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Electrocatalytic CO₂ reduction toward liquid fuels : on heterogeneous electrocatalysts and heterogenized molecular catalysts

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List of publications

This thesis is based on the following publications:

Chapter 2

Yuvraj Y. Birdja, Elena Pérez-Gallent, Marta C. Figueiredo, Adrien Göttle, Federico Calle-Vallejo and Marc T. M. Koper

Advances and Challenges in the Electrocatalytic conversion of Carbon Dioxide to Fuels

Nat. Energy, **in preparation**

Chapter 3

Yuvraj Y. Birdja and Marc T. M. Koper

The Importance of Cannizzaro-type Reactions during Electrocatalytic Reduction of Carbon Dioxide

J. Am. Chem. Soc., **2017**, 139, 2030 - 2034

Highlighted as Editors' Choice in Science by Phil Szuromi (Febr. 23, 2017)

CO₂ reduction off base

Science, **355** (6327), 809-810

Chapter 5

Yuvraj Y. Birdja, Jing Shen and Marc T. M. Koper

Influence of the metal center of metalloprotoporphyrins on the electrocatalytic CO₂ reduction to formic acid

Catal. Today, **2017**, 288, 37 - 47

Chapter 6

Yuvraj Y. Birdja, Rafaël E. Vos, Tim A. Wezendonk, Lin Jiang, Freek Kapteijn and Marc T. M. Koper

Effects of Substrate and Polymer encapsulation on CO₂ Electroreduction by Immobilized Indium(III) protoporphyrin

ACS Catal., **under revision**

Chapter 7

Yuvraj Y. Birdja, Olha Nahorna and Marc T. M. Koper

Optimization of Electrolyte Composition for CO₂ Electroreduction on Immobilized Indium(III) protoporphyrin

Manuscript in preparation

Other publications:

Lin Jiang, Wangyang Fu, Yuvraj Y. Birdja, Marc T. M. Koper, Grégory F. Schneider

Quantum and electrochemical interplays in hydrogenated graphene

Nat. Commun., **2018**, in press

Amanda C. Garcia, Yuvraj Y. Birdja, Germano Tremiliosi-Filho and Marc T. M. Koper

Glycerol electro-oxidation on bismuth-modified platinum single crystals

J. Catal., **2017**, 346, 117-124

Amanda C. Garcia, Manuel J. Kolb, Chris van Nierop y Sanches, Jan Vos, Yuvraj Y. Birdja, Youngkook Kwon, Germano Tremiliosi-Filho and Marc T. M. Koper

Strong Impact of Platinum Surface Structure on Primary and Secondary Alcohol Oxidation during Electro-Oxidation of Glycerol

ACS Catal., **2016**, 6, 4491-4500

Jing Shen, Ruud Kortlever, Recep Kas, Yuvraj Y. Birdja, Oscar Diaz-Morales, Youngkook Kwon, Isis Ledezma-Yanez, Klaas Jan P. Schouten, Guido Mul and Marc T. M. Koper

Electrocatalytic reduction of carbon dioxide to carbon monoxide and methane at an immobilized cobalt protoporphyrin

Nat. Commun., **2015**, 6, 8177

Jing Shen, Yuvraj Y. Birdja and Marc T. M. Koper

Electrocatalytic Nitrate Reduction by a Cobalt Protoporphyrin Immobilized on a Pyrolytic Graphite Electrode

Langmuir, **2015**, 31, 8495-8501

Youngkook Kwon, Yuvraj Y. Birdja, Saeed Raoufmoghaddam and Marc T. M. Koper

Electrocatalytic Hydrogenation of 5-Hydroxymethylfurfural in Acidic Solution

ChemSusChem, **2015**, 8, 1745-1751

Y. Y. Birdja, J. Yang and M.T.M. Koper

Electrocatalytic Reduction of Nitrate on Tin-modified Palladium

Electrochim. Acta, **2014**, 140, 518-524

Youngkook Kwon, Yuvraj Birdja, Ioannis Spanos, Paramaconi Rodriguez, Marc T. M. Koper

