

# Valorization of Transesterification byproduct Glycerol to Solketal using Heterogeneous Catalyst



Thesis submitted in partial fulfillment for the award of the degree

of

**DOCTOR OF PHILOSOPHY**

by

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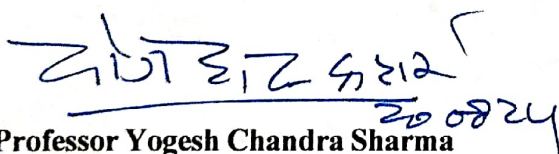


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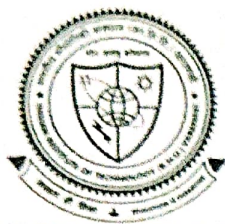
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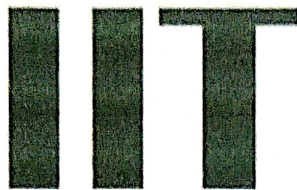
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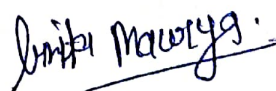
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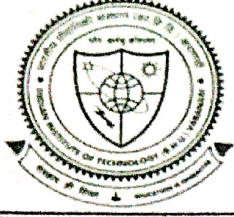
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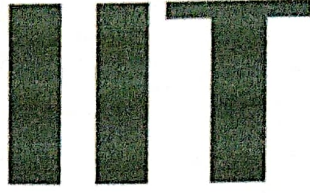
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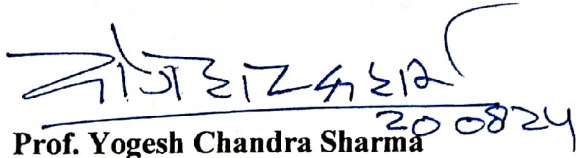
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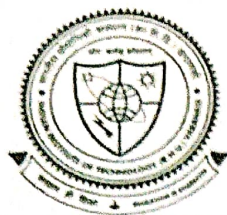
  
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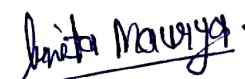
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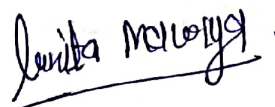
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## List of Abbreviations

Å	Angstrom
eV	Electron volt
FT-IR	Fourier transform infrared
GC-MS	Gas chromatography-mass spectrometry
NMR	Nuclear magnetic resonance
IEA	International Energy Agency
JCPDS	Joint Committee on Powder Diffraction Standards
Gly	Glycerol
Ace	Acetone
E-factor	Environmental factor
PMI	Process Mass Index
CE	Carbon Efficiency
TOF	Turnover Frequency
AE	Atom Economy
M	Molar
EIA	Energy Information Administration
FAME	Fatty acid methyl ester
FFA	Free fatty acid
Kg	Kilogram
KJ/mol	Kilojoule per mole
kV	Kilovolt
nm	Nanometre
mmol/g	Millimole per gram
N	Stoichiometric factor
T	Temperature
°C	Degree Celsius
K	Kelvin
λ	Lambda
mM	Micrometre
pH	Potential of hydrogen
XRD	X-ray diffraction
TGA	Thermogravimetric analysis
SEM	Scanning electron microscopy
EDX	Energy dispersive X-ray analysis
XPS	X-ray photo electron spectroscopy
BET	Brunauer-Emmett-Teller
BJH	Barrett-Joyner-Halenda
pKa	Dissociation constant of acid
nm	Nanometer
rpm	Revolution per minute

wt. %	Weight percentage
$\theta$	Theta
ZA	ZrO <sub>2</sub> -Al <sub>2</sub> O <sub>3</sub>
SZA	SO <sub>4</sub> <sup>-2</sup> /ZrO <sub>2</sub> -Al <sub>2</sub> O <sub>3</sub>
SC	SO <sub>4</sub> <sup>-2</sup> /CoAl <sub>2</sub> O <sub>4</sub> (1:0)
ST	SO <sub>4</sub> <sup>-2</sup> /TiO <sub>2</sub> (0:2)
SCAT (3:2)	SO <sub>4</sub> <sup>-2</sup> /CoAl <sub>2</sub> O <sub>4</sub> -TiO <sub>2</sub> (3:2)
SCAT (2:3)	SO <sub>4</sub> <sup>-2</sup> /CoAl <sub>2</sub> O <sub>4</sub> -TiO <sub>2</sub> (2:3)
SCAT (4:1)	SO <sub>4</sub> <sup>-2</sup> /CoAl <sub>2</sub> O <sub>4</sub> -TiO <sub>2</sub> (4:1)
SCAT (1:4)	SO <sub>4</sub> <sup>-2</sup> /CoAl <sub>2</sub> O <sub>4</sub> -TiO <sub>2</sub> (1:4)
SZZ	SO <sub>4</sub> <sup>-2</sup> /ZnAl <sub>2</sub> O <sub>4</sub> -ZrO <sub>2</sub>
SZT	SO <sub>4</sub> <sup>-2</sup> /ZnAl <sub>2</sub> O <sub>4</sub> -TiO <sub>2</sub>