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Pimpinan Universitas Katolik Widya Mandala Surabaya dengan ini menugaskan:

No.	Nama	Judul Makalah
1.	Aning Ayucitra, ST., M.Eng.Sc. <----- Felycia Edi Soetaredjo, ST., M.Phil.	*Solvent Free Acetylation of Sago Starch*
2.	Suryadi Ismadji, Ph.D.	*Incorporation of Fractional Surface Coverage on Extended Langmuir Isotherm: Binary Adsorption of Evans Blue and Malachite Green onto Organo-Bentonite*
3.	Felycia Edi Soetaredjo, ST., M.Phil. Suryadi Ismadji, Ph.D.	• *Removal of Lead (II) and Copper (II) Heavy Metals from Binary Mixture Using Rice Straw Wastes as Biosorbent* • *Density Based Modeling of Epicatechin Solubility in Supercritical Carbon Dioxide Fluid*

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PREFACE

The Regional Symposium on Chemical Engineering (RSCE) has become an important annual forum for academicians, researchers and professionals from both public and private organizations in the South East Asia and the Asia-Pacific regions. It is organized to serve as venue to exchange knowledge and information of relevance to the chemical engineering.

The committee received 282 abstracts and accepted around 230 papers in which around 170 papers came from aboard such as Japan, Taiwan, Korea, Malaysia, Thailand, and Australia, Philiphine, Vietnam, Saudi Arabia. All the papers have been reviewed with the help of experts in the areas.

The topics are classified into Chemical Reaction Engineering, New and Renewable Energy Technology, Fossil Fuel Technology, Polymer and Petrochemical Technology, Process Design and Control, Process Intensification, Separation and Purification Technology, Material Science and Technology, Food Science and Technology, Environmental and Science Technology, Transport Phenomena, Biochemical Engineering and Thermodynamics.

We wish to thank reviewers, plenary speakers, keynote speakers, and session moderators for their cooperation and valuable suggestions. We would like to extend our appreciation to members of organizing committees, International and National Scientific Committees for their valuable help and support.

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Dr. Ir. Tontowi Ismail
Prof. Dr. Ir. Ali Altway, MS
Minta Yuwana

CONTENTS

A-03 Extraction of Rice Bran Oil Using Limonene: A Mathematical Model for Rice Bran Oil Uptake
Teguh Ariyanto, Imam Prasetyo, and Ragaguci
Chemical Engineering DepartmentUniversitas Gadjah Mada, Yogyakarta 55281 Indonesia

A-04 Marine Biomass as a Source of Biorefinery
Jong Moon Park, Kyung A Jung, Seong-Rin Lim and Hong Soon Rhee
Advanced Environmental Biotechnology Research Center, Department of ChemicalEngineering, School of Environmental Science and Engineering, Division of Advanced NuclearEngineering, POSTECH, Pohang 790-784, South Korea
Department of Environmental Engineering, Kangwon National University, Chuncheon 200-701, South Korea
Samsung Advanced Institute of Technology, Suwon 440-600, South Korea

A-05 Storage of Methane by Using Water-Saturated Nanoporous Carbon
Imam Prasetyo, Budhijanto, Rochmadi, Rakhmat Yunanto, and Teguh Ariyanto
Department of Chemical Engineering, Gajah Mada University, Yogyakarta 55281, Indonesia

A-06 Self-ignition tendency of upgraded products obtained by a solvent treatment of low rank coals
Hiroyasu Fujitsuka, Ryuichi Ashida, and Kouichi Miura
Department of Chemical Engineering, Kyoto University,Katsura, Nishikyo-ku, 615-8510, JAPAN

A-07 Adsorption Behavior of Caffeine on Persimmon Tannin Gel Prepared by Autoxidation
La Ode Ahmad, Le Hoang My Linh, Mio Akimoto, Yusuke Kaneki, Mitsunori Honda, Mitsuhiro Suda, Ko-Ki Kunimoto
Graduate School of Natural Science and Technology, Kanazawa UniversityKakuma-machi, Kanazawa 920-1192, Japan

A-08 Fouling studies and Phenol Removal potential during Ultrafiltration of Palm Oil Mill Effluent (POME)
Muhammad Said, Abdul Wahab Mohammad
Department of Chemical and Process Engineering, Faculty of Engineering and Built Environment,
University of Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

A-09 Synthesis and Characterization of Phosphorylated and Acetylated Hanjeli (*Coix lacryma-jobi* L.) Starch for Food Thickener Applications
Asaf K. Sugih, Henky Muljana, Andi N. Alamsyah, Christine Saputra, Friska G. Mandalas

Department of Chemical Engineering, Parahyangan Catholic University,Jl. Ciumbuleuit 94, Bandung 40141 Indonesia
Indonesian Center for Agricultural Postharvest Research and Development (ICAPOSTRD)Jl. Tentara Pelajar 12 Cimanggu, Bogor 16111 Indonesia

A-10 Thin-Layer Analysis and Modelling of the Drying of Coconut Meat in a Fluidized Bed Dryer
Bernhard S. Valenzuela, Wilfredo I. Jose, Ph.D.
College of Engineering Graduate ProgramUniversity of the Philippines, Diliman, Quezon City, 1101 PhilippinesDepartment of Chemical Engineering,
College of EngineeringUniversity of the Philippines, Diliman, Quezon City, 1101 Philippines

A-11 Characterization of Bio-oil from Oil Palm Kernel Shell by Microwave Pyrolysis
Hafizah Afif, Yoshimitsu Uemura, Noridah Osman and Kaoru Onoe
Department of Chemical Engineering, Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750, Tronoh, Perak, Malaysia
Department of Life and Environmental Sciences, Chiba Institute of Technology, Japan

A-12 Concentrations of Acetic Acid and Phenol in Bio-oil Derived from Palm Kernel Shell Using Fluidized Bed Pyrolyzer
Norizan Ali, Yoshimitsu Uemura, Noridah Osman, Wissam Omar, and Toshio Tsutsui
Centre for Biofuel and Biochemical Research, Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750Tronoh, Perak, Malaysia
Department of Chemical Engineering, Faculty of Engineering, Kagoshima University, 1-21-40 Korimoto, Kagoshima 890-0065, Japan

A-13 Production of Green Hydrogen by Reaction of Aluminum and Water
Masatoshi Sugioka, Kazuyuki Higashino, Yoshio Uemichi and Yasuharu Kanda
Graduate School of Engineering, Muroran Institute of Technology, 27-1 Mizumoto,Muroran 050-8585, Japan

A-14 Hydrogel Based on Glutaraldehyde-Crosslinked Kappa Carrageenan:
Effect of Glutaraldehyde Concentration
Sperisa Distantina, Rochmadi, Mohammad Fahrurrozi, and Wiratni
Chemical Engineering Department, Gadjah Mada University, Jl. Grafika 2 Yogyakarta 55281,Indonesia
Chemical Engineering Department, Sebelas Maret University, Jl. Ir. Sutami 36 A Surakarta 57126,Indonesia

A-15 Solvent Free Acetylation of Sago Starch
Aning Ayucitra and Felycia Edi Soetaredjo
Department of Chemical Engineering, Widya Mandala Surabaya Catholic University, Kalijudan 37,Surabaya 60114, Indonesia

A-16 Research on biological activity of some extractsfrom Vietnamese *Carica papaya* leaves

Do Thi Hoa Vien, Phung Thi Thuy
School of Biotechnology and Food TechnologyHanoi University of Science andTechnology, 1 - Dai Co Viet, Hanoi, Vietnam

A-17 Potentiality of Citrus Pectin from Pomelo (*Citrus Grandis*) Wastesin Cu^{2+} Biosorption

Aries A. Arcega, Maria Lourdes P. Dalida, Virluz P. Laguerta, Lorielyn P. Marquez, Elisa D.Gutierrez, Anita P. Aquino
Department of Chemical Engineering, University of the Philippines Diliman, Quezon City 1101,Philippines
Chemical and Food Engineering Department, Batangas State University, Batangas City 4200,Philippines
Science Department, Batangas State University, Batangas City 4200, Philippines

A-18 Isolation and Physicochemical Properties of Starches from Vietnamese*Limnophila aromatica*

Quy Diem Do, Lien Huong Huynh and Yi-Hsu Ju
Department of Chemical Engineering, National Taiwan University of Science and Technology, 43 Sec.4,Keelung Road, Taipei 106-07, Taiwan.
Department of Chemical Engineering, Can Tho University, 3-2 Street, Can Tho City, Vietnam

A-19 Development of Biocoal from Waste of Tobacco Stem As a Source of an Alternative Energy

