

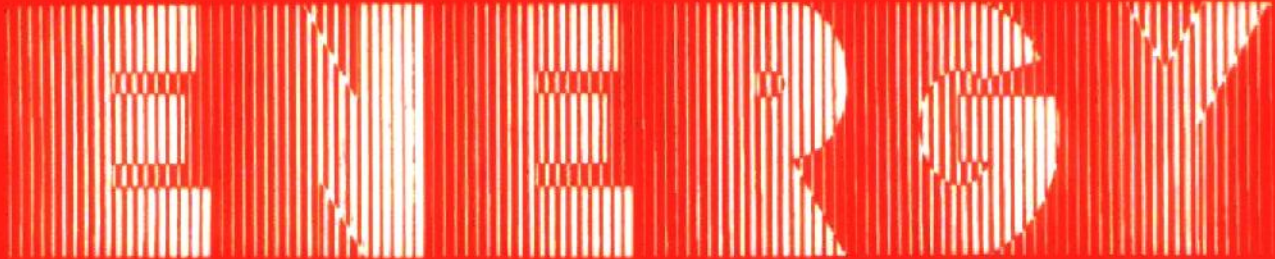


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POLICY

The International Journal

CONTENTS

Review

Z. Yang and X. Wu

1 Retrofits and options for the alternatives to HCFC-22

Full Length Articles

S.R. Chandratilake and W.P.S. Dias

22 Sustainability rating systems for buildings: Comparisons and correlations

Z.A. Ozdemir, K. Gokmenoglu and
C. Ekinci

29 Persistence in crude oil spot and futures prices

X. Liu, D. Chen, W. Zhang, W. Qin,
W. Zhou, T. Qiu and B. Zhu

38 An assessment of the energy-saving potential in China's petroleum refining industry from a technical perspective

S. Lefeng, Z. Qian and P. Yongjian

50 The reserve trading model considering V2G Reverse

CONTENTS— continued on outside back cover

CONTENTS— continued from outside front cover

A. Abuhabaya, J. Fieldhouse and D. Brown	56	The effects of using biodiesel on CI (compression ignition) engine and optimization of its production by using response surface methodology
S.H. Pishgar-Komleh, M. Omid and M.D. Heidari	63	On the study of energy use and GHG (greenhouse gas) emissions in greenhouse cucumber production in Yazd province
V. Letschert, L.-B. Desroches, J. Ke and M. McNeil	72	Energy efficiency – How far can we raise the bar? Revealing the potential of best available technologies
A.S. Bahaj and L.E. Myers	83	Shaping array design of marine current energy converters through scaled experimental analysis
B.B. Alagoz, A. Kaygusuz, M. Akcin and S. Alagoz	95	A closed-loop energy price controlling method for real-time energy balancing in a smart grid energy market
Y. Ma, Y. Yuan, J. Jin, H. Zhang, X. Hu and D. Shi	105	An environment friendly and efficient lignite-fired power generation process based on a boiler with an open pulverizing system and the recovery of water from mill-exhaust
C. McGlade, J. Speirs and S. Sorrell	116	Methods of estimating shale gas resources – Comparison, evaluation and implications
X. Wu, J. Mao, Z. Du and Y. Chang	126	Online training algorithms based single multiplicative neuron model for energy consumption forecasting
E. Kuznetsova, Y.-F. Li, C. Ruiz, E. Zio, G. Ault and K. Bell	133	Reinforcement learning for microgrid energy management
M.H. Sahraei, F. Farhadi and R.B. Boozarjomehry	147	Analysis and interaction of exergy, environmental and economic in multi-objective optimization of BTX process based on evolutionary algorithm
A. Osmani and J. Zhang	157	Stochastic optimization of a multi-feedstock lignocellulosic-based bioethanol supply chain under multiple uncertainties
S. Brand, R.F. Susanti, S.K. Kim, H.-s. Lee, J. Kim and B.-I. Sang	173	Supercritical ethanol as an enhanced medium for lignocellulosic biomass liquefaction: Influence of physical process parameters
D.R. Klein, M. Olonscheck, C. Walther and J.P. Kropp	183	Susceptibility of the European electricity sector to climate change
R. Parameshwaran and S. Kalaiselvam	194	Energy efficient hybrid nanocomposite-based cool thermal storage air conditioning system for sustainable buildings

