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To whom it may concern;

I hereby certify that the matters noted below are all true.

Koyo Norinaga

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CURRICULUM VITAE

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EDUCATION

- B.E. in Applied Chemistry, Faculty of Engineering, Hokkaido University, Sapporo 1994
- M.E. in Chemical Engineering, Hokkaido University, Sapporo 1996
- Ph.D. in Chemical Engineering, Hokkaido University, Sapporo 1999

RESEARCH POSITIONS

- Research Associate, Institute of Multidisciplinary Research for Advanced Materials, **Tohoku University**, 1999–2002. (Research Group Prof Masashi Iino)
- Alexander von Humboldt Fellow, Institute for Chemical Technology and Polymerchemistry, **Karlsruhe University**, 2002–2004. (Research Group Prof Klaus J Hüttinger)
- Senior Scientist, Institute for Chemical Technology and Polymerchemistry, **Karlsruhe University**, 2004–2006. (Research Group Prof Olaf Deutschmann)
- Associate Professor, Center for Advanced Research of Energy Conversion Materials, **Hokkaido University**, 2006–2009.(Research Group Prof Jun-ichiro Hayashi)
- Associate Professor, Institute for Materials Chemistry and Engineering, **Kyushu University**, 2009–2017
- Professor, Department of Chemical Systems Engineering, Graduate School of Engineering, **Nagoya University**, 2017–
- **Director, Institute of Materials Innovation (*i*-MI), Nagoya University, 2018–**

HONORS

- **2000** Awarded from American Chemical Society. Selected as an Editor's Choice Article for demonstrating the quality and impact of the *Energy and Fuels*.
- **2002** Alexander von Humboldt Foundation Fellowship
- **2010** Best paper award, Second International Symposium on Gasification and Its Application（iSGA2010）
  "Coproduction of Clean Syngas and Iron from Woody Biomass and Natural Goethite Ore"
- **2011** Award from Foundation for Steel and Environmental Protection Technology (Public Interest Incorporated Foundation) "Hydrogen production by coke oven gas reforming"
- **2012** Japan Institute of Energy Award for Distinguished Young Researchers.
  "Chemistry and kinetics of hydrocarbon pyrolysis"
- **2014** The best poster presentation award
  The 23rd International Symposium on Chemical Reaction Engineering (ISCRE 23)
  "Detailed Chemical Kinetic Modeling of In-Situ Thermal Reforming of Volatiles Derived from Fast Pyrolysis of Lignocellulosic Biomass"
- **2015** The distinguished paper award from The Japan Institute of Energy "Chemical Structures and Primary Pyrolysis Characteristics of Lignins Obtained from Different Preparation Methods"
- **2016** The distinguished paper award from The Japan Institute of Energy "Numerical study on steam reforming of biomass tar using detailed chemical kinetic model"

CURRENT RESEARCH INTERESTS

- Elementary reactions based kinetic modeling for the complex reaction systems including biomass thermochemical conversions.
- Integration of chemical kinetic model with the flow and heat transfer models for predicting phenomena in chemical reactors.
- Catalytic process for upgrading low rank solid fuels such as biomass and brown coal.
- Physical and chemical properties of heavy carbonaceous resources and their relations to reactivity.
- CO_2 separation with low energy consumption and industrialization of CO_2 utilization process.
- First principle based estimations for the reaction rates of biomass and coal related molecules.

PUBLICATIONS in the last 5 years

(1) Lin, Y.; Yang, C.; Choi, C.; Zhang, W.; Machida, H.; Norinaga, K. Lattice Boltzmann Simulation of Multicomponent Reaction-Diffusion and Coke Formation in a Catalyst with Hierarchical Pore Structure for Dry Reforming of Methane. *Chem. Eng. Sci.* **2021**, *229*, 116105.

(2) Machida, H.; Esaki, T.; Yamaguchi, T.; Norinaga, K. Energy-Saving CO2 Capture by H2 Gas Stripping for Integrating CO2 Separation and Conversion Processes. *ACS Sustain. Chem. Eng.* **2020**, *8* (23), 8732–8740.