Suryo Purwono, Bardi Murachman, Joko Wintoko,Fitri Fathmawati Laksono, and Tri Setia Pratiwi
Department of Chemical EngineeringGadjah Mada University, Yogyakarta, Indonesia

A-20 Ozonolysis of Vegetable Oilfor Synthesis of Aeroplane Turbine Jet Fuel

Rahayu G. Siwi, Rio K. Prianantyo, Irwan Kurnia, Tatang H. Soerawidjaja and Tirto Prakoso
Department of Chemical Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia

A-21 Application of Capric-Lauric Acid with Methyl Salicylate as Phase Change Material Impregnated To Wallboards in a Miniature Sample Unit For Thermal Energy Storage Cooling Application

Antonietta Ramona L. Faronilo, Rachelle Ingrid S. Fiala, John Lester C. Lim, and Maria Natalia R. Dimaano
Department of Chemical Engineering and b Research Center for the Natural and Applied Sciences, University of Santo Tomas, España, Manila 1008, Philippines

A-22 The Kinetic Reacion Of Virgin Coconut Oil (Vco) Fermentation In An IdealBioreactor Tank In A Batch Process
Sri Redjeki1, Ely Kurniati
Departement of Chemical Engineering UPN "Veteran" East Java 60295, Indonesia

A-23 Fabrication of Electrospun Chitosan Nanofibers Treated by UV Irradiation
Cendy Kurniawan, Doan Van Hong Thien, and Ming-Hua Ho
Department of Chemical Engineering National Taiwan University of Science and Technology, Taipei 10607 Taiwan
Department of Chemical EngineeringCan Tho University, Can Tho City, Vietnam

A-24 Production of Laccase by *Marasmius* sp. Grown in Rice Straw using a Packed Bed Bioreactor
Hendro Risdianto, Maya Fitriyantia, Sri Harjati Suhardi, Yogi W. Budhi and Tjandra Setiadi
Department of Chemical Engineering Faculty of Industrial Technology, Institut Teknologi Bandung, Bandung 40132 Indonesia
Center for Pulp and Paper Ministry of Industry, Bandung 40258 Indonesia
School of Life Sciences and Technology Institut Teknologi Bandung, Bandung 40132 Indonesia

A-25 From Palm Oil Waste to Valuable Products:Microbial Production of Xylitol
M.T.A.P. Kresnowati, A.B. Ardina, and V.P. Oetomo
Microbiology and Bioprocess Technology Laboratory, Department of Chemical Engineering,Bandung Insitute of Technology, Indonesia

A-26 *In Situ* Production of Biodiesel from Copra Using Methanol and Methanol-Tetrahydrofuran Mixtures
Dinh S. Khanga, Luis F. Razon, Cynthia B. Fabian-Madrazo, Raymond R. Tan, Shiro Saka
Department of Chemical Engineering, De La Salle University, 2401 Taft Avenue, Manila 1004, Philippines
Grad. School of Energy Science, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501, Japan

A-27 Effects of Operating Conditions inBiodiesel Fuel Production from Plant Oils
Hiroaki Habaki, Tomoki Hayashi, Patima Sinthupinyo, and Ryuichi Egashira
Department of International Development Engineering,Tokyo Institute of Technology, 2-12-1, O-okayama, Meguro-ku, Tokyo 152-8550, Japan

A-28 Submerged fermentation of glucose by *Aspergillus niger* into gluconic acid
Maria Inggrid, Ign.Suharto, William Lisan, Edwin Suhady, Soeseno Hadi
Department of Chemical Engineering, Faculty of Industrial Technology, Parahyangan Caholic University, Jalan Ciumbuleuit 94-96, Bandung 40141, University of Padjadjaran, Bandung.

A-29 Coconut Oil Biodiesel as an Emulsifier in Diesel-Ethanol Blends for Diesel Engines

Tanti Ardiyati, Nathaniel P. Dugos, Susan A. Roces, Masaaki Suzuki, Kusnanto
Chemical Engineering DepartmentDe La Salle University, Manila 1004 The Philippines
Chemical Engineering DepartmentTokyo Institute of Technology, Tokyo Japan
Physics Engineering DepartmentGadjah Mada University, Yogyakarta 55281 Indonesia

A-30 Biofouling effect on membrane (PEM) in Microbial Fuel Cell: A review

Manal Ismail, Madihah Miskan, Darman Nordin, Mostafa Ghasemi
Fuel Cell Institute,The National University of Malaysia, 43600 Bangi, Selangor Malaysia
Department of Chemical & Process Engineering,Faculty of Engineering & Built Environment,The National University of Malaysia, 43600 Bangi, Selangor, Malaysia.

A-31 Study of Bioethanol Production from Liquid Waste of Bogasari Factory in Mini Plant Scale

Ni Ketut Sari, C. Pujiastuti
Department of Chemical Engineering, Faculty of Industrial Engineering, UPN "Veteran" East java

A-32 Biodiesel Production from Waste Edible Oil (WEO)Assisted by Microwave Heating

Amie Thant, Susan A. Roces, Florinda T. Bacani, Raymond R. Tan,Masatoshi Kubouchi and Piyachat Wattanachai
De La Salle University, Chemical Engineering Department, 2401 Taft Ave., 1200, Philippines
Tokyo Institute of Technology, Department of Chemical Engineering, 2-12-1, O-okayama, Meguro-Ku, Tokyo, 152-8552, Japan
Burapha University, Department of Chemical Engineering, T. Saensuk A. Muang, Chonburi 20131,Thailand

A-33 The Enhancement of waste cooking oil esterfication catalyzed by sulfated zirconia and assisted by the addition of silica gel

Agus Adhiatma, Chahyo Purbo Anshory, Agus Purwanto, and Wirawan Ciptonugroho
Department of Chemical Engineering, Sebelas Maret University, Jalan Ir.Sutami No 36A, Surakarta 57126, Indonesia

A-34 Using shell-core structural $Ca(C_3H_7O_3)_2$/CaO catalyst in Stirred-Packed Bed Reactor to Synthesize Biodiesel

Zih-Hua Li, Pei-Hsuan Lin, Jeffrey C. S. Wu

Department of Chemical Engineering National Taiwan University, Taipei 10617 Taiwan

A-35 Effect of Power Block Operating Strategies on the Efficiency of Integrated Gasification Combined-Cycle with CO_2 Capture
Hsiu-Mei Chiu, Po-Chuang Chen, and Yau-Pin Chyou
Chemistry Division, Institute of Nuclear Energy Research, Longtan 32546 Taiwan (R.O.C.)

A-36 Performance Prediction of Biomass Gasification in Fixed-Bed Gasifier Based on Selection Size and Shape of Biomass Particle
Dwi Hantoko, Muflih Arisa Adnan , and Sunu Herwi Pranolo
Department of Chemical Engineering, Sebelas Maret University, Surakarta 57126, Indonesia

A-37 Discussion of high-temperature desulfurization reaction parameters
Ching-Ying, Huang, Liang-Wei, Huang, Yau-Pin Chyou
Chemistry Division, Institute of Nuclear Energy Research, Longtan, Taoyuan 32546, Taiwan, R.O.C

A-38 Effects of vacuum drying on structural changes of banana slices
Wannapit Junlakan, Ram Yamsaengsung, and Supawan Tirawanichakul
Department of Chemical Engineering, Prince of Songkla University, Songkhla 90110 Thailand

A-39 Hydrogen Production in Steam Gasification of Japanese Cedar below 500 °C
Kenji Murakami, Takahiro Kato, and Katsuyasu Sugawara
Department of Engineering in Applied Chemistry, Faculty of Engineering and Resource Sience, Akita University, Akita 010-8502, Japan

A-40 Fabrication of Uniform, Non-crosstalking Closely Spaced Microsensors Array for Instantaneous Glutamate Detection
Wen-Chin Chan, Zheng-Lin Yu, Wei-Fan Lu, Tina T.-C. Tseng
Department of Chemical Engineering, National Taiwan University of Science and Technology, Taipei, 10607, Taiwan (R.O.C.)

