

# **Green Energy and Technology**

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Magno Trindade  
Editor

# Increased Biodiesel Efficiency

Alternatives for Production, Stabilization,  
Characterization and Use of Coproduct

 Springer

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# Presentation

Despite countless valuable scientific texts and books highlighting the research into biofuels, the field is not fully explored in order to address all alternative sources of biomass, new technologies for biodiesel production and its characterization as well as the current green technologies on sample preparation for elemental determination and smart use of coproducts. In this book, the authors start to address the use of alternative non-food feedstock oilseed species to produce biodiesel, covering the new opportunities and challenges about the viability for exploring the biodiesel production in an economical way. New technologies for the synthesis of biodiesel via alternative protocols accompanied by alternative techniques for characterization are reported. The following chapters also address the current technologies to cover the alternative blends composed by multifunctional antioxidants (sometimes called secondary antioxidants) which are followed by the uses of chalcones and their derivatives to overcome the drawback associated with the biodiesel quality and provide its stabilization more efficiently and more cost-effectively. Moreover, efforts were made to cover some aspects based on biodiesel characterization, providing alternatives to overcome some of the limitation with the uses of traditional method, especially, showing the potential use of portable systems and the fluorescence spectroscopy as an alternative analytical tool for, in situ and in real time, monitoring the oxidative stability of biodiesel. The concerns about the recent advances on green technologies for sample preparation and for determination of the content of metallic species are also addressed, focusing in the alternatives based on nondestructive measurement for elemental determination in the entire biodiesel production chain. The last chapter brings the current technologies for smart use of coproducts, addressing how the biodiesel byproduct can provide alternative uses for glycerol as a source of energy and high valuable chemicals. Finally, in the book, we focused in many topics—sometimes neglected in previously published books. This allows the readers to understand the challenges regarding technological resources and research required to overcome the drawback associated with the biodiesel production chain, starting from the choice of non-food feedstocks up to the use of coproducts.

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# Abbreviations and Symbols

%SYN	Percent of synergism
[Hmim][PF6]	1-Hexyl-3-methylimidazolium hexafluorophosphate
[Hmim][TF2N]	1-Hexyl-3-methylimidazolium bis(trifluoromethylsulfonyl) imide
[Omim][TF2N]	1-Octyl-3-methylimidazolium bis(trifluoromethylsulfonyl) imide
AAS	Atomic absorption spectrometry
AEM-DGFC	Anion-exchange membrane-direct glycerol fuel cell
AES	Atomic emission spectrometry
AFS	Atomic fluorescence spectrometry
AgNPs	Silver nanoparticles
ALZ	Alizarin
ANP	National Agency of Petroleum, Natural Gas and Biofuels
ASTM	American Society for Testing and Materials
AuNPs	Gold Nanoparticles
B100	Pure biodiesel
B20	20% Blend of biodiesel in diesel
BEQ	1,4-Bis(ethylamino)-9,10-anthraquinone
BHA	Butylhydroxyanisole or butylated hydroxyanisole
BHT	Butylhydroxytoluene or butylated hydroxytoluene
CA	Citric acid
CCD	Central composite design
CFA	Caffeic acid
CG	Gas chromatography
CHI	Chalcone isomerase
CICP	Cetylpyridinium chloride
CoA	Coenzyme A
CPE	Cloud point extraction
CRM	Certified reference materials
CSH	Chalcone synthase



