AN APPLICATION OF ADVANCED OXIDATION PROCESS TO PHOTOPOLISH PALM OIL MILL EFFLUENT OVER TiO₂ AND ZnO PHOTOCATALYSTS

NG KIM HOONG

DOCTOR OF PHILOSOPHY
(CHEMICAL ENGINEERING)

UNIVERSITI MALAYSIA PAHANG
SUPERVISOR’S DECLARATION

We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy in Chemical Engineering

(Supervisor’s Signature)
Full Name : Assoc. Prof. Dr. Cheng Chin Kui
Position : Associate Professor
Date : 01/07/17

(Co-supervisor’s Signature)
Full Name : Assoc. Prof. Dr. Md. Maksudur Rahman Khan
Position : Associate Professor
Date : 01/07/17
STUDENT’S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_______________________________
(Student’s Signature)

Full Name : NG KIM HOONG
ID Number : MKC14028
Date : 01/07/17
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NG KIM HOONG

Thesis submitted in fulfillment of the requirements for the award of the degree of Doctor of Philosophy of Chemical Engineering

Faculty of Chemical and Natural Resources Engineering
UNIVERSITI MALAYSIA PAHANG

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Figure 6.4 Recyclability study for both TiO₂ and ZnO system

Figure 6.5 Longevity study for both TiO₂ and ZnO system
**LIST OF SYMBOLS**

θ angle of incidence, Bragg’s angle  
γ the surface tension of N\textsubscript{2} at its boiling point  
λ wavelength of X-ray beam (nm)  
A Absorbance  
Ads\textsubscript{t} Absorption at time \textit{t}  
Ads\textsubscript{i} Absorption at time \textit{i}  
β\textsubscript{d} true line width at half maximum intensity  
β\textsubscript{obs} observed width at half maximum intensity  
β\textsubscript{inst} instrumental line width by standard  
β\textsubscript{a} angular width at half maximum intensity  
C a characteristic constant of the adsorbate  
d inter plane distance of crystal  
D crystalline size  
D\textsubscript{1}, D\textsubscript{2} DO values of POME  
E\textsubscript{bg} band gap energy  
\textit{hν} photon energy  
k\textsubscript{Sch} Scherrer constant  
n order of reflection  
P decimal volumetric fraction of sample used  
P gas pressure  
P\textsubscript{s} saturation pressure of the adsorbate gas  
P\textsubscript{a} ambient pressure  
P/P\textsubscript{o} relative pressure of N\textsubscript{2}  
r\textsubscript{k} the Kelvin radius of the pore  
R\textsubscript{0}, R apparent absorbance  
R gas constant  
S\textsubscript{BET} BET specific surface area  
t thickness of the adsorbed layer  
T ambient temperature  
V volume of gas adsorbed  
V\textsubscript{m} volume of gas adsorbed corresponding to monolayer coverage
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<table>
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<th>Meaning</th>
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<tr>
<td>AMP</td>
<td>Ampicillin</td>
</tr>
<tr>
<td>AMX</td>
<td>Amoxicillin</td>
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<tr>
<td>AOP</td>
<td>Advanced oxidation process</td>
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<tr>
<td>ASGSC</td>
<td>attached growth system where granular activated carbon was seeded with activated sludge</td>
</tr>
<tr>
<td>BET</td>
<td>Brunauer-Emmett-Teller</td>
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<tr>
<td>BOD</td>
<td>Biochemical oxygen demand</td>
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<tr>
<td>CB</td>
<td>Conduction band</td>
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<tr>
<td>CCD</td>
<td>Central composite design</td>
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<tr>
<td>CLX</td>
<td>Cloxacillin</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical oxygen demand</td>
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<tr>
<td>CO$_2$</td>
<td>catalytic ozonation</td>
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<tr>
<td>CWPO</td>
<td>catalytic wet peroxide oxidation</td>
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<tr>
<td>DRS</td>
<td>diffuse reflectance spectroscopy</td>
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<tr>
<td>EDX</td>
<td>X-ray microanalysis</td>
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<tr>
<td>FESEM</td>
<td>Field Emission Scanning Microscopy Analysis</td>
</tr>
<tr>
<td>FTIR</td>
<td>Fourier transform infrared spectroscopy</td>
</tr>
<tr>
<td>HOMO</td>
<td>highest occupied molecular orbital</td>
</tr>
<tr>
<td>HRT</td>
<td>hydraulic retention time</td>
</tr>
<tr>
<td>LDH</td>
<td>layered double hydroxide</td>
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<td>LED</td>
<td>Light emitting diodes</td>
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<tr>
<td>LUMO</td>
<td>lowest unoccupied molecular orbital</td>
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<td>MBR</td>
<td>membrane bioreactor</td>
</tr>
<tr>
<td>MO</td>
<td>Methyl Orange</td>
</tr>
<tr>
<td>O&amp;G</td>
<td>Oil and grease</td>
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<tr>
<td>OA</td>
<td>Oxolinic acid</td>
</tr>
<tr>
<td>OFAT</td>
<td>one variable at a time</td>
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<td>POME</td>
<td>Palm oil mill effluent</td>
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<td>R&amp;D</td>
<td>Research and development</td>
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<td>RSM</td>
<td>Response surface methodology</td>
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<td>Abbreviation</td>
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<tr>
<td>SAS</td>
<td>suspended activated sludge</td>
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<td>SBR</td>
<td>sequencing batch reactor</td>
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<td>SEM</td>
<td>Scanning electron microscopy</td>
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<td>SKM</td>
<td>Schuster-Kubleka-Munk</td>
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<tr>
<td>SS</td>
<td>Suspended solid</td>
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<td>TC</td>
<td>Tetracycline</td>
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<td>Total solid</td>
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<td>Ultrafiltration</td>
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<td>Ultra-violet</td>
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