A-41 Production of Metallurgical Coke from Low Rank Coal and/or BiomassWaste Utilizing Hot Press Pretreatment
Kazumi Iwase, Kyosuke Nakagawa, Ryuichi Ashida, and Kouichi Miura
Department of Chemical Engineering, Kyoto UniversityKyoto daigaku katsura, Nishikyo-ku, Kyoto 615-8510, Japan

A-42 Measurement of coal char gasification rate under high temperature andhigh pressure by a mini directly-heated reactor (mini-DHR)
Shunsuke Imai, Eiji Sasaoka, Ryuichi Ashida, and Koichi Miura

Department of Chemical Engineering, Kyoto UniversityKatsura, Nishikyo-ku, Kyoto 615-8510, Japan

A-43 Biodiesel production with heterogeneous catalystby conventional stirrer and static mixer
Paweetida Sungwornpatansakul, Yuuki Nigahara, Thumesha Kaushalya Jayasinghe,and Kunio Yoshikawa
Department of Environmental Science and Technology, Tokyo Institute of Technology4259 Nagatsuta, Midori-ku, Yokohama 226-8502, Japan

A-44 Selection of Gasification Technique for Processing Low Rank Coals as a Raw Material of Fertilizer Plant
Andri Wibawa Syarip, Nurhadi, and Herri Susanto
Department of Chemical Engineering, Institut Teknologi Bandung Jalan Ganesha 10,Bandung, Indonesia Research and Development Center for Mineral and Coal TechnologyJalan Sudirman 623, Bandung, Indonesia

A-45 Electrochemical Characterization of Proton-Exchange Membrane Fuel Cell (PEMFC) for Fuel Cell Vehicle Application
Aditya F. Arif, Hary Devianto, Isdiriayani M. Nurdin
Department of Chemical Engineering Institut Teknologi Bandung, Bandung 40132, Indonesia

A-46 Study on Reactor Configurations for Air/Steam Gasification of Sludge Cake to Produce Medium Heating Value Gas
Febryana Nugrahany, Nurani Galuh Safitri, Syamsudin and Herri Susanto
Chemical Engineering Department, Faculty of Industrial TechnologyInstitut Teknologi Bandung, Jl. Ganesha 10, Bandung 440132 Indonesia

A-47 Characterization of Sulfated Zirconia and Its Catalytic Activity for Esterification of Palm Fatty Acid Distillate
Dyah Retno Sawitri, Arif Hidayat, Sutijan, Kunio Yoshikawa, Arief Budiman
Department of Chemical Engineering, Faculty of Industrial Technology, Islamic University of Indonesia, Yogyakarta 55501 Indonesia
Department of Chemical Engineering, Faculty of Engineering, Gadjah Mada University, Yogyakarta 55281 Indonesia
Department of Environmental Science and Technology, Tokyo Institute of Technology, Yokohama, 226-8502 Japan

A-48 Effects of Fluxing Agents On Filter Aids Prepared From Lam-Dong Diatomite
Mai Thanh Phong, Tran Duy Hai, Phan Dinh Tuan
Faculty of Chemical Engineering, Ho Chi Minh City University of Technology 68 Ly Thuong Kiet Str., Dist. 10, Ho Chi Minh City

A-49 Role of Surface and Interaction Energies on Adhesion Mechanism of *P. aeruginosa*and *B. subtilis* on Stainless Steel

Ardiyan Harimawanand Yen-Peng Ting
Department of Chemical Engineering, Institut Teknologi Bandung Jalan Ganesha 10, Bandung 40132 Indonesia
Department of Chemical and Biomolecular Engineering, National University of Singapore 4 Engineering Drive 4, Singapore 117576

A-50 Evaluation on Potential Emissions of NOx and SOx in Utilization of SludgeCake as Alternative Energy Resources
Syamsudin and Herri Susanto
Chemical Engineering Department, Faculty of Industrial TechnologyInstitut Teknologi Bandung, Jl. Ganesha 10, Bandung 440132 Indonesia

A-51 Transesterification of Palm Oil in refluxed methanol with heterogeneous Base Catalyst
Nyoman Puspa Asri, Santi Diyah Savitri, Suprapto1, Kusno Budikarjono, Achmad Roesyadi
Chemical Engineering Department, Industrial Technology Faculty, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia, 60111
Chemical Engineering Department, Faculty of Engineering , WR. Supratman University, Surabaya, Indonesia, 60111

A-52 DFT-TDDFT Molecular Design of Innovated Dyesfor Dye-Sensitized Solar Cell (DSSC)
Fadlilatul Taufany, Huei-Tang Wang, Chieh-Yu Tseng, and Kuan-Hwa Lai¸Nachimuthu Santhanamoorthi¸ Jyh-Chiang Jiang,
Department of Chemical Engineering National Taiwan University of Science and Technology, Taipei 106 Taiwan
Department of Chemical Engineering Sepuluh Nopember Institute of Technology, Surabaya 60111 Indonesia

A-53 Repellent Activity of Bio-active Agent from Artocarpus camansi against Ae. Aegypti
Dianti HadiyoanA, Heni Anggorowati, Vikki Herawati, Arshita Wahyuning Atmoko, Dyah Retno Sawitri, Arif Hidayat
Chemical Engineering Department, Faculty of Industrial Technology, University of Islam IndonesiaJalan kaliurang km. 14,5 Yogyakarta

A-54 Rate of Transesterification of Model Feed Oil in Batch Stirred Vessel for Biodiesel Production
Tomoki Hayashia, Hiroaki Habakia, and Ryuichi Egashira
Department of International Development Engineering, Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo 152-8550 Japan

A-55 Synthesis of perovskite manganite magnetic fine particles by ultrasonic spray pyrolysis for self-controlled magnetic hyperthermia
Takamitsu Furuyabu, Ayako Yasuda, Takuya Kinoshita, and Motoaki Adachi

Department of Chemical EngineeringOsaka Prefecture University, 1-1 Gakuen-cho Naka-ku, Sakai, Osaka, Osaka 599-8531, Japan

A-56 A photoelectric biosensor based on bacteriorhodopsin and nanogolds
Kai-Ru Jheng and Hsiu-Mei Chen
Department of Chemical EngineeringNational Taiwan University of Science and Technology

A-57 Effect of Extraction Conditions on the Yield of Oil fromMicroalgae Nannochloropsis sp.
Ni'mah Ayu Lestari, M Hamzah Ismail, Arif Hidayat,Budi Setiadi Daryono, Arief Budiman
Chemical Engineering Department, Faculty of Engineering, Gadjah Mada University
Chemical Engineering Department, Faculty of Industrial Technology, University of Islam Indonesia
Genetics Laboratory, Faculty of Biology, Gadjah Mada University, Y ogyakarta 55281, Indonesia
Process System Engineering (PSE) research group, Chemical Engineering Department,Gadjah Mada University

A-58 Drying Curve Characteristics of Garlic (*Allium sativum* L.) Subjected toHigh Temperature – Short-Time (HTST) Vacuum Drying
Kristian July R. Yap, Marjorie L. Baynosa, Jerson M. Carullo, Daisy Grace B. Magbuhos,Jennifer T. Romero and Benjamin P. Villamin
Department of Chemical Engineering, University of the Philippines-Diliman, Quezon City 1101,Philippines

A-59 Effects of vacuum drying on structural changes of pineapple slices
Wannapit Junlakan, Ram Yamsaengsung, and Supawan Tirawanichakul
Department of Chemical Engineering, Prince of Songkla University, Songkhla 90110 Thailand

A-60 Assessment of Teak Wood Sawdust Gasification
Abdul Kadir Muhamad Jamal, Agnes Catur Adi Nugroho, and Sunu Herwi Pranolo
Departmen of Chemical Engineering, Sebelas Maret University, Surakarta 632112 Indonesia

A-61 Characterization of Palm Mesocarp Fiber after Torrefaction
Yoshimitsu Uemura, Muafah A. Aziz, Khalik M. Sabil
Center for Biofuel and Biochemical Research, Universiti Teknologi PETRONAS, 31750 Tronoh, Perak, Malaysia
Petroleum Engineering Department, Universiti Teknologi PETRONAS,31750 Tronoh, Perak, Malaysia

A-62 Green diesel production from hydrotreating of oleic acid over CoMo/γ-$Al2O_3$ and CoMoW/γ-$Al2O_3$ catalyst

Pongsatorn Jantharak, Worapon Kiatkittipong, Suwimol Wongsakulphasatch, Navadol Laosiripojana, Suttichai Assabumrungrat
Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok 10330 Thailand
Department of Chemical Engineering, Faculty of Engineering and Industrial Technology, Silpakorn University, Nakhon Pathom 73000, Thailand
The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok 10140, Thailand

A-63 Hydrodeoxygenation of methyl esterfor diesel-like hydrocarbon production

Cholada Laokittikul, Worapon Kiatkittipong, Suwimol Wongsakulphasatch, Navadol Laosiripojana, Suttichai Assabumrungrat
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Department of Chemical Engineering, Faculty of Engineering and Industrial Technology,Silpakorn University, Nakhon Pathom, 73000, Thailand
The Joint Graduate School of Energy and Environment,King Mongkut's University of Technology Thonburi, Bangkok 10140, Thailand