CTAB	Hexadecyltrimethylammonium bromide
DAFC	Direct alcohol fuel cells
DDBS	Sodium dodecyl benzene sulfonate
DGFC	Direct glycerol fuel cell
DHA	Dihydroxyacetone
DHQ	1,4-Dihydroxanthraquinone
DLLME	Dispersive liquid–liquid microextraction
DME	Bio-dimethyl ether
DMF	N,N-dimethyl formamide
DSC	Differential scanning calorimetry
DTBP	2,6-Di-tert-butylphenol
DTPA	Diethylenetriaminepentaacetic acid
EDTA	Ethylenediaminetetraacetic acid
EF	Enrichment Factor
EN	European Norms
EPE	Energy Research Company
ER	Extraction recovery
ET AAS	Electrothermal atomic absorption spectrometry
EtOH	Bioethanol
EU	European Union
F AAS	Flame atomic absorption spectrometry
F AES	Flame atomic emission spectrometry
FA	Ferulic acid
FAs	Fatty acid
FAME	Fatty acid methyl esters
FS FAAS	Fast sequential flame atomic absorption spectrometry
FSB	Fried soybean oil
FT	Fischer–Tropsch fuels
FTIR	Fourier transform Infrared
GA	Gallic acid
GC	Gas chromatography
GC-FID	Gas chromatography with flame ionization detector
GC-MS	Gas chromatography coupled to mass spectrometry
GEOR	Glycerol electrooxidation reaction
GF AAS	Graphite furnace atomic absorption spectroscopy
GHG	Greenhouse gas
GT-C	Green tea chloroform extract
GT-M	Methanol extracts of green tea
HF-LPME	Hollow fiber liquid-phase microextraction
HLB	Hydrophilic–lipophilic balance
HLLE	Homogeneous liquid–liquid extraction
HPLC	High-performance liquid chromatography
HVO	Hydrotreated vegetable oil
ICP-MS	Inductively coupled plasma mass spectrometry
ICP-OES	Inductively coupled plasma optical emission spectrometry

IL-DLLME	Ionic liquid dispersive liquid–liquid microextraction
ILs	Ionic liquids
IP	Induction period
IRAM	Argentine Institute for Standardization and Certification
LLE	Liquid–liquid extraction
LLLME	Liquid–liquid–liquid microextraction
LPME	Liquid-phase microextraction
LPME-SFO	Liquid-phase microextraction based on solidified of floating organic drop
MEA	Membrane exchange assembly
MEMR	Indonesian Ministry of Energy and Mineral Resources
MeOH	Biomethanol
MFC	Microfluidic fuel cell
MIP-OES	Microwave-induced plasma optical emission spectrometry
MOM	Methoxymethyl protecting groups
MWCNTs	Multi-walled carbon nanotubes
NPs	Nanoparticles
OCV	Open circuit voltage
OIT	Oxidation induction time
OOT	Oxidation onset temperature
OSR	Oilseed radish
OSRB	Oilseed radish biodiesel
PEM	Proton exchange membrane
PG	Propyl gallate or propyl 3,4,5-trihydroxybenzoate
PH-M	Pomegranate hull
PNPB	National Biodiesel Production and Usage Program
ppm	Parts per million
PROALCOOL	National Alcohol Program
PROBIODIESEL	Brazilian Program of Technological Development for Biodiesel
PRO-ÓLEO	Plan of Production of Vegetable Oils for Energy Purposes
p-TSA	p-Toluenesulfonic acid
PY	Pyrogallol or 1,2,3-trihydroxybenzene/pyrogallol
QC	Quercetin
RANP	Resolution of the National Oil Agency
Rf	Retention factor
RFS	Renewable fuel standard
RHE	Reversible hydrogen electrode
ROS	Reactive oxygen species
SAR	Structure–activity relationship
SB	Soybean biodiesel
SB-35	Solvent blue 35
SDME	Single-drop microextraction

SDS	Sodium dodecyl sulfate
SFME	Surfactant-free microemulsion
SOFC	Solid oxide fuel cell
STS	Stilbene synthase
TBHQ	<i>tert</i> -Butylhydroquinone or <i>tert</i> -butylated hydroxyquinone
TG	Thermogravimetry
THFA	Tetrahydrofurfuryl alcohol
TLC	Thin-layer chromatography
U.S.	United States
UA-SMDLLME-SFO	Ultrasonic-assisted supramolecular dispersive liquid–liquid microextraction based on solidification of a floating organic droplet
US EPA	United States Environmental Protection Agency
UV-Vis	Ultraviolet-visible
VA-LLME	Vortex-assisted liquid–liquid microextraction
WCAES	Tungsten coil atomic emission spectrometry
WCO	Waste cooking oil
WWII	World War II
$\theta_{sb}$	Antimony coverage degree