



- Book title: Materials and processes for energy: communicating current research and technological developments
- Editor: A. Mendez-Vilas
- ISBN: 978-84-939843-7-3
- Publisher: Formatex Research Center
- Publication date: August 2013

## **Valorisation of glycerol into biofuel additives over heterogeneous catalysts**

**J. Farinha, M. Caiado and J. E. Castanheiro\***

Centro de Química de Évora, Departamento de Química, Universidade de Évora, 7000-671 Évora, Portugal

Transesterification of glycerol with methyl acetate was carried out over resins, poly(vinyl alcohol) (PVA) and chitosan (CH) with sulfonic acid groups at 70° C. The products of glycerol transesterification are monoacetin, diacetin and triacetin. It was observed that the catalytic activity increases with the amount of sulfonic acid groups on materials. The CH material showed the highest catalytic activity of all catalysts. In order to study the catalytic stability of CH-SO<sub>3</sub>H, three consecutive batch runs with the same catalyst were carried out. The CH-SO<sub>3</sub>H catalyst can be recycled and reused with negligible loss in the activity, after third use.

**Keywords:** bio-additives, biodiesel, glycerol, heterogeneous catalysts

**- Chapter title: “Valorisation of glycerol into biofuel additives over heterogeneous catalysts”**

**- Pages of the mentioned chapter: 422-429(both included)**

- Book title: “Materials and processes for energy: communicating current research and technological developments”

- Editor: A. Méndez-Vilas

- Publisher: Formatex Research Center

- ISBN (13): 978-84-939843-7-3

- Publication date: August 2013

## TABLE OF CONTENTS

<b>Introduction</b> .....	XIII
---------------------------	------

### Solar Energy and Related Topics

<b>Analysis of impact of distributed generation in a distribution grid by the use of photovoltaic generators</b> M. F. da Silveira, J. B. Dias and J. V. C. dos Santos.....	3-10
<b>Design of Low Bandgap Conjugated Polymers for Organic Solar Cell Application</b> Qiang Peng, Tao Liang and Kui Feng.....	11-21
<b>Efficiency improvement of crystalline silicon solar cells</b> M. Al-Amin and A. Assi.....	22-31
<b>Energy storage: Preparations and physicochemical properties of solid-liquid Phase change materials for thermal energy storage</b> Daolin Gao and Tianlong Deng.....	32-44
<b>Evaluation of energy produced by grid-connected photovoltaic systems in Porto Alegre - Brazil</b> C.H. Rossa, J. B. Dias and G.A.M. Karnas.....	45-51
<b>Features of the nanostructured materials for solar energy application: Increased charge carrier mobility</b> N.V.Kamanina.....	52-58
<b>High efficiency heterojunction with intrinsic thin layer solar cell: A short review</b> S. M. Ifthiqar, Youngseok Lee, Vinh Ai Dao, Sangho Kim and Junsin Yi.....	59-67
<b>High performance and stability of chemically modified graphene oxide organic solar cells</b> Hyeong Pil Kim, Abd. Rashid bin Mohd Yusoff and Jin Jang.....	68-74
<b>Maximum Power Point Tracking (MPPT) of Partially Shaded Photovoltaic Cells: A Technical Review</b> Pervez Hameed Shaikh, Nursyarizal Bin Mohd. Nor, Irraivan Elamvazuthi and Perumal Nallagownden.....	75-83
<b>Minimizing Energy Consumption in Wireless Sensor Networks using Solar Powered sensors</b> Maryam El azhari, Rachid Latif, Ahemd Toumanari.....	84-94
<b>Optimum Locations for Photovoltaic Life Cycle</b> Kotaro Kawajiri.....	95-102

<b>Photovoltaic materials and solar power plant optimization design in relation to its environmental impact</b> R. D. Piacentini, J. A. Schmidt, N. Budini, M. Vega, E. Giandoménico, N. Feldman and R. Buitrago.....	103-113
<b>Photovoltaics Based on Semiconductor Powders</b> Dieter Meissner.....	114-125
<b>Recent Advanced Materials for Mesoporous Sensitized Solar Cells</b> Getachew Alemu, Kun Cao, Mingkui Wang, Yan Shen.....	126-133
<b>Solar cooking figures of merit. Extension to heat storage</b> A. Lecuona, J. I. Nogueira, C. Vereda and R. Ventas.....	134-141
<b>Solar Thermosyphon</b> Himanshu Dehra.....	142-149
<b>Thermal relaxations and transitions in EVA encapsulant material during photovoltaic module encapsulation process</b> K. Agroui and G. Collins.....	150-157