A-64 Effect of Heat Treatment on Doping Efficiency of Metal Oxide

Pramujo Widiatmoko,Yosuke Kondo, and Wuled Lenggoro
Graduate School of Bio-Applications and Systems Engineering,
Department of Chemical Engineering and Institute of Engineering, Tokyo University of Agriculture and Technology, Tokyo 184-8588, Japan
Department of Chemical Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia

A-65 Recombinant Protein Production by baculovirus-infected Insect Cells with Cost-Effectively Inhibiting Proteolytic Degradation

Takeshi Gotoh, Shindo Yuuki, Hiroki Ono, Saki Yokota, and Saori Takahashi
Department of Applied Chemistry, Graduate School of Engineering and ResourceScience,
Akita University, 1-1 Tegata Gakuen-cho, Akita 010-8502, Japan
Akita Research Institute of Food and Brewing, 4-26 Sanuki Arayamachi, Akita 010-1623, Japan

A-66 Synthesis and Characterization of Visible Light-Responsive Cu-doped $SrTiO_3$ Photocatalyst for Hydrogen Production

Kristine R. Tolod, Cyril Jose E. Bajamundi, Rizalinda L. de Leon, Ph.D, Paiboon Sreearunothai, Ph.D, Nurak Grisdanurak, Ph.D
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A-67 Sterilization of *Escherichia coli* in water using atmospheric inductivelycoupled plasma
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A-68 Co-processing of low rank coal/biomass-derived carbonaceous materialsand low-grade iron ore
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A-69 Carbon fibers preparation by low-molecular-weight extracts obtained from low-rank coal or biomass by degradative solvent extraction
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A-70 Performance of Gasifier Stove With Variety Biomass Fuels in Riau
Sri Helianty , Zulfansyah, Darwis Damanik and Rio Sunarya
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A-71 Impact of High Electric Field Pulses on Apple Juice Extraction
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A-72 Application of High Electric Field Pulses for Fermentation of Red Beet
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A-73 Kinetics of Catalytic Cracking From Oleic Acid to Liquid Biofuel
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A-74 Development ofAu/HZSM-5 Catalyst forProducingBiofuel

fromPalm Oil
Agus Budianto, Ignatius Gunardi, Achmad Roesyadi, Kusno Budhikarjono and Danawati Hari Prajitno
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A-75 The Effect of Vessel Metal Contact Surface Area onOxidation Stability of Jatropha Biodiesel
Rina Mariyana, Chikaya Sakai and Tirto Prakoso
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A-76 Liquid-Liquid Extraction In Packed Column Using *n-amyl alcohol* And *1-dodecanol* as Solvent to Separate Ethanol From Synthetic Broth
Tri Widjaja, Ali Altway, Setyo Gunawan, Achbarida Praba, and Ika Purwantiningsih
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A-77 Utilization of Hemicellulose in Rice Straw For Production of Biofuel
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A-78 Enzymatic Hydrolysis of Alkali-Pretreated Sugar Cane Bagasse ForProduction of Biofuel
Arief Widjaja, Timoteus Yuwono and Eduward Rolanda
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A-79 Size Reduction, Steaming and Enzymatic Hidrolysis Of Palm Oil Empty Fruit Bunch
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A-80 Integrated System for Underutilised Biomass Supply Chain
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A-81 Effect of Bread Yeast and Tempeh Yeast on Total Titrable acidity (TTA) and pH during Cassava Fermentation
Setiyo Gunawan, Ary Yusen Pratama, Rima Nur Febriani, Sri Rachmania Juliastuti, Tontowi Ismail, and Tri Widjaja
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A-82 Composition and Analysis of Calophyllum Inophyllum Seed and It's Oil
Setiyo Gunawan, Bayu Biru Chandra, Filan Setiawan, Mulyanto, Sri Rachmania Juliastuti, Arief Widjaja, Tri Widjaja
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A-83 In-Situ Production of Biodiesel from Rice Bran and Its Effect on Carbohydrate Recovery in Defatted Rice Bran
Siti Zullaikah, M. Rachimoellah, Sumarno and Tri Widjaja
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A-84 Biodiesel Production from Cottonseed Oil via Transesterification Method Using Cao as Catalyst
M. Rachimoellah, Siti Zullaikah, Romanus K. T. N., Yulia Tri R., Nidya Santoso and Ferdy Pradana
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A-85 Natrium Hydroxide (Naoh) As Alkaline Hydrolysis On Pretreatment Of Water Hyacinth (*EichorniaCrassipes)* As Raw Material In Biogas Production
Sri Rachmania Juliastuti, Nuniek Hendrianie, Jaka Abdillah, Gawa Reza Mahadin
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A-86 Agent-based Modeling of Visible Light-Driven Hydrogen Production
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B. Process System Engineering

B-01 Mathematical Modelling of a Solid Oxide Fuel Cell For The Thermal Modeling
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B-02 Thermal Conductivity Enhancement of Alumina Nanoparticles in an Aqueous [HMIM]LS Solution
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B-03 Discussion on Time Difference Models for Application of Soft Sensors
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B-04 A Statistical Approach for Selecting Control Components in Process Design
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B-05 The Treatment Of A Simulated Liquid Radioactive Waste Containing Tributyl Phosphate Using Ozone Followed By Adsorption
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B-06 PT Badak NGL Case: Optimum LNG Plant Operation
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B-07 PT Badak NGL Case : Optimization of Molecular Sieve Dehydration Regeneration
Dedik Rahmat Ermawan

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B-08 Process Failure Of The High Pressure Co_2 Stripper Urea Plant Pusri-IB
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B-09 Next Generation in Biomass Processing: Extraction Process and Depolymerization
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B-10 Henry's Constant Of Polar Solutes In Polymer Solutions
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B-11 Optimisation Of Ls54/Dx Aqueous Two Phase System Conditionsfor Cutinase Recovery
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B-12 Principal Component Analysis of Optimum Linear Estimator in Chemical Processing System
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B-13 State and Parameter Estimation of Large Scale Chemical Processing System
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B-14 A decision modeling approach to evaluate the climate change mitigation options in the Philippines

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B-15 Esterification of Phthalic Anhydride
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B-16 Optimization of Hydroxylation Reaction For Synthesis of Polyol FromEpoxidized Palm Oil Methyl Ester
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B-17 Design and Control of Alkali-Catalyzed Transesterification Reactors
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B-18 A Dynamic Model for Ultrasonic – Assisted Extraction of Bio-ActiveCompounds from Natural Products
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B-19 Study on Chemical Reaction Equilibrium of MethanolSynthesis in Liquid Phase
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B-20 Different Types of Observers Applied in Process Systems
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B-21 The Development of Pertamax Racing

Ery Gunarto, Murtina Dwi Lastuti
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B-22 Design and Control of Biodiesel Production in Esterification Section
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B-23 Dynamic Simulation the Influence of Gas Compressor Suction Pressure Controlto Improve Anti Surge Control System Performance in Two Stages CentrifugalGas Compression System
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B-24 Optimal Design Based RSM and ANN of High Vacuum Distillation for Beta-Carotene Recovery
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B-25 Dynamic Simulation of Optimization of Load Sharing Compressor and LinePacking Utilization
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B-26 Optimization Process of Biodiesel Production with Ultrasound Assisted by Using Central Composite Design Methods
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B-27 Dynamic Simulation and Control in A Non-Interacting-Tank System
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B-28 Technical and Economics study of biodiesel production by supercritical transesterification
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B-29 Modelling of Risk Assessment Using Layer of Protection Analysis (LOPA) on Enclosed Ground Flare at Onshore Facilities
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C. Chemical Engineering Fundamentals

C-01 Improvement of Antifouling Potential on Anion Exchange Membrane by Layer by Layer Deposition
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C-02 Effect of Coalescer Height to Oil Separation in Produced Water Using Gas Flotation Vessel Cell
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C-03 Comparison of Cutinase Separation in Different Chromatographic Media
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C-04 Hydrothermal Extraction of Valuable Compounds from Kikurage (*Auricularia auricula-judae*)
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C-05 *PVT* Properties for Mixtures of Ionic Liquid 1-Butyl-3-Methylimidazoliumbis(Trifluoromethylsulfonyl)imide[C_4mim][NTf_2]with Anisole
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C-06 CFD Simulation and ERT visualization of Gas-Liquid Oscillatory Flow in a Baffled Column
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C-07 A Study on The Application of Orange Peel Waste as Low Cost Biosorbent for Dye Removal
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C-08 Simple Extraction Method of Galanthamine from *Narcissus pseudonarcissus* bulbs
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C-09 Incorporation of Fractional Surface Coverage on Extended Langmuir Isotherm: Binary Adsorption of Evans Blue and Malachite Green onto Organo-Bentonite
Suryadi Ismadji, Alfin Kurniawan, and Hogiartha Sutiono
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C-10 Density Based Modeling of Epicatechin Solubility in Supercritical Carbon Dioxide Fluid
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C-11 Transesterification mechanism for PET recycle by molecular orbital method
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C-12 Kinetics of Amidation for The Synthesis of Diethanolamide From Methyl Ester and Diethanolamine by Using Sulfuric Acid Catalyst

