

REFERENCES

- ASTM D 3172 Standard Practice for Proximate Analysis of Coal and Coke, 1989.
- ASTM D 3176 Standard Practice for Ultimate Analysis of Coal and Coke, 1989.
- Agarwal, P.K., La Nauze, R.D., 1989. Transfer processes local to the coal particles, a review of drying, devolatilisation and mass transfer in fluidized bed combustion. Chem. Eng. Res. Des. 67, 457–480.
- Bien, J. B., Bien, J.D., Matysiak, B., 2000. Research on possibilities of sewage sludge utilization in the process of pyrolysis. In Pawlowski, L., Dudzinska, M.R., Gonzalez, M.A., (Eds.). Thermal Solid Waste Utilization in Regular and Industrial Facilities (pp. 103-111). USA: Kluwer Academic/Plenum Publishers.
- Borodulya, V.A., Dikalenko, V.I., Palchonok, G.I., Stanchits, L.K., 1995. Fluidized bed combustion of solid organic waste and low grade coal, research and modelling. In: Heinschel, K.J., editor. Proceedings 13th International Conference on Fluidized Bed Combustion. Orlando, FL: ASME, 1995:135–142.
- Bradbury, A.G.W., Sakai, Y., Shafizadeh, F., 1979. A kinetic model for pyrolysis of cellulose. J. Appl. Polym. Sci. 23, 32-71.
- Bridgwater, A.V., Peacocke, G.V.C., 2000. Fast pyrolysis processes for biomass. Renew. Sust. Energ. Rev. 4(1), 1-73.
- Bridgwater, A.V., 2003. Renewable fuels and chemicals by thermal processing of biomass. Chem. Eng. J. 91(2-3), 87-102.
- Chapman, D.V., White, S.L., Rainbow, P.S., Taylor, M., 1988. Interactions between marine crustaceans and digested sewage sludge. Marine Pollut. Bull. 19(3), 115-119.
- Czernik, S., French, R., Feik, C., 2002. Hydrogen by catalytic steam reforming of liquid byproducts from biomass thermo conversion processes. Ind. Eng. Chem. Res. 41, 4209–4215.
- Chiaramonti, D., Bonini, M., Fratini, E., 2003. Development of emulsions from biomass pyrolysis liquid and Diesel and their use in engines—Part 1: Emulsion production. Biomass Bioenerg. 25, 85–99.
- Chobanoglous, G., 1987. Wastewater engineering, treatment, disposal and reuse. New Delhi: Tata McGraw-Hill.

- Coats, A.W., Redfern, J.P., 1964. Kinetic parameters from thermogravimetric data. *Nature* 201, 68–69.
- Conesa, J.A., Marcilla, A., Moral, R., Moreno-Caselles, J., Perez-Espinosa, A., 1998. Evolution of gases in the primary pyrolysis of different sewage sludge. *Thermochemica Acta* 313(1), 63-73.
- Conesa, J.A., Marcilla, A., Caballero, J.A., Font, R., 2001. Comments on the validity and utility of the different methods for kinetic analysis of thermogravimetric data. *J. Anal. Appl. Pyrol.* 58–59, 617–633.
- Davis, R.D., 1996. The impact of EU and UK environmental pressures on the future of sludge treatment and disposal. *CIWEM's Water and Environ. J.* 10, 65–69.
- Di Blasi, C., Russo, G., 1994. Modeling and simulation of combustion processes of charring and non-charring solid fuels. *Prog. Energy Combust. Sci.* 71-104.
- Di Blasi, C., Russo, G., 1994. Modeling of transport phenomena and kinetics of biomass pyrolysis, In: Bridgwater, A.V. (Ed): *Advances in thermochemical biomass conversion*. Blackie Academic & Professional, London, 906-921.
- Dickinson, C.F., Heal, G.R., 1999. Solid–liquid diffusion controlled rate equations. *Thermochemica Acta.* 340-341, 89-103.
- de Lange, M.W., van Ommen, J.G., Lefferts, L., 2001. Deoxygenation of benzoic acid on metal oxides 1. The selective pathway to benzaldehyde. *Appl. Catal. A: General* 220, 41-49.
- de Lange, M.W., van Ommen, J.G., Lefferts, L., 2002. Deoxygenation of benzoic acid on metal oxides 2. Formation of byproducts. *Appl. Catal. A: General* 231, 17-26.
- Demirbas, A., 1998. Yields of oil products from thermochemical biomass conversion process. *Energ. Conv. Manag.* 39(7), 685-690.
- Doshi, V.A., Vuthaluru, H.B., Bastow, T., 2005. Investigations into the control of odour and viscosity of biomass oil derived from pyrolysis of sewage sludge. *Fuel Proc. Technol.* 86, 885-897.
- Domínguez, A., Menéndez, J.A., Pis, J.J., 2006. Hydrogen rich fuel gas production from the pyrolysis of wet sewage sludge at high temperature. *J. Anal. Appl. Pyrol.* 77(2), 127-132.

