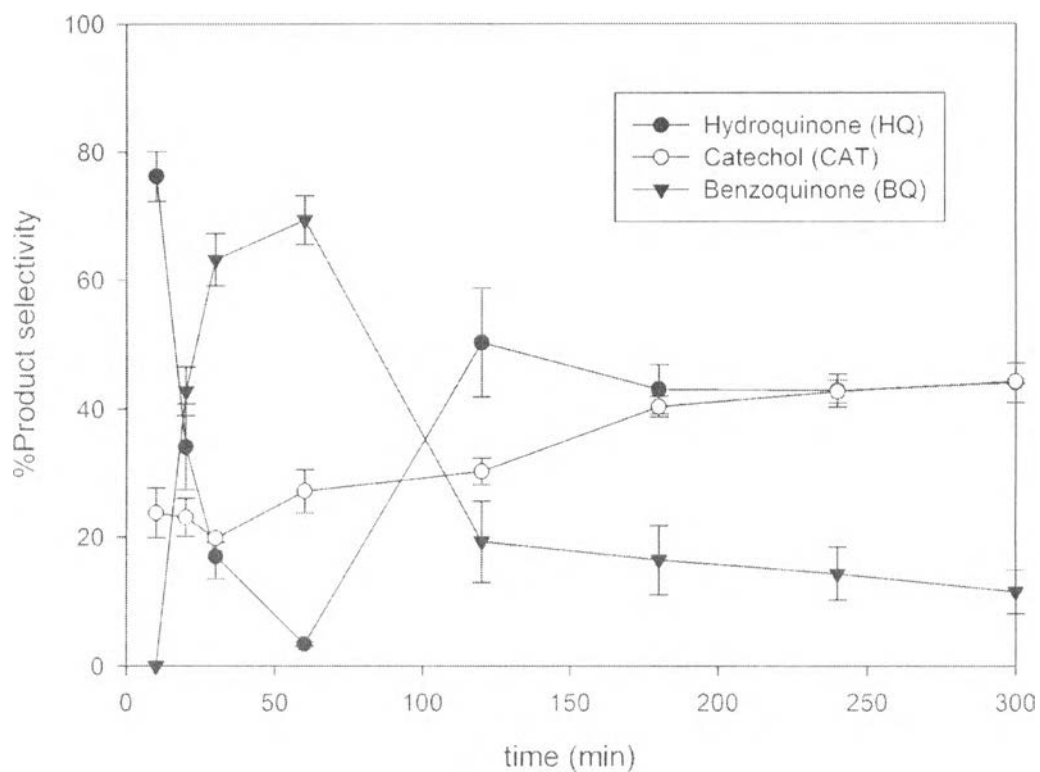


Figure B2 Effect of reaction time and reaction temperature for phenol hydroxylation at 50 °C.

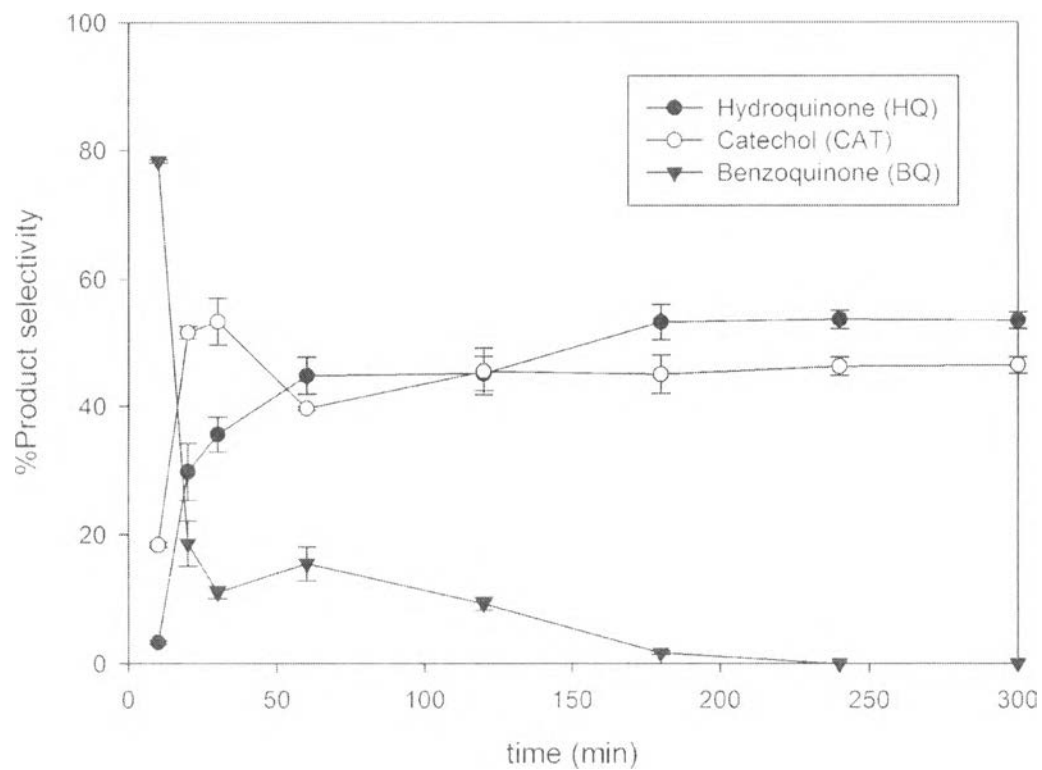


Figure B3 Effect of reaction time and reaction temperature for phenol hydroxylation at 70 °C.

CURRICULUM VITAE

Name: Mr. Supakorn Tantisriyanurak

Date of Birth: March 8, 1990

Nationality: Thai

University Education:

2008-2011 Bachelor Degree of Science in Chemistry, Faculty of Science,
Prince of Songkla University, Hat Yai, Thailand.

Presentations:

1. Tantisriyanurak, S.; Poorahong, S.; Thammakhet, C.; Thavarungkul, P.; Kanatharana, P. (2012, January 11-13) Polypyrrole/multiwalled carbon nanotubes composite sorbents for sample preparation. Paper presented at the 6th Pure and Applied Chemistry international conference 2012 (PACCON), Chiang Mai, Thailand.
2. Tantisriyanurak, S.; Poorahong, S.; Thammakhet, C.; Thavarungkul, P.; Kanatharana, P. (2012, May 2-4) Polypyrrole/multiwalled carbon nanotubes composite sorbents for sample preparation. Paper presented at the 7th Science and Technology Conference for Youths, Bangkok, Thailand.
3. Tantisriyanurak, S.; Maneesuwan, H.; Chaisuwan, T.; Wongkasemjit, S. (2014, February 27-28) Catalytic activity study of Fe, Ti loaded TUD-1. Paper presented at ICCEE 2014 : International Conference on Chemical and Environmental Engineering, Barcelona, Spain.
4. Tantisriyanurak, S.; Maneesuwan, H.; Chaisuwan, T.; Wongkasemjit, S. (2014, April 22) Catalytic activity study of Fe, Ti loaded TUD-1. Paper presented at the 5th Research Symposium on Petrochemical and Materials Technology and The 20th PPC Symposium on Petroleum, Petrochemicals and Polymers, Bangkok, Thailand.