CONTENTS— continued on inside back cover

Abstracted/indexed in: Applied Sci. & Tech. Index, Biosis Data, Carn. Sci. Abstr. Chem. Abstr. Serv. Curr. Cont. Eng. Tech. & Applied Sci., Elsevier BIOBASE/Current Awareness in Biological Sciences; Eng. Ind., Environ. Per. Bibl., INSPEC Data, Res. Alert, Curr. Cont. Sci. Cit. Indx., Curr. Cont. SCISEARCH Data. Also covered in the abstract and citation database SCOPUS®. Full text available on ScienceDirect®



ISSN 0360-5442

J.D. Nixon, P.K. Dey, S.K. Ghosh and P.A. Davies	215	Evaluation of options for energy recovery from municipal solid waste in India using the hierarchical analytical network process
A. Mahmoud and M. Shuhaimi	224	Systematic methodology for optimal enterprise network design between bio-refinery and petroleum refinery for the production of transportation fuels
Y. Nakatake, S. Kisu, K. Shigyo, T. Eguchi and T. Watanabe	233	Effect of nano air-bubbles mixed into gas oil on common-rail diesel engine
B. Lin and X. Liu	240	Electricity tariff reform and rebound effect of residential electricity consumption in China
W.-L. Cheng, T.-T. Li, Y.-L. Nian and C.-L. Wang	248	Studies on geothermal power generation using abandoned oil wells
A.H.H. Ali, M. Ahmed and S.M. Abdel-Gaied	255	Investigation of heat transfer and fluid flow in transitional regime inside a channel with staggered plates heated by radiation for <i>PVT</i> system
W.-L. Cheng and X.-D. Yuan	265	Numerical analysis of a novel household refrigerator with shape-stabilized PCM (phase change material) heat storage condensers
Sanjay and B.N. Prasad	277	Energy and exergy analysis of intercooled combustion-turbine based combined cycle power plant
H. Qudrat-Ullah	285	Understanding the dynamics of electricity generation capacity in Canada: A system dynamics approach
J. Zhong, P. Wang, Y. Zhang, Y. Yan, S. Hu and J. Zhang	295	Adsorption mechanism of oil components on water-wet mineral surface: A molecular dynamics simulation study
D.A. Chwieduk	301	Dynamics of external wall structures with a PCM (phase change materials) in high latitude countries
M.H. Khoshgoftar Manesh, P. Navid, A.M. Blanco Marigorta, M. Amidpour and M.H. Hamed	314	New procedure for optimal design and evaluation of cogeneration system based on advanced exergoeconomic and exergoenvironmental analyses
W. Yang	334	Experimental performance analysis of a direct-expansion ground source heat pump in Xiangtan, China
I. Janghorban Esfahani and C.K. Yoo	340	Exergy analysis and parametric optimization of three power and fresh water cogeneration systems using refrigeration chillers
W. Gong and Z. Cai	356	Accelerating parameter identification of proton exchange membrane fuel cell model with ranking-based differential evolution
A. Ashouri, S.S. Fux, M.J. Benz and L. Guzzella	365	Optimal design and operation of building services using mixed-integer linear programming techniques
Z. Li, G. Liu, Z. Chen, L. Zeng and Q. Zhu	377	Effect of angle of arch-supplied overfire air on flow, combustion characteristics and NO _x emissions of a down-fired utility boiler
D. Johansson, P.-Å. Franck, K. Pettersson and T. Berntsson	387	Comparative study of Fischer–Tropsch production and post-combustion CO ₂ capture at an oil refinery: Economic evaluation and GHG (greenhouse gas emissions) balances
D. Wang, N. Zamel, K. Jiao, Y. Zhou, S. Yu, Q. Du and Y. Yin	402	Life cycle analysis of internal combustion engine, electric and fuel cell vehicles for China
L. Hughes and A. Ranjan	413	Event-related stresses in energy systems and their effects on energy security