- Elliott, D.C., Neuenschwander, G.G., 1996. Liquid fuel by low-severity hydrotreating of biocrude. *Developments in thermochemical biomass conversion*. London: Blackie Academic and Professional; p. 611–621.
- Fonts, I., Azuara, M., Gea, G., Murillo, M.B., 2008. Study of the pyrolysis liquids obtained from different sewage sludge. *J. Anal. Appl. Pyrol.* (corrected proved).
- González-Velasco, J.R., Gutiérrez-Ortiz, M.A., Marc, J.-L., Botas, J.A., González-Marcos, M.P., Blanchard, G., 2000. Effects of redox thermal treatments and feedstream composition on the activity of Ce/Zr mixed oxides for TWC applications. *Appl. Catal. B: Environmental* 25(1), 19-29.
- Gomez-Rico, M.F., Font, R., Fullana, A., Martin-Gullon, I., 2005. Thermogravimetric study of different sewage sludges and their relationship with the nitrogen content. *J. Anal. Appl. Pyrol.* 74, 421-428.
- Grønli, M.G., Va'rhegyi, G., Blasi, C.D., 2002. Thermogravimetric analysis and devolatilization kinetics of wood. *Ind. Eng. Chem. Res.* 41, 4201–4208.
- Guo, X.Y., Yan, Y.J., Ren, Z.W., 2003. The using and forecast of catalyst in biooil upgrading. *Acta Energiæ Solaris Sin.* 124(12), 206–212.
- Hall, J.E., 1992. Treatment and use of sewage sludge in EC. In: Bradshaw AD, Southwood R, Warner F, editors. *The treatment and handling of wastes*. London: Chapman and Hall.
- Hall, J.E., Dalimier, F., 1994. Waste management—sewage sludge: survey of sludge production, treatment, quality and disposal in the EC. EC Reference No: B4-3040/014156/92, Report No: 3646.
- Hsiau, P., Lo, S., 1998. Extractabilities of heavy metals in chemically-fixed sewage sludges. *J. Hazard. Mat.* 58, 73–82.
- Ikura, M., Stanciulescu, M., Hogan, E., 2003. Emulsification of pyrolysis derived bio-oil in Diesel fuel. *Biomass Bioenerg.* 24, 221–232.
- Inguanzo, M., Menéndez, J.A., Fuente, E., Pis, J.J., 2001. Reactivity of pyrolyzed sewage sludge in air and CO₂. *J. Anal. Appl. Pyrol.* 58-59, 943-954.
- Inguanzo, M., Domínguez, J.A., Menéndez, C.G., Blanco, C.G., Pis, J.J., 2002. On the pyrolysis of sewage sludge: the influence of pyrolysis conditions on solid, liquid and gas fractions. *J. Anal. Appl. Pyrol.* 63(1), 209-222.