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C-13 Effect of Agitation on the Metastable Zone, Nucleation and Growth of Struvite Crystals in a Batch Crystallizer
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C-14 Shock Loads and Revival of Activity after Shutdown in Single Stage Stirred Tank Anaerobic Reactors fed Continuously and Intermittently
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C-15 Bioproduct-Based Solvents for Dissolving Styrofoam and Comparison of its Solubility with Thermodynamic Model
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C-16 Isolation and Physicochemical Properties of Starches from Vietnamese Limnophila aromatic
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C-17 Mass Transfer of stevioside in stevia rebaudiana extraction
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C-18 Thermophysical Characterization of Glycol (DEG/TEG/T_4EG) + TRIS + Water: Measurements and Correlation
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C-19 Liquid-Liquid Equilibrium of Acetonitrile + Water in the Presence of Biological Buffer MOPS
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C-20 Analysis of Flux Decline during Microfiltration of Different Types of Feed
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C-21 The Use of Ion-Exchange Resin in The Production of Clean Biodiesel
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C-22 Co-solvent Selection for Supercritical Fluid Extraction of Essential Oil andBioactive Compounds from *Polygonum minus*
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C-23 Vegetable oil reforming for high-temperature PEMFCs
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C-24 Novel heterogeneous monolithic catalyst in biodiesel production: A review
Manal Ismail, Siti Rahayu Azman, Abdul Amir Hassan Kadhum, and Zahira Yaakob
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C-25 Comparison of Pyrolysis Products between Jatropha Curcas L Waste and Jatropha Curcas L Nut
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C-26 Enhancing CO2 Adsorption Using Strong Base Anion Exchange Resin
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C-27 Liquefaction of low-molecular-weight extracts obtained from low-rank coal and biomass by degradative solvent extraction under mild condition
Dedy Eka Priyanto, Xian Li, Ryuichi Ashida, Kouichi Miura
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C-28 Effect of Paraffins on Benzene Photocatalytic Oxidation of Clean Room in Semiconductor Fab
Yi-Ting Wu, Yi-Hui Yu, Jeffrey Chi-Sheng Wu, Angela Yu-Chen Lin, Luh-Maan Chang, and Ming-Hao Hsu
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C-29 Kinetic Evaluation of the Graft Copolymerization of Acrylic Acid onto Starch Based on Concentration Measurements and on Torque Observation
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C-30 Identification of Potential Dyesand Developing Methods to Improve Dye-sensitized Solar Cell's Efficiency
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C-31 Separation of Aromatic Hydrocarbons from Cracked Oils by Solvent Extraction
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C-32 Prediction of Solubilities of CO, H2 and Its Mixture in Various Solvents
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C-33 Optimizing Lipase Immobilization by Entrapment Method on Chitosan as Biocatalyst for Biodiesel Synthesis
Heri Hermansyah, Merisa Bestari Faiz, Intan Afridawaty Sipangkar and Renly James Yosua
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C-34 Miscibility Development Calculation in Model Oil Injection by Flare-Flue Gas Mixtures
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C-35 Adsorption of copper(II), cadmium(II) and zinc(II) ions by SDS-functionalized mesoporous silica
Wanchai Kaewprachum, Suwimol Wongsakulphasatch,Worapon Kiatkittipong, and Suttichai Assabumrungrat
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C-36 Dye Adsorption on Silica-filled ENR/PVC Beads
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C-37 Phase Behaviour Of CH_4-CO_2 Mixture in Cryogenic Heat Exchanger Process
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C-38 Optimization research into the ultrasonic-assisted extraction to separate polyphenol from green tea waste
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C-39 Kinetic Reaction Comparison of CO2 Absorption Into Promoted Potassium Carbonate (K2CO3)
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Chemical Engineering Department, ITS Surabaya Indonesia.

C-40 Supercritical CO2 Extraction and Micronization of Carotenoids
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C-41 Kinetic studies on the removal of reactive blue 19 and reactive yellow 145 by Putsan(tiwi) clay
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C-42 Activation of Mesoporous Carbon Synthesized from SBA-16 for CO2 Storage
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C-43 Transient Heat Transfer Analysis of Latent Heat Thermal Energy Storage System Using Phase Change Material
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C-44 A Review on CFD Modeling of Fluidization Bed Gas Phase Reactor For Polyolefin Production
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C-45 Growth of Carbon Nanotube from Banana Peel Activated Carbon with Simple Pyrolisis Methode and Methane Decomposition
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C-46 Mass Transfer Model for Basic Blue Adsorption onto Pillared Bentonite Clay by Taking Into Account the Intra Particle Concentration Gradient
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C-47 Removal of Terpenes from Citrus Oil Model Compounds with Supercritical CO_2 Fractionation
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C-48 Flow instabilitiesinAgitated Tanks withSide Entering Mixers
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C-49 A Computational Fluid Dynamics Study into Turbulent Characteristic that Affect the Combustion Process
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C-50 Liquid-Liquid Equilibria of Ternary System Eugenol + Isopropanol + Water at 303.15, 313.15, and 323.15 K
Zuhriyyah R.A, Rachma F., and Nur Andriani P.K , Kuswandi
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C-51 Bitumen Extraction from Asbuton Rock Using Pertasol
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D. Polymer, Petrochemical and Material Science and Technology

D-01 Investigation of Rice Husk Loading on The Characterization and Water Permeation of ENR/PVC Composite Membrane
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D-02 One step synthesis of hybrid single-wall carbon nanohorns with metallic nanoparticles using arc discharge in water with nitrogen gas injection
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D-03 PreparationofAmine-GraftedMesoporousMaterialMCM-48UsingGeothermalSolidWasteSilica
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D-04 Synthesis of Furfural from Locally Available Agricultural Residues in the Philippines
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D-05 Granulation of Organic and Inorganic Mixtures
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D-06 Thermal Compression Effects on Hybrid Poplar Wood: Lignin Analysis
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D-07 Preparation of CO Gas Sensor from WO_3 Nanomaterial Synthesized via Sol-Gel Method Followed by Calcination
Diah Susanti, A.A. Gede Pradnyana Diputra, Lucky Tananta, Hariyati Purwaningsih, George Endri Kusuma, Chen-Hao Wang, Shao-Ju Shih and Ying-Sheng Huang
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D-08 Green Synthesis of Zinc Oxide Nanoparticles via Simple Precipitation Method
Nur Hanis Hayati Hairoma, Abdul Wahab Mohammad
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Universiti Tun Hussein Onn Malaysia

D-09 Differential Scanning Calorimetry (DSC) analysis of PP/Organoclay Nanocomposites: Isothermal Crystallization Study
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D-10 Shape Memory Polymer Based on Benzoxazine-modifed Epoxy
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D-11 Highly Filled Graphite Based Benzoxazine Composites for an Application as Bipolar Plates in Fuel Cells
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D-12 Synthesis and Characterization of ZeoliteMonolith
by Ice-Templating and Steam-Assisted Crystallization
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D-13 Modeling of Gas Phase Propylene Polymerization in Fluidized Bed reactors Using Aspen Polymer Plus and Two Phase Models
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D-14 In-situ observation of convection and phase separation behavior under microwave radiation
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D-15 Production and Characterization of Polyethylene-Clay Nanocomposites through in situ Polymerization using Montmorillonite Supported Metallocene Catalyst
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D-16 Thermomechanical Properties of Kevlar^{TM} Reinforced Benzoxazine-Urethane Alloys
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D-17 Effectiveness of Tannin as Corrosion Inhibitor for Carbon Steel in Chloride Solutions
I.M. Nurdin, Stephanie, P.S. Ayudiani, W.K. Effendy, E.A. Pravasta
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D-18 Polymer Flooding for Improving Oil Recovery
Suryo Purwono, Bardi Murachman, Rochmadi, Wahyu Hasokowati, Dodi Irawan and Yudha Endriadi
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D-19 Evaluation of micro-catalytic reactor with *in situ* UV microscopy
Tomohiko TAGAWA, Lee Yi Fuan and Hiroshi YAMADA
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D-20 Innovation process and equipment in the traditional tempe industries without pollution
Ign. Suharto
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D-21 Fluorimetric Determination of Boron Levels in Semiconductor Cleanroom
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D-22 Bimodality Criterion for Sequence Length Distribution of Ethylene/1-olefin Copolymers
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D-23 Simulation of Morphological Development during Crystallization of Syndiotactic Polypropylene in a Temperature Field
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D-24 Effect of Ethylene-Vinyl Acetate Copolymer on Properties of Acrylonitrile-Butadiene-Styrene/Zinc Oxide Nanocomposites
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D-25 Developing Anti-Fogging Visor Using Titania Nanoparticle Coating
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D-26 Synthesis and in vitro Characteristics of Sintered Hydroxyapatite
Kha Minh Nguyen, Ha Ky Phuong Huynh, Phu Xuan Nguyen and Tram Thi Ngoc Pham
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D-27 Stable aluminum oxide/water nanofluids with ionic liquid dispersant
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D-28 Predicting of parameters effect on PE wax powder size distribution and shape in atomization process
Ubonwan Madua, Kulchanat Prasertsit, Paiboon Innachitra, Tanakorn Keatkhunboot.
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D-29 Investigation of Thermal and Mechanical Properties of Highly Filled Polybenzoxazine Composites
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D-30 Preparation of Activated Carbon from Extraction Residue of Low-Rank Coal
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Department of Chemical Engineering, Kyoto University Japan