## Biomass – Biofuels and Related Topics

---

<b>A computational fluid dynamic study on the behaviour of sugarcane bagasse suspension in pipe and baffled pipe</b> A. González Quiroga, E.L Martínez, A.C Costa and R. Maciel Filho.....	161-168
<b>A predictive model for the determination of some densification characteristics of corncob briquettes</b> J. T. Oladeji and C. C. Enweremadu.....	169-177
<b>Agricultural waste products as a valuable source of renewable energy</b> M. Owczuk, D. Wardzińska, A. Zamojska-Jaroszewicz and A. Matuszewska.....	178-184
<b>Alternative fuel production using heterogeneous catalysis in a closed reactor</b> Viomar, A. L. Gallina, E. do Prado Banczek and P. R. P. Rodrigues.....	185-189
<b>An Analysis on the Opportunities, Technology and Potential of Biomass Residues for Energy Production in Portugal</b> Valter Silva, Eliseu Monteiro and Abel Rouboa.....	190-201
<b>Analysis of gases released in the glycerin microbiological fermentation in dextrose medium</b> H. W. Herrmann, G. Kovalski, R. Caparica, A. L. Gallina, C. B. Fürstenberger and P. R. P. Rodrigues.....	202-205

<b>Application of Molybdenum Catalysts in Biorefinery</b> A. Malinowski .....	206-211
<b>Aspen plus simulation of biomass gasification in a steam blown dual fluidised bed</b> W. Doherty, A. Reynolds and D. Kennedy.....	212-220
<b>Biocomponents and their effect on the aging process in a fuel storage</b> K. Biernat, M. Skolniak and P. Bukrejewski.....	221-229
<b>Biodiesel production from natural resources via supercritical fluid extraction and catalytic transesterification reaction</b> Maliheh Mir and Seyyed M. Ghoreishi.....	230-238
<b>Biodiesel Production from Non Food Crops: A Step towards Self Reliance in Energy</b> M. Ahmad, L. K. Teong, S. Sultana and M. Zafar.....	239-243
<b>Biodiesel production: process and characterization</b> N.L. Da Silva, L.F. Rios, M.R. Wolf Maciel and R. Maciel Filho.....	244-251
<b>Determination of biodiesel commercial mixer reaction kinetics</b> L. A. C. Matos, A. B. Brugnera, E. P. Banczek and P. R. P. Rodrigues.....	252-256
<b>Exploitation of biomass energy technologies (BETs) for sustainable future: A review</b> Shazia Sultana, Ahmad Zuhairi Abdullah and Mushtaq Ahmad.....	257-263
<b>Gasification of biomass in supercritical water (SCWG)</b> A. Möbius, N. Boukis and J. Sauer.....	264-268
<b>Jatrofa Seeds; oil and biodiesel quality: nutrients and potentially toxic elements determined by mass spectroscopy inductively coupled plasma</b> M. N. C. Harder; E. C. M. Duarte; L. L. S. Barros; P. B. Maciel; C. H. Abreu Jr.; F. C. A. Villanueva and V. Arthur.....	269-273
<b>Lipid production by <i>Yarrowia lipolytica</i> for biofuels</b> M. N. C. Harder; A. S. Delabio; S. Cazassa; R. R. Remedio; J. A. Pires; T. R. R. Monteiro and V. Arthur.....	274-278
<b>Materials technological challenges for the biodiesel industry development in Mexico</b> Marcos Alberto Coronado Ortega, Gisela Montero Alpírez, Amir Eliezer, Conrado García González, Jesús Cerezo Román, Laura Janet Pérez Pelayo, José Ramón Ayala Bautista.....	279-288
<b>Methyl Esters of Different Origin as a Fuel for Compression-Ignition Engines</b> S. Kruczynski, K. Kolodziejczyk, P. Orlinski, M. Owczuk.....	289-296
<b>Microbiological fermentation of glycerol to obtain alcohol in tryptose culture medium</b> G. Kowalski, H. W. Herrmann, A. L. Gallina, R. Caparica, C. B. Fürstenberger and P. R. P. Rodrigues .....	297-301