- Jindarom, C., Meeyoo, V., Rirksomboon, T., Rangsunvigit, P., 2007. Thermochemical decomposition of sewage sludge in CO₂ and N₂ atmosphere. Chemosphere 67, 1477-1484.
- Johnson, J.E., 1994. Formation and reduction of nitrogen oxides in fluidised bed combustion. Fuel. 73(9), 1398–415.
- Krogmann, U., Boyles, L.S., Bamka, W.J., Chaiprapat, S., Martel, C.J., 1999. Biosolids and sludge management. Water and Environ. Res. 71(5), 692–714.
- La Nauze, R.D., 1985. Fundamentals of coal combustion in fluidized beds. Chem. Eng. Res. Des. 63, 3–33.
- Liu, N.A., Fan, W., Dobashi, R., Hyang, I., 2002. Kinetic modeling of thermal decomposition of natural cellulosic materials in air atmosphere. J. Anal. Appl. Pyrol. 63, 303-325.
- Linden, A.G., Berruti, F., Scott, D.S., 1988. A kinetic model for the production of liquids from the flash pyrolysis of biomass. Chem. Eng. Comm. 65, 207-221.
- Lowe, P., 1995. Development in the thermal drying of sewage sludge. CIWEM's Water Energ. Manag. J. 9, 306–316.
- Maschio, G., Koufopoulos, C., Lucchesi, A., 1992. Pyrolysis, a promising route for biomass utilization. Biores. Technol. 42, 219-231.
- McGhee, T.J., 1991. Water supply and sewerage. New York: McGraw-Hill.
- McKendry, P., 2002. Energy production from biomass (part 2): conversion technologies. Biores. Technol. 83, 47-53.
- Mathias, B., 1994. Basic knowledge of environmental technology], 2nd edn. Wuřzburg: Vogel Buchverlag.
- Mathys, R.G., 1994. Nitrification and denitrification—new aspects and processes. gwa 2/94, 89–103.
- Max Lu, G.Q. and Lau, D.D., 1996. Characterization of sewage sludge-derived adsorbents for H₂S removal. Part 2: Surface and pore structural evolution in chemical activation. Gas Sep. Purif. 10(2), 103-111.
- Menéndez, J.A., Domínguez, A., Inguanzo, M., Pis, J.J., 2004. Microwave pyrolysis of sewage sludge: analysis of the gas fraction. J. Anal. Appl. Pyrol. 71, 65-667.
- Metcalf, Eddy, editors. (1991) Wastewater engineering—treatment, disposal and reuse. 3rd ed. New York, USA: McGraw Hill.

- Morf, P.O., 2001. Secondary Reactions of Tar during Thermochemical Biomass Conversion, Ph.D. Thesis at the Swiss Federal Institute of Technology Zurich. Zurich, Switzerland.
- Nokkosmaki, M.I., Kuoppala, E.T., Leppamaki, E.A., 2000. Catalytic conversion of biomass pyrolysis vapours with zinc oxide. J. Anal. Appl. Pyrol. 55,119–131.
- Ogada, T., Werther, J., 1996. Combustion characteristics of wet sludge in a fluidised bed, release and combustion of the volatiles. Fuel 75(5), 617–626.
- Oasmaa, A., Czernik, S., 1999. Fuel oil quality of biomass pyrolysis oils-state of the art for the end-users. Energy Fuels. 13, 914–921.
- Parida, K., Mishra, H. K., 1999. Catalytic ketonisation of acetic acid over modified zirconia 1. Effect of alkali-metal cations as promoter. J. Mol. Catal A 139, 73–80.
- Pengpanich, S., Meeyoo, V., Rirksomboon, T., Bunyakiat, K., 2002. Catalytic oxidation of methane over CeO₂-ZrO₂ mixed oxide solid solution catalysts prepared via urea hydrolysis. Appl. Catal. A: General 234, 221–233.
- Pindoria, R.V., Lim, J.-Y., Hawkes, J.E., 1997. Characterization of biomass pyrolysis tars/oils from eucalyptus wood wastes: effect of H₂ pressure and samples configuration. Fuel 76(11), 1013–1023.
- Pindoria, R.V., Megaritis, A., Herod, A.A., 1998. A two-stage fixed-bed reactor for direct hydrotreatment of volatiles from the hydrolysis of biomass: effect of catalyst temperature, pressure and catalyst ageing time on product characteristics. Fuel 77(15), 1715–1726.
- Piskorz, J., Radlein, D., Scott, D.S., 1986. On the mechanism of the rapid pyrolysis of cellulose. J. Anal. Appl. Pyrol. 9(2), 121–137.
- Radovic, L.R., Silva, I.F., Ume, J.I., Menéndez, J.A., León y León, C.A., Scaroni, A.W., 1997. An experimental and theoretical study of the adsorption of aromatics possessing electron-withdrawing and electron-donating functional groups by chemically modified activated carbons. Carbon 35, 13–49.
- Sailasuta, S., 2005. Thailand energy policy, APEC Symposium on Foresighting Future Fuel Technology, Chiangmai, Thailand.
http://www.apecforesight.org/apec_widedocs/future_fuel/chiangmai/ThailandEnergyPolicy.pdf.