D-31 Electrochemical Characterization of Cathode For MCFC (Molten Carbonate Fuel Cell) Produced By Dry Casting
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Department of Chemical Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia

D-32 Activation of polymer supported catalysts using atmospheric non-equilibrium plasma
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D-33 Study of Structure and Properties of Nano Composite Poly(Acrylic-co-Acrylamide)/Bentonite
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D-34 Synthesis technique and applications of carbon nanotubes directly grown on stainless steel surfaces
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D-35 Effect of Temperature and Type of Inorganic Acid in Acidolysis of Epoxy and Polyurethane Thermosetting Resins
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D-36 SynthesisofProton Exchange Membrane from SO_3H-Grafted Silica Membrane in Production of Electrolized Oxidized Water (EOW)
Zarra Miantina Putrie, Rizki Pratama, Vania Mitha Pratiwi, Minta Yuwana and Heru Setyawan
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D-37 Coating Steel With Nanosilica By Electrophoresis For Corrosion Protection
Ni Made Intan P.Suari, Heru Setyawan, Samsudin Affandi, Rian Intan Saputra, Ririn Kurniasari

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D-38 The Effects of Silica Addition on The Characterization and Gas Permeation of ENR/PVC Membrane
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D-39 Purification of Silica Recovered from Dieng's Geothermal Sludge
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D-40 Validation of a Base-Extraction □-Al2O3 Catalyst Support Synthesis Route
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D-41 Lifetime Prediction of Furan Resin using Thermal Analysis
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D-42 Thermal Degradation Kinetics of Orthophthalic Unsaturated Polyester
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D-43 A protocol to detect chemical residues using a nanoparticle-based sensor combined with a Raman spectroscopic method
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D-44 Stable non-fouling polymeric nanofilms for biomaterial applications
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D-45 The Effect of Plasticizer on Mechanical Properties and Chemical Structure of Chitosan-Starch Film Composites
Natalia S. , Emma S., Andrew L.
Chemical Engineering Department, University of Surabaya, Indonesia

D-46 Diffusivity of Methanol in Modified Nafion and PolyAcrylonitrile-Acrylamide Membranes
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D-47 Effect of NaCl and Seed Crystal on Induction Time for Struvite Precipitation
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D-48 Preliminary Study on Degradation of Chitosan with Sonication
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D-49 Effect of Reaction Time to Production of Nanocarbon by Catalytic Decomposition of Methane From Banana Peel Activated Carbon
Praswasti PDK Wulan1, Imia Ribka
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D-50 Synthesis of gold/iron-oxide composite nanoparticles by ultrasonic spray pyrolysis for magnetic separation of biomolecules
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D-51 Characterization and UV Photocatalytic Activity of Nano-TiO2 Co-doped with Iron and Niobium for Lindane Removal
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Tokyo Institute of Technology, Japan
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D-52 Preparation and characterisation of carbon nanotube buckypapers synthesized from SWNTs and MWNTs in different dispersants
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D-53 Effect of Metal Oxide on Electrical Properties of Tapioca/Metal Oxide Composites
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D-54 Low Molecular Weight Chitosan Production by Hydrolisis Using Commercial α-amylase Hypertermophilic
Nur Rokhati, Bambang Pramudono, Heru Susanto, Prita Issolikha Wijayanti
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D-55 Fabrication of Dye-Sensitized Solar Cell using Spray Coating Method
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Department of Physics,Diponegoro University,Jl. Prof. H. Soedarto SH, Semarang, Central Java 50275, Indonesia

D-56 The Influence of Urea as Additive on the Particle Characteristics of Hydroxyapatite Synthesized by Flame Spray Pyrolysis Method
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E. Environmental Science and Technology

E-04 Removal of Acid Blue 158 from Solution by Sunflower Seed Hull
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E-05 Synthesis of Ferrate (Fe(VI)) from Sludge and its Performance in Arsenite Removal from Water evaluated by Response Surface Methodology (RSM)
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E-06 Removal of Lead(II) and Copper (II) Heavy Metals From Binary Mixture Using Rice Straw Wastes As Biosorbent
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E-07 Improving the performance of cellulose acetate pervaporation membrane by the addition of bentonite and natural zeolite Malang
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E-08 The Use of Natural Coagulants in Wastewater Treatment
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E-09 Recent Development In Solid Waste Management Through Composting and Vermicomposting
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E-10 Treatments of Pulp and Paper Mill Effluent
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E-11 Variation of Size Distribution and Iron Loading in Iron Oxide-Coated Sand Sorption Systems
Jay R T. Adolaciona and Maria Lourdes P. Dalida

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E-12 Photocatalytic Degradation of Azo Dyes (Reactive Red 198) using Platinum-loaded AgBr-TiO_2 Coupled Catalysts
Argenia B. Co, Daryll Anne T. de Joya,Eunice H. Mabutas, and Rolly G. Santos
School of Chemical Engineering and Chemistry
Mapúa Institute of Technology, Manila Philippines

E-13 Treatment of Quick-Service Restaurant Wastewater by Electrocoagulation: Effect of Charge Loading on Pollutant Removal and Energy Consumption
Jem Valerie D. PEREZ and Wilfredo I. JOSE
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E-14 Photocatalytic Degradation of Acetaminophen in TiO2/Visible Light Reactor System
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Department of Environmental Resources Management, Chia Nan University of Pharmacy and Science, Tainan 717 Taiwan

E-15 Decomposition of gas-phase benzene using Ag/TiO2 packed nonthermal plasma catalysis reactor
Christian David C. Pangilinan, Hirofumi Hinode, and Chris Salim
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E-16 Treatment of Quick Service Restaurant Wastewater through Compact Electrocoagulation Technology
Jake Lawrie T. Chin, Christopher Kenneth N. Choa, Gladys Paz T. Cruz, and Pag-asa D. Gaspillo
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E-17 Two Stages Phytoremediations Of Palm Oil Mill Effluent (Pome) By Using Apu-Apu(*Pistia Stratiotes)* Plant And Algae Spirulina Sp For Protein Production
Hadiyantoand Danny Soetrisnanto
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E-18 Ultrasound-Assisted Oxidative Desulfurization of Organosulfur Compounds using Ferrate (VI) from Sludge
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Additional Paper

Ad-1 Comparation between Multi-culture Fermentation Method and Series in Bioethanol Production using Saccharomyces cerevisiae and P.pastoris GS115 mut+
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Ad-2 Numerical Study on A Bead Mill by Lagrangian-Lagrangian Coupling Method
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Research Fellow of the Japan Society for the Promotion of Science
Department of Nuclear Engineering and Management
School of Engineering, University of Tokyo

Ad-3 Effect H_2O and SO_2 Concentration on Selective Catalytic Reduction of Nitrogen Oxide by Ammonia over V_2O_5-WO_3/TiO_2 Catalyst
Piyasan Praserthdam and Phraewphan Kuntanate
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Ad-4 Synthesis of Gold Nanostructures Using Paper for Active SERS Substrate
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Solvent Free Acetylation of Sago Starch

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Abstract

Starch is the major carbohydrate in a normal diet. Acetic anhydride and acetic acid were used to modify sago starch. The solvent free acetylation was conducted using the process of microwave radiation heating. Iodine served as a catalyst and had a greater influence on the degree of substitution (DS) of sago starch acetate than did the acetylation reagents. As the DS increased, the thermal properties (ΔH_G and Tp) of sago starch acetate significantly reduced. Scanning electron micrographs confirmed that the alteration of the initial morphology of sago starch became more evident as DS increased.