Highly Selective Electro-Oxidation of Glycerol to Dihydroxyacetone on Platinum in the Presence of Bismuth

ACS Catal., **2012**, 2, 759-764

Curriculum Vitae

Yuvraj Birdja was born in Voorburg, the Netherlands and grew up in Paramaribo, Suriname, where he attended the Algemene Middelbare School (AMS). After graduation from the AMS as nationwide most successful student in 2006, Yuvraj came to the Netherlands for his higher education, and started with the bachelor program Mechanical Engineering at the TU Delft. Due to his interest in chemistry, but the absence hereof in the Mechanical Engineering curriculum, Yuvraj decided to start with the bachelor program Molecular Science & Technology at TU Delft and Leiden University in 2007. Throughout this period as bachelor student, Yuvraj was a member of TopTrack (Honours program community of the faculty 3mE, TU Delft).

After obtaining the Bachelor of Science degree in Mechanical Engineering and Molecular Science & Technology, Yuvraj continued with the respective master programs Mechanical Engineering at the TU Delft, and Chemistry at the Leiden University. As part of the master curriculum Chemistry, Yuvraj did a research internship in the Electrochemical Energy Lab at Massachusetts Institute of Technology, USA, where he worked on lithium-air batteries under supervision of prof. Yang Shao-Horn. Back in the Netherlands, he started his M.Sc. thesis project Mechanical Engineering under supervision of prof. dr. ir. Christian Poelma and prof. dr. ir. Jerry Westerweel at the Laboratory for Aero- and Hydrodynamics, TU Delft. In 2012, Yuvraj graduated as mechanical engineer from TU Delft after he successfully defended his thesis *Laminar to Turbulent Transition in Pulsatile Flow of non-Newtonian Fluids*. Yuvraj was selected by the TU Delft, and afterwards nominated by the jury, for the ECHO award, which is an award for successful students with non-western roots, who distinguish themselves by excellent performance and social involvement. After finishing the master mechanical engineering at TU Delft, Yuvraj started his master thesis project in the group Catalysis and Surface Chemistry of prof. dr. Marc Koper, under supervision of dr. Jian Yang, entitled *Electrocatalytic Nitrate Reduction on Tin-modified Palladium Electrodes*. After finishing the master program chemistry, Yuvraj pursued his PhD with prof. dr. Marc Koper as supervisor, where he worked on the electrocatalytic reduction of carbon dioxide. The results of this work are presented in this dissertation.

During his time as PhD candidate, Yuvraj did a research internship in the group of prof. dr. Marc Robert at the Laboratoire d'Electrochimie Moléculaire,

Université Paris Diderot, France, where he expanded his knowledge on experimental molecular electrocatalysis of CO₂ reduction, particularly in aprotic solvents. Moreover, Yuvraj collaborated with Lin Jiang, M.Sc. and dr. Grégory Schneider on the electrochemistry of graphene. Yuvraj supervised several bachelor students, one master student, practical chemistry courses (PBV - 1st year bachelor) and chemistry working classes (FCK - 2nd year bachelor). He has presented (parts of) his work at several (inter)national conferences and summer schools:

- Annual Meeting of the International Society of Electrochemistry, 2017, Providence, USA - *oral and poster presentation (the poster presentation was awarded the best poster prize of symposium "physical & interfacial electrochemistry")*
- the Netherlands' Catalysis and Chemistry Conference, 2017, Noordwijkerhout, the Netherlands - *oral presentation*
- International Summer School on CO₂ conversion; From fundamentals towards Applications, 2016, Switzerland - *poster presentation*
- Annual Meeting of the International Society of Electrochemistry 2016, The Hague, The Netherlands - *2 poster presentations*
- Summer school: Reactivity of nanoparticles for more efficient and sustainable energy conversion III; rising technologies, 2014, Denmark - *poster presentation*
- Summer school: Advanced Metal-Organic Chemistry and Catalysis, 2014, Deurne, the Netherlands - *poster presentation*