- Sakata, Y., van Tol-Koutssal, C.A., Poncet, V., 1997. Selectivity problems in the catalytic deoxygenation of benzoic acid, journal of catalysis. Appl. Catal. A: General 169, 13-21.
- Sakata, Y., Poncet, V., 1998. Reduction of benzoic acid on CeO₂ and, the effect of additives, Appl. Catal. A: General 166, 173-184.
- Senol, O.I., Viljava, T.R., Krause, A.O.I., 2005. Hydrodeoxygenation of methyl esters. Catal Today 100(3-4), 331-335.
- Shen, L., Zhang, D.-K., 2003. An experimental study of oil recovery from sewage sludge by low-temperature pyrolysis in a fluidised-bed. Fuel 82(4), 465-472.
- Shihadeh, A., Hochgreb, S., 2002. Impact of biomass pyrolysis oil process conditions on ignition delay in compression ignition engines. Energ. Fuels 16, 552-561.
- Scholze, B., Meier, D., 2001. Characterization of the water-insoluble fraction from pyrolysis oil (pyrolytic lignin) Part I. PY-GC/MS, FTIR, and functional groups. J. Anal. Appl. Pyrol. 60, 41-54.
- Scott, S.A., Denis, J.S., Davidson, J.F., Hayhurst, A.N., 2006. Thermogravimetric analysis measurements of the kinetics of pyrolysis of dried sewage sludge. Fuel 85, 1248-1253.
- Stassen, H.E., 1995. Small-Scale Biomass Gasifiers for Heat and Power. Washington, D.C.: The World Bank.
- Speight, J.G., 1994. The Chemistry and Technology of Coal. New York: Marcel-Dekker.
- Splithoff, H., Hein, K.R.G., 1998. Effect of co-combustion of biomass on emissions in pulverized fuel furnaces. Fuel Process. Technol. 54, 189-205.
- Takanabe, K., Aika, K., Seshan, K., 2004. Sustainable hydrogen from bio-oil-steam reforming of acetic acid as a model oxygenate. J. Catal. 227, 101-108.
- Thipkhunthod, P., Meeyoo, V., Rangsunvigit, P., Kitiyanan, B., Siemanond, K., Rirksomboon, T., 2006. Pyrolytic characteristics of sewage sludge. Chemosphere 64, 955-962.
- Vesilind, P.A., Ramsey, T.B., 1996. Effect of drying temperature on the fuel value of wastewater sludge. Wastewater Manag. Res. 14, 189-196.
- Vitolo, S., Bresci, B., Seggiani, M., Gallo, M.G., 2001. Catalytic upgrading of pyrolytic oils over HZSM-5 zeolite: behaviour of the catalyst when used in repeated upgrading-regenerating cycles. Fuel 80(1), 17-26.