Keywords: Sago starch acetate, degree of substitution, thermal properties, surface morphology.

1. Introduction

A few palms can effectively be used as a main starch staple (e.g. the sago palm, *Metroxylon* spp.). Sago is native to Indonesia and it is believed that sago is from the region around Sentani lake, Jayapura, Papua (Indonesia 2007). The greatest number of sago plantations are in Papua (1.2 million ha) and Papua New Guinea (1.0 million ha), and comprises about 90% of the total sago in the world. Sago palm contains a large amount of starch in its trunk; and has a yield that is greater than that of paddy rice (Ahmad, Williams et al. 1999). Sago is an annual crop, and it produces about 25 tons of dry starch/ha/year (Indonesia 2007). Sago palm is environmentally friendly since it survives in swampy, acidic peat; submerged and saline soils. It is also immune to floods, draught, fire and strong winds.

Starch modification is commonly performed using genetic, physical and chemical techniques (BeMiller 1997). Genetic modification of plants can yield novel starches with certain properties similar to postharvest modified starch (Visser and Jacobsen 1993; Slattery, Kavakli et al. 2000; Jobling 2004). Physical modification of starch is primarily heat-moisture treatments. The critical parameters that need to be controlled are the starch to moisture ratio, temperature and heating time (Tester and Debon 2000). Chemical modification involves hydroxyl group oxidation, crosslinking, stabilization and depolymerization (BeMiller 2003). Certain chemical reactions such as esterification, etherification or oxidation can also be used to significantly alter starch properties.

Acetylation is obtained by treating starch slurry with acetylated reagent at specific pH values. This process needs large amounts of water to maintain pH, is time consuming and yields large amounts of wastewater. A straightforward solvent-free method that requires less water and time involves the use of microwave radiation as the energy source (Koroskenyi and McCarty 2002; Biswas, Shogren et al. 2005; Shogren and Biswas 2006; Biswas, Shogren et al. 2008; Diop, Li et al. 2011). In solvent-free acetylation, iodine is typically used as a catalyst. The effect of acetylating agent and reaction time in the solvent-free acetylation has already been studied for corn starch (Biswas, Shogren et al. 2008; Diop, Li et al. 2011), potato starch (Koroskenyi and McCarty 2002; Liu, Ming et al. 2012), sago starch (Soetaredjo, Ismadji et al. 2012) and cellulose (Biswas, Shogren et al. 2005; Biswas, Selling et al. 2007; Hu, Chen et al. 2011). This study, therefore, investigates the effect of acetylation reagents and iodine concentration on DS, thermal properties, and surface morphology of sago starch acetate.

2. Experimental

2.1. Materials

Sago pith at the *plawei* growth stage (estimated age 10 years) from Manokwari, West Papua was sun dried then crushed into powder. Before starch isolation, a number of characteristics were measured (e.g. protein content (AOAC 2000) and proximate analysis (AOAC 2000)). The proximate analyses of sago pith included moisture, ash, and fixed carbon, which were 4.50%, 0.32%, and 84.20%, respectively. The amount of crude protein and total starch in sago pith were 0.62% and 75.88%.

Acetic acid (≥ 99%) and acetic anhydride (≥ 98%) were analytical grade from Sigma-Aldrich (St. Louis, USA). Sodium thiosulfate, ethanol, iodine, and potassium hydroxide were analytical grade supplied by Merck (Darmstadt, Germany). Hydrochloric acid was obtained from Fluka (Steinheim, Germany).

2.2. Starch isolation and acetylation

Sago starch was obtained by soaking sago pith in water for 6 hours with a ratio of solid to water of 1:5. The mixture was then filtered, and the filtrate was centrifuged at 1000 g for 20 min to obtain sago starch. Sago starch was dried in a vacuum oven (Lab-Line Duo-Vac Oven, Lab-Line Instrument Inc., Melrose Park, ILL, USA) at 60°C for 3h.

Before the acetylation process, sago starch was dried in an oven (Memmert GmbH, Germany) and its MC then measured at 3.4 %. A detailed procedure of starch acetate synthesis and degree of substitution determination has been previously described (Soetaredjo, Ismadji et al. 2012). Constant variables considered in this experiment were reaction temperature (100°C), medium stirring (equipment setting), microwave power (100 W), the mole ratio of starch to acetylation agent (1:4) and reaction time (10 min). Two variables, the ratio of acetic anhydride to acetic acid and iodine concentration were kept at two levels, high level (+1) and lower levels (-1) as listed in Table 1. An analysis of variable interaction based on two-level full factorial design of experiment (DOE) was calculated by variance (ANOVA) technique using Minitab 16 software.

Table 1. Two variables considered for Design of Experiment (DOE)

Parameters	Low level (-1)	High level (+1)
Mole ratio of acetic anhydrate to acetic acid (A)	1:0	0:1
Iodine catalyst (%mole of starch) (B)	0.15	5

2.3. Thermal properties analysis

Thermal properties of sago starch acetate were analyzed using a differential scanning calorimetry (DSC Jade, Perkin Elmer). Samples of sago starch acetate (3.5 mg) and distilled water (70%) were put in 40-µL aluminum pans (TA Instruments, USA). The samples were sealed and allowed to stand for 1 h at room temperature before heating in the DSC. Sample pans were heated from 25 to 100°C at 10°C/min. The calibration of DSC was performed using indium and an empty aluminum pan as reference.

Thermal stability was studied using a Perkin Elmer Diamond TG/DTA Instrument (Perkin Elmer, Japan). In order to determine the decomposition temperature, sago starch acetate (± 6 mg) was placed on a platinum pan and heated from 30 to 950°C at a heating rate of 10°C/min. Air flow through the system was maintained at 20 mL/min and atmospheric pressure, during the entire measurements.

2.4. Scanning electron microscopy analysis

The scanning electron micrographs of native and sago starch acetate were taken with a Cambridge scanning electron microscope (S-360) at an accelerating voltage of 20 kV. Granules of native starch and sago starch acetate were sprinkled onto a double-sided tape attached to a stub and then coated with gold.

3. Results and Discussion

The isolation of starch from sago pith yielded 78.5%, and the moisture content was 11.2%. The results of amylose and amylopectin analysis of sago starch were 23.9% and 76.1%, respectively. The moisture content of sago starch from Manokwari, West Papua was found to be similar to sago

starch from Serawak, Malaysia, likewise the amylose and amylopectin content (Ahmad, Williams et al. 1999; Tie, Karim et al. 2008).

Sago starch acetate was synthesized using a facile preparation method with acetic anhydride and acetic acid as acetylation reagent and iodine as catalyst. This method saves considerable time when compared to the conventional method (± 6 h) because it used microwaves as the heating source. The result of DS from the matrix of two variables of two levels full factorial DOE is listed in Table 2, and the result of statistical analysis is summarised in Table 3. The lowest DS was 0.014 that was obtained using only acetic acid as acetylation reagent and a low concentration of catalyst; whereas the highest DS was 1.190 and obtained when using only acetic anhydride as acetylation reagent and high concentration of iodine catalyst. The influence of catalyst concentration on DS is more significant than the ratio of acetic anhydride to acetic acid (Figure 1). For the same ratio of acetylation reagent, higher concentrations of iodine gave higher DS. Starch can be regarded as a polyalcohol; therefore, iodine serving as Lewis acid catalyst activates the carbonyl carbon of the acetylation reagent to make it more reactive in the absence of a solvent (Li, Zhang et al. 2009). The mechanism has been reported by Biswas et al.(Biswas, Shogren et al. 2005) and Li et al.(Li, Zhang et al. 2009) that iodine facilitates the initial step for the reaction of acetic anhydride with hydroxyl group. The interaction of both variables has less effect compared to the independent variable on the determination of DS.