<b>Molecular mechanisms for detoxification of major aldehyde inhibitors for production of bioethanol by <i>Saccharomyces cerevisiae</i> from hot-compressed water-treated lignocellulose</b> Lahiru N. Jayakody, Nobuyuki Hayashi and Hiroshi Kitagaki.....	302-311
<b>Nickel functionalized mesostructured cellular foam (MCF) silica as a catalyst for solventless deoxygenation of palmitic acid to produce diesel-like hydrocarbons</b> Lilis Hermida, Ahmad Zuhairi Abdullah and Abdul Rahman Mohamed.....	312-319
<b>Optimization of production variables of biodiesel using calcium oxide as a heterogeneous catalyst: an optimized process</b> Hilary Rutto and Christopher Enweremadu.....	320-326
<b>Possibilities of Argentina to produce biokerosene for aviation under sub-humid dry to arid areas</b> S. Falasca, A. Ulberich and C. Waldman.....	327-334
<b>Production of ethanol from jerivá, <i>Syagrus romanzoffiana</i></b> G. A. R. Maia, D. Borsato, P. R. P. Rodrigues, M. E. Payret Arrúa, P. H. Weirich Neto, S. M. Kurchaidt, A. C. Antunes, J. A. A. Pereira and S. R. M. Antunes.....	335-339
<b>Progress in liquid biofuel and biohydrogen from agro-industrial wastes by clostridia</b> Mohamed Hemida Abd-Alla, Ahmed Abdel-salam Issa, Fathy Mohamed Morsy and Magdy Khalil Bagy.....	340-351
<b>Properties of bioethanol - diesel oil mixtures</b> A. Matuszewska, M. Odziemkowska and J. Czarnocka.....	352-359
<b>Prospects of using bioenergy crop <i>Miscanthus × giganteus</i> in Serbia</b> Ž. Dželetović, N. Mihailović and I. Živanović.....	360-370
<b>The Brazilian technology of fuel ethanol fermentation – yeast inhibition factors and new perspectives to improve the technology</b> Pedro de Oliva-Neto, Claudia Dorta, Ana Flavia Azevedo Carvalho, Valeria Marta Gomes de Lima, Douglas Fernandes da Silva.....	371-379
<b>The potential for sustainable bioethanol production in Serbia: available biomass and new production approaches</b> L. Mojović, S. Nikolić, D. Pejin, J. Pejin, A. Djukić-Vuković, S. Kocić-Tanackov, V. Semenčenko....	380-392
<b>The two-stage technology of biomass conversion into synthesis gas</b> V.V. Kosov, V.F. Kosov, V.A. Sinelshchikov and V.M. Zaichenko.....	393-398
<b>The use of thermally modified koalin as a heterogeneous catalyst for producing biodiesel</b> Hilary Rutto.....	399-406
<b>Thermal events during the combustion of agricultural and forestry lopping residues</b> A. Garcia-Maraver, L.C. Terron, M. Zamorano, A.F. Ramos-Ridao.....	407-413

<b>Thermodynamics of Thermal Biomass Processing</b> E. Rostek and K. Biernat.....	414-421
<b>Valorisation of glycerol into biofuel additives over heterogeneous catalysts</b> J. Farinha, M. Caiado and J. E. Castanheiro.....	422-429

## Hydrogen

---

<b>Hydrogen storage in boron nitride and carbon nanomaterials studied by TG/DTA and molecular orbital calculations</b> Takeo Oku.....	433-440
<b>Hydrogen: Value Chain and its Challenges as a Future Fuel</b> Shikha Jain, Sonal Singh, Avanish K. Tiwari and M R. Nouni.....	441-451
<b>Role of sodium hydroxide for hydrogen gas production and storage</b> Sushant Kumar, Surendra K. Saxena.....	452-463
<b>The use of stainless steel 254 to produce hydrogen</b> A. L. Gallina, B. V. Dias and P. R. P. Rodrigues.....	464-469

## Fuel Cells

---

<b>Anodic Catalyst Design for the Ethanol Oxidation Fuel Cell Reactions</b> Xiaowei Teng.....	473-484
<b>Composite Electrolytes and electrodes for Intermediate Temperature Hybrid Fuel Cells</b> S. Rajesh, D. A. Macedo and Rubens M. Nascimento.....	485-494
<b>Modeling of durability of polyelectrolyte membrane of O<sub>2</sub>/H<sub>2</sub> fuel cell</b> Vadim V. Atrazhev and Sergei F. Burlatsky.....	495-503
<b>Modelling of ammonia-fed solid oxide fuel cells</b> Denver F. Cheddie.....	504-511
<b>Nanotechnology for improving solid oxide fuel cells</b> R. Pinedo, I. Ruiz de Larramendi, N. Ortiz-Vitoriano, D. Jimenez de Aberasturi and T. Rojo.....	512-522