



Universiteit
Leiden
The Netherlands

Biomass Electrochemistry : from cellulose to sorbitol

Kwon, Y.

Citation

Kwon, Y. (2013, September 5). *Biomass Electrochemistry : from cellulose to sorbitol*. Retrieved from <https://hdl.handle.net/1887/21649>

Version: Not Applicable (or Unknown)

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/21649>

Note: To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/21649> holds various files of this Leiden University dissertation.

Author: Kwon, Youngkook

Title: Biomass electrochemistry : from cellulose to sorbitol

Issue Date: 2013-09-05

Biomass Electrochemistry: from cellulose to sorbitol

Proefschrift

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van Rector Magnificus prof.mr. C.J.J.M. Stolker,
volgens besluit van het College voor Promoties
te verdedigen op donderdag 5 september 2013
klokke 13.45 uur

door

Youngkook Kwon

Geboren te Gimcheon in 1979

Promotiecommissie:

Promoter: Prof. Dr. M. T. M. Koper

Overige Leden: Prof. Dr. J. Brouwer
Prof. Dr. B. E. Nieuwenhuys
Prof. Dr. E. Bouwman
Prof. Dr. B. M. Weckhuysen (Univ. Utrecht)
Prof. Dr. J. Lee (GIST)
Prof. Dr. P. Strasser (TU Berlin)
Dr. E. De Jong (Avantium)

This research has been performed within the framework of the CatchBio program. The author gratefully acknowledges the support of the Smart Mix Program of the Netherlands Ministry of Economic Affairs and the Netherlands Ministry of Education, Culture, and Science.

*For God so loved the world that he gave his one and only Son,
that whoever believes in him shall not perish but have eternal life.*

John 3:16

Contents

1 Introduction	9
1.1 Biomass	9
1.2 Catalysis	11
1.3 Biomass electrocatalysis	12
1.4 Scope of this thesis	14
1.5 References	17
2 Combining voltammetry with HPLC: Application to electro-oxidation of glycerol	19
2.1 Introduction	20
2.2 Experimental	21
2.2.1 Reagents	21
2.2.2 Electrochemistry	22
2.2.3 Fraction collection	22
2.2.4 Chromatographic determination of products	23
2.3 Results and discussion	23
2.4 Conclusion	30
2.5 References	31
3 Mechanism of the catalytic oxidation of glycerol on polycrystalline gold and platinum electrodes	33
3.1 Introduction	34
3.2 Experimental	35
3.2.1 Electrochemistry	35
3.2.2 Fraction collection	36
3.2.3 Chromatographic determination of products	37
3.2.4 On-line Electrochemical Mass Spectrometry (OLEMS)	37
3.3 Results and discussion	37
3.3.1 Glycerol oxidation in alkaline condition	37
3.3.2 Glycerol oxidation in neutral condition	43
3.3.3 Glycerol oxidation in acidic condition	48
3.4 Conclusion	52
3.5 References	53
4 Highly selective electro-oxidation of glycerol to dihydroxyacetone on platinum in the presence of bismuth	57

4.1 Introduction	58
4.2 Experimental	58
4.3 Results and discussion	60
4.4 Conclusion	70
4.5 References	71
5 Electrocatalytic oxidation of alcohols on gold in alkaline media: base or gold catalysis?	73
5.1 Introduction	74
5.2 Experimental	75
5.3 Results and discussion	76
5.4 Conclusion	81
5.5 References	82
6 Cellobiose Hydrolysis and Decomposition by Electrochemical Generation of Acid and Hydroxyl Radicals	85
6.1 Introduction	86
6.2 Experimental	87
6.2.1 Chemical reactions	87
6.2.2 Electrochemical reactions	87
6.2.3 Fraction Collection and Product Analysis	88
6.2.4 On-line Electrochemical Mass Spectrometry (OLEMS)	88
6.3 Results and discussion	88
6.3.1 Hydrolysis of cellobiose in acid	88
6.3.2 Cellobiose hydrolysis by electrochemically generated acid	92
6.3.3 Cellobiose decomposition by Fenton's reaction	94
6.3.4 Electrochemical cellobiose decomposition on BDD	98
6.4 Conclusion	103
6.5 References	104
7 Electrocatalytic hydrogenation and deoxygenation of glucose on solid metal electrodes	107
7.1 Introduction	108
7.2 Experimental	110
7.2.1 Electrochemical procedures	110
7.2.2 Fraction collection and product analysis	111
7.3 Results and discussion	111
7.3.1 Sorbitol forming metals	112
7.3.2 Sorbitol and 2-deoxysorbitol forming metals	115
7.3.3 Metals producing only H ₂	118

7.3.4 A mechanistic view of glucose reduction	122
7.4 Conclusion	124
7.5 References	125
8 Electrocatalytic hydrogenation of 5-hydroxymethylfurfural in the absence and presence of glucose	129
8.1 Introduction	130
8.2 Experimental	131
8.2.1 Electrochemical procedures	131
8.2.2 Fraction collection and product analysis	132
8.3 Results and discussion	133
8.3.1 HMF reduction in the absence of glucose	134
8.3.2 HMF reduction in the presence of glucose	139
8.3.3 A mechanistic view of HMF hydrogenation	143
8.4 Conclusion	146
8.5 References	147
9 Outlook	151
Summary	155
Samenvatting	159
List of Publications	163
Curriculum Vitae	167