(3) Sato, M.; Tran, K. V. B.; Yamaguchi, T.; Machida, H.; Norinaga, K. Online Composition Analysis of Phase Separation Solvent for Carbon Dioxide Capture Using ATR-FT-IR. *J. Adv. Manuf. Process.* **2020**, *2* (4), e10067.

(4) Nakaoka, M.; Tran, K. V. B.; Yanase, K.; Machida, H.; Norinaga, K. Prediction of Phase Behavior of CO2 Absorbents Using Conductor-like Screening Model for Real Solvents (COSMO-RS): An Approach to Identify Phase Separation Solvents of Amine/Ether/Water Systems upon CO2 Absorption. *Ind. Eng. Chem. Res.* **2020**, *59* (42), 19020–19029.

(5) Esaki, T.; Machida, H.; Norinaga, K. Rate of CO2 Absorption of a Phase-Separation Absorbent. *J. Adv. Manuf. Process.* **2020**, *2* (1), e10033.

(6) Zhang, W.; Machida, H.; Takano, H.; Izumiya, K.; Norinaga, K. Computational Fluid Dynamics Simulation of CO2 Methanation in a Shell-and-Tube Reactor with Multi-Region Conjugate Heat Transfer. *Chem. Eng. Sci.* **2020**, *211*.

(7) Tran, K. V. B.; Ando, R.; Yamaguchi, T.; Machida, H.; Norinaga, K. Carbon Dioxide Absorption Heat in Liquid-Liquid and Solid-Liquid Phase-Change Solvents Using Continuous Calorimetry. *Ind. Eng. Chem. Res.* **2020**, *59* (8), 3475–3484.

(8) Fukuoka, T.; Takeda, N.; Zhang, L.; Machida, H.; Zhang, W.; Watanabe, M.; Nishibata, Y.; Hayashi, J. I.; Norinaga, K. Quantitative Analyses of Chemical Structural Change and Gas Generation Profile of Coal upon Heating toward Gaining New Insights for Coal Pyrolysis Chemistry. *ISIJ Int.* **2019**, *59* (8), 1376–1381.

(9) Matoba, M.; Kudo, S.; Mori, A.; Norinaga, K.; Uchida, K.; Dohi, Y.; Uebo, K.; Hayashi, J. I. Production of High-Strength Cokes from Non-/Slightly Caking Coals. Part I: Effects of Coal Pretreatment and Variables for Briquetting and Carbonization on Coke Properties. *ISIJ Int.* **2019**, *59* (8), 1440–1448.

(10) Uchida, K.; Kudo, S.; Mori, A.; Ashik, U. P. M.; Norinaga, K.; Dohi, Y.; Uebo, K.; Hayashi, J. I. Production of High-Strength Cokes from Non- And Slightly Caking Coals. Part II: Application of Sequence of Fine Pulverization of Coal, Briquetting and Carbonization to Single Coals and Binary Blends. *ISIJ Int.* **2019**, *59* (8), 1449–1456.

(11) Halim, N.; Ashik, U. P. M.; Gao, X.; Kudo, S.; Sanwani, E.; Norinaga, K.; Hayashi, J. I. Quantitative Description of Catalysis of Inherent Metallic Species in Lignite Char during CO2 Gasification. *Energy and Fuels* **2019**, *33* (7), 5996–6007.

(12) Machida, H.; Ando, R.; Esaki, T.; Yamaguchi, T.; Norinaga, K. Modelling of CO2 Solubility in Phase Separation Solvent Composed of Amine/Ether/Water System for CO2 Capture. *J. Mol. Liq.* **2019**, *292*.

(13) Zahara, Z. F.; Kudo, S.; Daniyanto; Ashik, U. P. M.; Norinaga, K.; Budiman, A.; Hayashi, J. I. CO2 Gasification of Sugar Cane Bagasse: Quantitative Understanding of Kinetics and Catalytic Roles of Inherent Metallic Species. *Energy and Fuels* **2018**, *32* (4), 4255–4268.

(14) Kudo, S.; Mori, A.; Hayashi, G.; Yoshida, T.; Okuyama, N.; Norinaga, K.; Hayashi, J. I. Characteristic Properties of Lignite to Be Converted to High-Strength Coke by Hot Briquetting and Carbonization. *Energy and Fuels* **2018**, *32* (4), 4364–4371.