- Wang, D., Czernik, S., Montane, D., 1997. Biomass to hydrogen via pyrolysis and catalytic steam reforming of the pyrolysis oil and its fractions. Ind. Eng. Chem. Res. 36, 1507–18.
- Wang, D., Czernik, S., Chornet, E., 1998. Production of hydrogen from biomass by catalytic steam reforming of fast pyrolytic oils. Energ. Fuel 12, 19–24.
- Wang, S.R., Luo, Z.Y., Tan, H, 2004. The analyses of characteristics biooil produced from biomass flash pyrolysis. J. Eng. Thermophys. 25(6), 1049–52.
- Werther, J., Ogada, T., 1999. Sewage sludge combustion. Prog. Energ. Combust.,Sci. 25, 55–116.
- Yaman, S., 2004. Pyrolysis of biomass to produce fuels and chemical feedstock. Energ. Conserv. Manag. 45, 651-671.

CURRICULUM VITAE



Name: Mr. Charothon Ung-jinda (Jindarom)

Date of Birth: April 17, 1981

Nationality: Thai

University Education:

1998-2002 Bachelor Degree of Chemical Engineering, Faculty of Engineering, King Mongkut's University of Technology Thonburi, Bangkok, Thailand (1st Class Honor/ Medalist)

2002-2009 Doctor of Philosophy in Petrochemical Technology, The Petroleum and Petrochemical College, Chulalongkorn University, Bangkok Thailand

Publications and publishable papers:

1. Jindarom, C., Meeyoo, V., Rirksomboon, T. and Rangsunvigit, P. (2007) Thermochemical Decomposition of Sewage Sludge in CO₂ and N₂ atmosphere, Chemosphere, 67, 1477-1484.
2. Jindarom, C., Meeyoo, V., Kitiyanan, B., Rirksomboon, T. and Rangsunvigit, P. (2007) Surface Characterization and Dye Adsorptive Capacities of Char obtained from Pyrolysis/Gasification of Sewage Sludge, Chemical Engineering Journal, 133, 239-246
3. Ung-jinda, C., Meeyoo, V., Rirksomboon, T. and Rangsunvigit, P., Characterization of products derived from the pyrolysis of different raw materials (Submitted to Chemical Engineering Journal).
4. Ung-jinda, C., Meeyoo, V., Kitiyanan, B., Rirksomboon, T. and Rangsunvigit, P. Reactivity study of obtained char from the thermal decomposition of sewage sludge under N₂ and CO₂ atmosphere, (Submitted to Fuel).
5. Ung-jinda, C., Meeyoo, V., Kitiyanan, B., Rirksomboon, T. and Rangsunvigit, R. Catalytic Deoxygenation of Oleic Acid over Ceria-Zirconia Catalysts, (Submitted to Catalysis Communications).

Proceedings:

1. Jindarom, C., Meeyoo, V., Rangsunvigit, P., Siemanond, K., Kitiyanan, B. and Rirksomboon T. (2004) The Production of Bio-oil by Oxidative Pyrolysis of

Sewage Sludge in Rotating Fixed Bed Reactor, Proc. of the Joint International Conference on Sustainable Energy and Environment - SEE, Cha-am, Thailand.

2. Jindarom, C., Meeyoo, V., Rangsunvigit, P., Siemanond, K., Kitiyanan, B. and Rirksomboon T. (2004) Proc. of Annual Conference of the Thai Institute of Chemical Engineering and Applied Chemistry (TIChE), Bangkok, Thailand.

Presentations:

1. Jindarom, C., Meeyoo, V., Rangsunvigit, P., Siemanond, K., Kitiyanan, B. and Rirksomboon T. (2006) Pyrolysis/Gasification of Sewage Sludge: Effect of CO₂ on the Products Yields and Their Characteristics, 17th International Symposium on Analytical and Applied Pyrolysis, Budapest, Hungary.
2. Jindarom, C., Cheewasukthaworn, W., Kitiyanan, B., Rangsunvigit, P., Meeyoo, V., Rirksomboon, and Schwank, J. (2006) Catalytic Pyrolysis of Cellulose under Carbon Dioxide Atmosphere, 17th International Symposium on Analytical and Applied Pyrolysis, Budapest, Hungary.