## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td>i</td>
</tr>
<tr>
<td>CERTIFICATE</td>
<td>ii</td>
</tr>
<tr>
<td>PLAGIARISM CERTIFICATE</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>vi</td>
</tr>
<tr>
<td>PREFACE</td>
<td>xvi</td>
</tr>
<tr>
<td>ABBREVIATION</td>
<td>xviii</td>
</tr>
</tbody>
</table>

1. **Introduction** 01

1.1 Introduction to Materials 01

1.1.1 Materials overview 01

1.1.2 Nanomaterials 01

1.1.3 Metal oxides 03

1.1.3.1 Metal oxides in Photocatalysis 03

1.1.3.2 Metal oxides in Lithium ion batteries 07

1.1.3.3 Metal oxides as sensors 08

1.1.4 Nanometal- complexes 09

1.1.5 Naturally occurring fuels in combustion synthesis 10
1.2 Literature review

2. Materials and Methods

2.1 Materials

2.2 Methods

2.2.1 Methods of synthesis

2.2.1.1 Combustion synthesis

2.2.1.1.1 Preparation of Cassava starch

2.2.1.1.2 Preparation of metal oxide nanomaterials

2.2.1.2 Co-precipitation

2.2.1.2.1 Preparation of Copper hexacyano ferrate-graphene nanocomposite

2.2.2 Photocatalytic dye degradation

2.2.3 Photocatalytic hydrogen generation

2.2.3 Lithium ion batteries

2.2.5 Microbial growth retardation

2.2.6 Electrochemical sensing

2.2.7 Rechargeable aqueous metal ion battery

2.3 Instrumentation

2.3.1 X-Ray Diffraction

2.3.2 Fourier Transform Infra-Red Spectroscopy

2.3.3 Raman Spectroscopy
2.3.4 Ultra-violet- Visible spectroscopy 29
2.3.5 Photoluminescence spectroscopy 30
2.3.6 BET surface area analyzer 31
2.3.7 X-ray Photoelectron spectroscopy 31
2.3.8 Dynamic light scattering 31
2.3.9 Zeta potential 32
2.3.10 Scanning electron microscopy 32
2.3.11 Transmission electron microscopy 33
2.3.12 Cyclic voltammetry 33
2.3.13 Electrochemical impedance spectroscopy 34

3. **ZnO Nanoparticles for photocatalytic dye degradation, hydrogen generation and antibacterial activity** 35

3.1 Introduction 35
3.2 Experimental procedure 36
3.2.1 Preparation of cassava starch 37
3.2.2 Preparation of ZnO NPs using Cassava starch 37
3.2.3 Optimization of Fuel 37
3.3 Results and discussion 38
3.3.1 Interaction of fuel and precursor 38
3.3.2 Diffraction studies 38
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3.3.1 FTIR studies</td>
<td>41</td>
</tr>
<tr>
<td>3.3.3.2 Raman spectral studies</td>
<td>42</td>
</tr>
<tr>
<td>3.3.4.1 UV–Vis spectral studies</td>
<td>43</td>
</tr>
<tr>
<td>3.3.4.2 Photoluminescence studies</td>
<td>46</td>
</tr>
<tr>
<td>3.3.4.3 Quantum yield</td>
<td>49</td>
</tr>
<tr>
<td>3.3.5 Morphology studies</td>
<td>50</td>
</tr>
<tr>
<td>3.3.6. XPS studies</td>
<td>53</td>
</tr>
<tr>
<td>3.3.7. BET surface area and pore volume</td>
<td>55</td>
</tr>
<tr>
<td>3.3.8.1.1 Photolysis</td>
<td>55</td>
</tr>
<tr>
<td>3.3.8.1.2 Optimization of fuel</td>
<td>56</td>
</tr>
<tr>
<td>3.3.8.1.3. 2 UV-Vis Spectra of MB</td>
<td>56</td>
</tr>
<tr>
<td>3.3.8.1.4 3 Effect of initial concentration of MB</td>
<td>58</td>
</tr>
<tr>
<td>3.3.8.1.4.4 Effect of catalytic load</td>
<td>59</td>
</tr>
<tr>
<td>3.3.8.1.4.5. Effect of pH</td>
<td>60</td>
</tr>
<tr>
<td>3.3.8.1.4.5. Effect of stirring</td>
<td>62</td>
</tr>
<tr>
<td>3.3.8.1.4.5. Efficiency of the recycled catalyst</td>
<td>63</td>
</tr>
<tr>
<td>3.3.8.2. Photocatalytic hydrogen generation</td>
<td>64</td>
</tr>
<tr>
<td>3.3.8.3. Anti-bacterial activity</td>
<td>66</td>
</tr>
</tbody>
</table>
3.4. Conclusion

4. NiO NPs as energy storage material, as photocatalyst in dye degradation and as microbial growth retardant

4.1 Introduction

4.2 Experimental procedure

4.3 Results and discussion

4.3.1 XRD studies

4.3.2.1. Infrared spectral (IR) studies

4.3.2.2. Raman spectral studies

4.3.3.1. PL spectral studies

4.3.3.2. UV-Vis spectral studies

4.3.4. Diffuse light scattering and zeta potential studies

4.3.5.1 SEM studies

4.3.5.2 TEM studies

4.3.6.1. Energy storage studies

4.3.6.2 Photocatalytic degradation studies

4.3.6.3 Microbial growth retardation studies
4.4 Conclusion

5. Hematite Nanoparticles for energy storage, electrochemical sensing and antimicrobial activity

5.1 Introduction

5.2 Experimental Procedure

5.3 Results and discussion

5.3.1 XRD studies

5.3.2 IR spectral studies

5.3.2.2 Raman spectral studies

5.3.3 UV-Vis spectral studies

5.3.4 Diffuse light scattering and zeta potential studies

5.3.5.1 SEM studies

5.3.5.2 TEM studies

5.3.6.1 Galvanostatic cycling

5.3.6.2 Cyclic Voltammetry (CV)

5.3.7 Electrochemical Sensing

5.3.8 Antimicrobial activity

5.4 Conclusion

6 Vanadia Nanowire clusters for lithium batteries and bactericidal activity
6.1 Introduction

6.2 Experimental Procedure

6.3 Results and discussion

6.3.1 Effect of Fuel and Mechanism of nanowire clusters formation
6.3.2 XRD studies
6.3.3 FTIR spectral studies
6.3.4.1 UV-Vis spectral studies
6.3.4.2 PL spectral studies
6.3.5.1 SEM studies
6.3.5.2 TEM studies
6.3.6.1 Cyclic voltammetry studies
6.3.6.2 Galvanostatic cycling studies
6.3.6.3 EIS studies
6.3.7 Bactericidal activity

6.4 Conclusion

7 Copper hexacyanoferrate-Graphene Nanocomposite Electrodes for Potassium ion Aqueous Battery

7.1 Introduction

7.2 Experimental Procedure
7.3 Results and Discussion 127
7.3.1 Structure and Morphology 127
7.3.2 Electrochemical studies 130
7.4 Conclusion 134

8 Conclusion 135
General observation 138
Scope of future work 138
Publication 139
Bibliography 140