(15) Tang, Z.; Li, A.; Hatakeyama, T.; Shuto, H.; Hayashi, J. ichiro; Norinaga, K. Transient Three-Dimensional Simulation of Densification Process of Carbon Fibre Preforms via Chemical Vapour Infiltration of Carbon Matrix from Methane. *Chem. Eng. Sci.* **2018**, *176*, 107–115.

(16) Zhang, L.; Qi, S.; Takeda, N.; Kudo, S.; Hayashi, J.; Norinaga, K. Characteristics of Gas Evolution Profiles during Coal Pyrolysis and Its Relation with the Variation of Functional Groups. *Int. J. Coal Sci. Technol.* **2018**, *5* (4), 452–463.

(17) Furutani, Y.; Dohara, Y.; Kudo, S.; Hayashi, J. I.; Norinaga, K. Theoretical Study on Elementary Reaction Steps in Thermal Decomposition Processes of Syringol-Type Monolignol Compounds. *J. Phys. Chem. A* **2018**, *122* (3), 822–831.

(18) Furutani, Y.; Dohara, Y.; Kudo, S.; Hayashi, J. I.; Norinaga, K. Computational Study on the Thermal Decomposition of Phenol-Type Monolignols. *Int. J. Chem. Kinet.* **2018**, *50* (4), 304–316.

(19) Yang, H.; Norinaga, K.; Li, J.; Zhu, W.; Wang, H. Effects of HZSM-5 on Volatile Products Obtained from the Fast Pyrolysis of Lignin and Model Compounds. *Fuel Process. Technol.* **2018**, *181*, 207–214.

(20) Furutani, Y.; Kudo, S.; Hayashi, J. ichiro; Norinaga, K. Predicting Molecular Composition of Primary Product Derived from Fast Pyrolysis of Lignin with Semi-Detailed Kinetic Model. *Fuel* **2018**, *212*, 515–522.

(21) Yu, P.; Norinaga, K.; Watanabe, H.; Kitagawa, T. Prediction of Hot Coke Oven Gas Reforming by LES Coupled with the Extended Flamelet/Progress Variable Approach. *Fuel* **2018**, *231*, 234–243.

(22) Zhang, L.; Qi, S. C.; Iwanaga, K.; Uemura, K.; Zhang, L. X.; Kudo, S.; Hayashi, J. ichiro; Furuya, K.; Norinaga, K. An Approach for On-Line Analysis of Multi-Component Volatiles from Coal Pyrolysis with Li+-Attachment Ionization Mass Spectrometry. *Fuel Process. Technol.* **2017**, *158*, 141–145.

(23) Qi, S. C.; Zhang, L.; Einaga, H.; Kudo, S.; Norinaga, K.; Hayashi, J. ichiro. Nano-Sized Nickel Catalyst for Deep Hydrogenation of Lignin Monomers and First-Principles Insight into the Catalyst Preparation. *J. Mater. Chem. A* **2017**, *5* (8), 3948–3965.

(24) Kudo, S.; Goto, N.; Sperry, J.; Norinaga, K.; Hayashi, J. I. Production of Levoglucosenone and Dihydrolevoglucosenone by Catalytic Reforming of Volatiles from Cellulose Pyrolysis Using Supported Ionic Liquid Phase. *ACS Sustain. Chem. Eng.* **2017**, *5* (1), 1132–1140.

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(26) Qi, S. C.; Zhang, L.; Kudo, S.; Norinaga, K.; Hayashi, J. I. Theoretical Study on Hydrogenolytic Cleavage of Intermonomer Linkages in Lignin. *J. Phys. Chem. A* **2017**, *121* (15), 2868–2877.

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(35) Appari, S.; Tanaka, R.; Li, C.; Kudo, S.; Hayashi, J. ichiro; Janardhanan, V. M.; Watanabe, H.; Norinaga, K. Predicting the Temperature and Reactant Concentration Profiles of Reacting Flow in the Partial Oxidation of Hot Coke Oven Gas Using Detailed Chemistry and a One-Dimensional Flow Model. *Chem. Eng. J.* **2015**, *266*, 82–90.