Table 2. The effect of two level variables on the DS

Standard Run	A	B	DS
7	-	+	1.185
8	+	+	0.587
4	+	+	0.543
5	-	-	0.177
3	-	+	1.190
6	+	-	0.018
2	+	-	0.014
1	-	-	0.158

Table 3. Statistical analysis result

Factors/ Interactions	Effect	Coef	SE Coef	T	P
Constant		0.4840	0.006044	80.08	0.000
A	-0.3870	-0.1935	0.006044	-32.01	0.000
B	0.7845	0.3922	0.006044	64.90	0.000
A*B	-0.2355	-0.1177	0.006044	-19.48	0.000
S = 0.0170953					
R-Sq = 99.93%					
R-Sq (adj) = 99.88%					

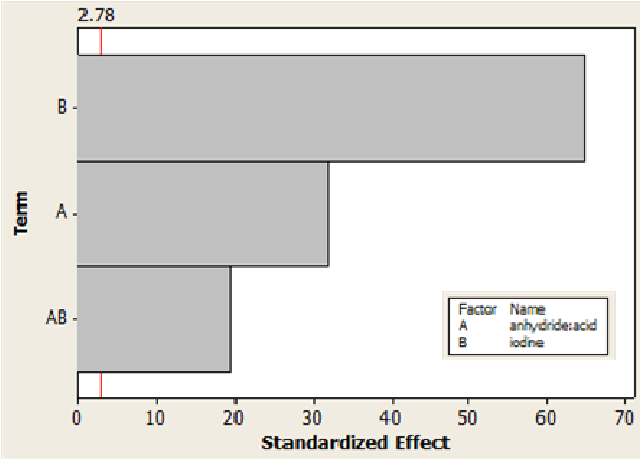

Figure 1. Pareto chart of the standardized effects (response is DS, Alpha= 0.05)

Figure 2 shows the thermal decomposition profile of native sago starch and starch acetate. The first thermal decomposition is dehydration, and occurs in the temperature interval of 50 – 120°C for free moisture and 120 – 210°C for bound water. The decomposition of native sago starch and sago starch acetate occurs in the same temperature interval of 210 – 550°C; however the major decomposition of sago starch acetate (310.02°C) occurs at lower temperature compared to native sago starch (316.02°C). This result is similar to that of corn starch acetate (Diop, Li et al. 2011). Substitution of hydroxyl groups by acetyl groups causes the rupture of the amylopectin double helices, consequently the decomposition temperature become lower (Singh, Kaur et al. 2007).

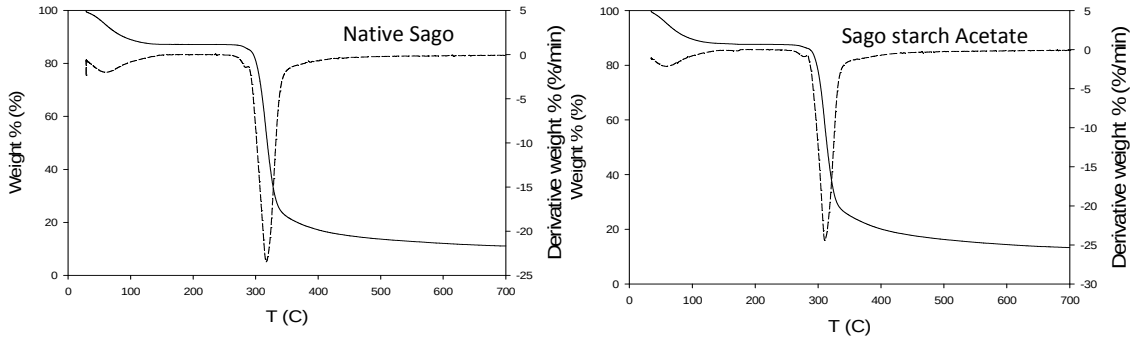

Figure 2. Thermogravimetric curves of native sago starch and sago starch acetate. Weight loss curve (–). Derivative of weight loss (--)

Table 4. The effect of DS on the thermal properties

Sample	Gelatinisation		
	ΔH_G [J/g]	T_o [°C]	T_p [[°C]
Native	16.3	69.1	72.6
DS 0.016	15.2	65.6	70.1
DS 0.168	12.7	58.1	67.3
DS 0.565	11.5	53.3	60.8
DS 1.188	10.1	50.7	57.1

Thermal studies of gelatinization of sago starch acetate revealed that acetylation reduced T_o (the mean onset temperature) and T_p (the peak temperature) (Table 4). The peak temperature of gelatinization of native sago starch is slightly higher compared to commercial sago starch, as analyzed by Ahmad et al (Ahmad, Williams et al. 1999). Sago starch acetate with higher DS reduced in the enthalpy of gelatinization as also observed for other sources of starches (Singh, Kaur et al. 2007). This phenomenon is due to the incorporation of the ester group into a starch molecule which increases the free volume inside the chain and reduces the tension provoked by the intermolecular hydrogen bond (Diop, Li et al. 2011).

The scanning electron micrographs of native sago starch and sago starch acetate are shown in Figure 3. Native sago starch has an irregular oval shape, and there is no significant difference between native and commercial sago starch. The diameter of sago starch granules is in the range of 20-40 μm (Ahmad, Williams et al. 1999). Figure 3 shows the effect of DS on the starch granule surface, and it is shown that the effect of acetylation in the absence of a solvent significantly influences the surface morphology (Singh, Kaur et al. 2007; Diop, Li et al. 2011). Using acetic anhydride as an acetylation reagent and increasing the iodine concentration caused the DS increase from 0.158 to 1.185, while using acetic acid as acetylation reagent caused the DS increase from 0.014 to 0.587. The influence of iodine as a catalyst on the surface morphology of starch after acetylation is more significant compared to those of acetylation reagent. Iodine serves as a Lewis acid and acts as an oxidizing agent and the action of acid could cause an exo-corrosion all over the starch granule surface (Atichokudomchai, Shobsngob et al. 2000; Diop, Li et al. 2011). Other authors explained that acid can provoke exfoliation on the surface of the starch granule and the effect of an oxidizing agent causes the surface of starch become rougher (Sorokin, Kachkarova-Soronika et al. 2004; Ferrini, Rocha et al. 2008).

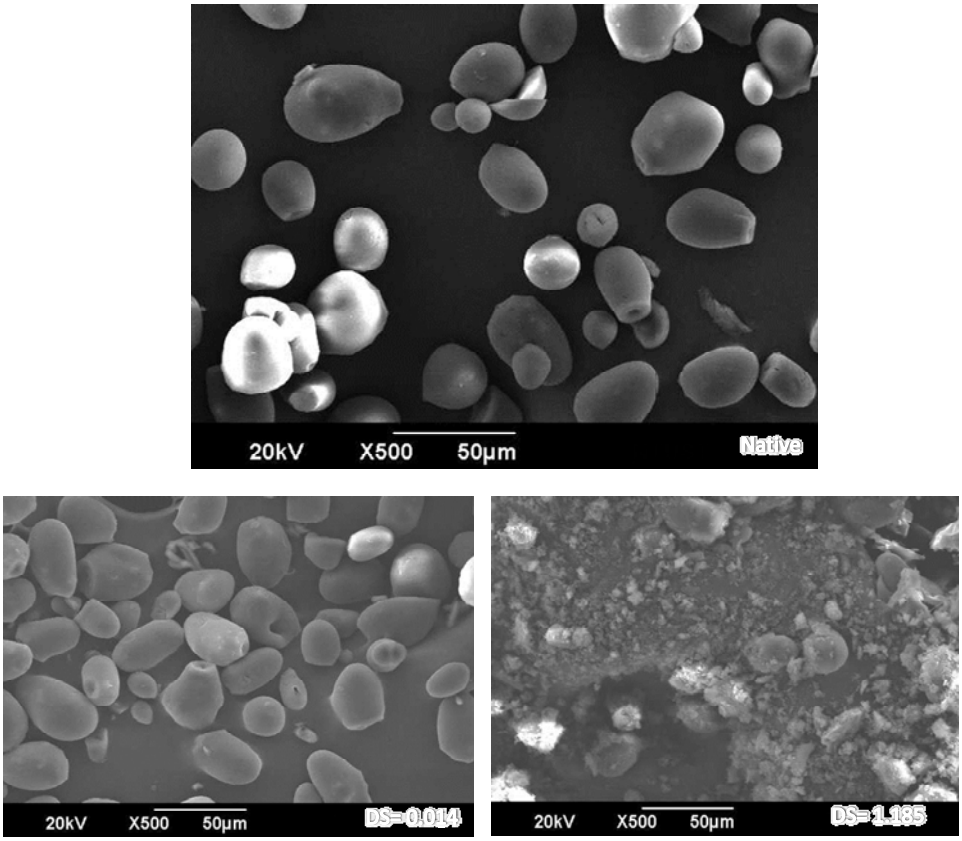

Figure 3. Scanning electron micrograph of native and sago starch acetate

4. Conclusion

In the acetylation of sago starch from sago pith, iodine concentration as catalyst more significantly affects DS, thermal properties, and surface morphology compared to the acetylating agent. High concentration of iodine and acetic anhydride as the acetylating agent result on high DS, lower thermal properties, and porous surface. For food products, low concentration of iodine and acetic acid as acetylating agent produce a form of sago starch acetate that fulfill the requirements for a safe food as stated by FAO/WHO.

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