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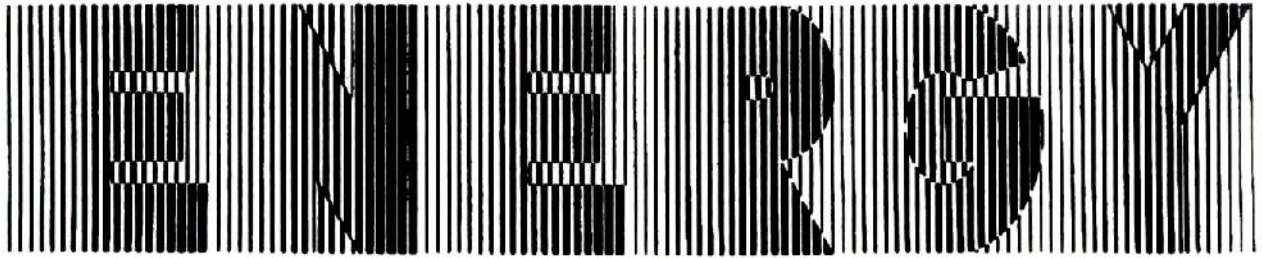
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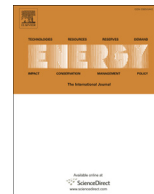
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Supercritical ethanol as an enhanced medium for lignocellulosic biomass liquefaction: Influence of physical process parameters



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ABSTRACT

In this study, the influence of various physical process parameters on the liquefaction of lignocellulosic biomass (pine wood) in supercritical ethanol was investigated. The parameters include reaction temperature (280–400 °C), initial nitrogen pressure (0.4–7.5 MPa), reaction time (0–240 min), and biomass-to-solvent ratio (0.06–0.25 g/g). The reaction temperature and residence time were found to have a more significant effect on biomass conversion and product yield than pressure and biomass-to-solvent ratio had; conversion in the range 34.0–98.1% and biocrude yield in the range 15.8–59.9 wt% were observed depending on the process parameters. Despite the absence of catalysts and external hydrogen source, solid biomass to liquid and gaseous products conversion of 98.1%, and a high biocrude yield of approximately 65.8 wt% were achieved at 400 °C, 120 min, and a biomass-to-solvent ratio of 0.06 g/g. Moreover, the biocrude contained considerably lower amounts of oxygen and higher amounts of carbon and hydrogen, resulting in a substantially higher heating value (>30 MJ/kg) as compared to raw feedstock (20.4 MJ/kg). A comparison with sub- or supercritical water-based liquefaction revealed that supercritical ethanol produced biocrude with a lower molecular weight and much better yield. Finally, a new biomass liquefaction reaction mechanism associated with supercritical ethanol is proposed.

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1. Introduction

Extensive efforts are being made to develop renewable and sustainable energy sources, and cost-effective energy processes, owing to concerns regarding global warming and fossil fuel depletion [1]. Biomass is considered as one of the most promising renewable energy resources as it is carbon neutral and abundant. Several thermochemical conversion technologies such as fast pyrolysis, liquefaction, and gasification followed by Fischer–Tropsch synthesis (or biomass-to-liquid, BTL) have been investigated to

convert biomass into liquid fuels and valuable platform chemicals. In a typical BTL process, biomass is first gasified at high temperatures of 600–1300 °C to produce syngas (CO and H₂) and then the syngas is converted to mostly straight chain alkanes using Co-, Fe- or Ru-based catalysts. Fast pyrolysis and liquefaction generate multicomponent oxygenated hydrocarbon mixtures called “bio-oils” or “biocrude.” Fast pyrolysis and liquefaction are similar but not identical processes with many differences in reaction parameters and product characteristics. Fast pyrolysis is the thermal degradation of organic matter in the absence of oxygen at atmospheric pressure. The high heating rate combined with short residence time (both few seconds) and the medium operating temperatures (450–650 °C) associated with fast pyrolysis convert biomass into oxygenated hydrocarbons. Subsequent rapid quenching of produced organic vapors results in high-yield bio-oil. The bio-oil produced in fast pyrolysis, however, typically has less desirable physicochemical properties such as, higher oxygen

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