(36) Thimthong, N.; Appari, S.; Tanaka, R.; Iwanaga, K.; Kudo, S.; Hayashi, J. I.; Shoji, T.; Norinaga, K. Kinetic Modeling of Non-Catalytic Partial Oxidation of Nascent Volatiles Derived from Fast Pyrolysis of Woody Biomass with Detailed Chemistry. *Fuel Process. Technol.* **2015**, *134*, 159–167.

(37) Li, C. Y.; Appari, S.; Zhang, L. X.; Huang, A. N.; Kuo, H. P.; Kudo, S.; Hayashi, J. I.; Norinaga, K. Modeling of Gas/Particle Flow in Coal Conversion with a Drop Tube Reactor Using a Lumped Kinetic Model Accounting Volatiles-Char Interaction. *Fuel Process. Technol.* **2015**, *138*, 588–594.

(38) Yang, H. M.; Zhao, W.; Norinaga, K.; Fang, J. J.; Wang, Y. G.; Zong, Z. M.; Wei, X. Y. Separation of Phenols and Ketones from Bio-Oil Produced from Ethanolysis of Wheat Stalk. *Sep. Purif. Technol.* **2015**, *152*, 238–245.

(39) Karnowo; Kudo, S.; Mori, A.; Zahara, Z. F.; Norinaga, K.; Hayashi, J. I. Modification of Reactivity and Strength of Formed Coke from Victorian Lignite by Leaching of Metallic Species. *ISIJ Int.* **2015**, *55* (4), 765–774.

(40) Uemura, K.; Appari, S.; Kudo, S.; Hayashi, J. I.; Einaga, H.; Norinaga, K. In-Situ Reforming of the Volatiles from Fast Pyrolysis of Ligno-Cellulosic Biomass over Zeolite Catalysts for Aromatic Compound Production. *Fuel Process. Technol.* **2015**, *136*, 73–78.

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Koyo Norinaga's publication records can be found at;

Google scholar
https://scholar.google.co.jp/citations?user=w4h8MygAAAAJ&hl=ja

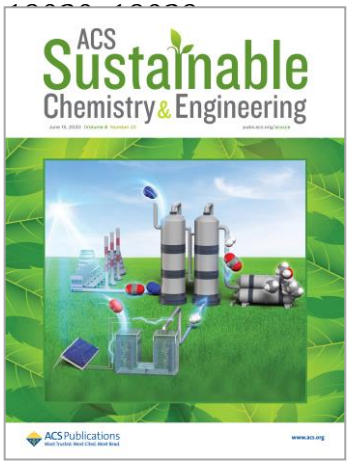
Scopus
https://www.scopus.com/authid/detail.uri?authorId=7003414097

Researcher ID
http://www.researcherid.com/rid/A-2597-2010

Journal cover

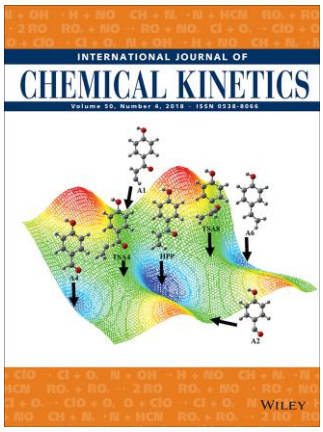
2020

Nakaoka, M.; Tran, K. V. B.; Yanase, K.; Machida, H.; Norinaga, K. Prediction of Phase Behavior of CO2 Absorbents Using Conductor-like Screening Model for Real Solvents (COSMO-RS): An Approach to Identify Phase Separation Solvents of Amine/Ether/Water Systems upon CO2 Absorption. *Ind. Eng. Chem. Res.* **2020**, *59* (42),



Machida, H.; Esaki, T.; Yamaguchi, T.; Norinaga, K. Energy-Saving CO2 Capture by H2 Gas Stripping for Integrating CO2 Separation and Conversion Processes. *ACS Sustain. Chem. Eng.* **2020**, *8* (23), 8732–8740.

2018



Furutani, Y.; Dohara, Y.; Kudo, S.; Hayashi, J. I.; Norinaga, K. Computational Study on the Thermal Decomposition of Phenol-Type Monolignols. *Int. J. Chem. Kinet.* **2018**, *50* (4), 304–316.