

BOOK SERIES - 50th Year of Hacettepe University
Series Editor: Adil Denizli

ADVANCED ELECTROCHEMISTRY

***Serdar Abaci
Editor***



**HACETTEPE
UNIVERSITY
2018**

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HACETTEPE UNIVERSITY PRESS
ANKARA - 2018

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ISBN : 978-975-491-472-6

Yayına Hazırlama : **PALME**  **Dizgi-Grafik Birimi**

Yayınevi Sertifika No. : 14142

Baskı : Step Repro Dijital

Sertifika No : 14142

Kitapta yer alan yazı, resim ve şekil 5846 sayılı yasanın hükümlerine göre kısmen ya da tamamen basılamaz, dolaylı dahi olsa kullanılamaz, teksir, fotokopi ya da başka bir teknikle çoğaltılamaz. Her hakkı saklıdır, HACETTEPE ÜNİVERSİTESİ'ne aittir.

PREFACE

We have proudly celebrated the 50th anniversary of the foundation of Hacettepe University. We take pride in being one of the most successful universities in Turkey and being ranked among the leading universities in the World. Since the year 1967, when Hacettepe earned the status of ‘*University*’, it has never given up on its principle of continuously going ahead and reaching for the very best. Hacettepe, always preserving its values and basic principles, has become a pioneer university that has been intertwined with the society and pursued innovations, achieving many “firsts” ahead of others.

From medicine to biology, philosophy, statistics, physics and chemistry; from history of arts to the English, German and French languages; from sociology to engineering, fine arts and conservatory, Hacettepe University started almost 50 years ago developing interdisciplinary collaborations across a wide range of scientific fields, a research trend which has achieved a status of global recognition in the 21st century.

Hacettepe University, which was recognized as “*Research University*” by the decision of Council of Higher Education, dated September 26, 2017, has built a strong “brand” image over these 50 years with its qualified and unique contributions to science in Turkey and has been the country’s gateway to global scientific advances. It has graduated tens of thousands of students, each of whom has been our source of pride with their contributions to science, society and humanity as well as with their worldwide achievements. So have its graduates always been proud of Hacettepe.

Hacettepe University owes its success to its people who have always aimed to move forward by promoting interdisciplinarity and without giving up on the understanding “*To the leading edge... Toward being the best...*”

The Turkish and English series of books you are presented have been prepared in memory of the 50th anniversary of Hacettepe University by Prof. Dr. Adil Denizli, a distinguished researcher and faculty member who has heartily devoted himself to his university and science. Among the editors and authors of the book series are respected scientists from Hacettepe University, Turkey and abroad. The series covers the studies from the multi-/interdisciplinary research areas of sciences, mainly from Medicine, Science and Engineering Sciences, which particularly stand out among the World’s and Hacettepe’s research interests.

Readers benefiting from these books will certainly appreciate the value of the profound contributions Hacettepe University made to science both in the country and in the World each time they see the name of “*Hacettepe University*” in the context of the authors, editors, footnotes, citations and bibliographies. This work is an expression of respect for Hacettepe University and for those who have meticulously served in this university for 50 years with an interdisciplinary understanding.

Thank you Adil Denizli... I would like to express my sincere gratitude and thanks to all those who have contributed to this precious work.

I wish many 50 more years to go forward in line with our motto “*To the leading edge... Toward being the best...*”

Prof. Dr. A. Haluk ÖZEN
Rector

PREFACE

In 1954 “Hacettepe” was founded in two chambers of an old Ankara house as a Chair of Child Health, then in 1967 officially earned “university” status. Hacettepe University celebrated its 50th anniversary in 2017 by proud of rich heritage and the positive, life-changing impact globally through the strength of our research, teaching, innovation and enterprise. In just 50 years Hacettepe University has managed to forge a powerful global reputation as a strong research-led university. To celebrate 50th anniversary numerous standout events were planned and performed by proud of past and dreaming of the future.

The Hacettepe Book Series are published to honor the five decades of work not only for the field but also for society at large and to leave the scientific mark of Hacettepe University to the history.

Prof. Dr. Adil Denizli,
Series Editor

PREFACE

Electrochemistry is the branch of chemistry which involves a vast number of fundamental research and application areas including electrode fabrication, kinetics studies, investigation of materials, sensors for biological or inorganic systems, surface modification and synthesis and characterization, electrochromism, corrosion, solar cells etc. Over the past ten years, great progress have been devoted in electrochemistry research area that new concepts have been explored.

I am honored to find an opportunity to edit “Advanced Electrochemistry” book for the 50th anniversary of Hacettepe University. Hacettepe University was established in 1967 and since then a number of expert researchers and senior academicians have been trained to gain their places in society, education and science. Among these professionals, this book is constructed comprehensively under favour of expert electrochemists. With this book, we want to provide a broad knowledge about recent advances in electrochemistry. For this goal, the book was brought together with readers in eight chapters: *Ultramicroelectrodes (UMEs) as Functional Electroanalytical Tools: Theory, Fabrication and Applications of UMEs* (Chapter 1), *Solar Cell Applications in Electrochemistry* (Chapter 2), *Electrochemical Biosensors for Detection of Important Molecules* (Chapter 3), *Nanomotors: Their Synthesis and Applications* (Chapter 4), *Electrochromism and Electrochromic Conjugated Polymers* (Chapter 5), *Spectroelectrochemistry* (Chapter 6), *Underpotential Deposition (UPD) Technique* (Chapter 7), *Surface Modification of Electrodes with Different Strategies* (Chapter 8).

Chapter 1 covers the concept of ultramicroelectrodes (UMEs), having at least one dimension, on the order of a micrometre (1 μm). Electrochemical behavior of these ultramicroelectrodes is different from that of classical microelectrodes and they offer advantages including minimized ohmic drops, reduced capacitive charging currents, high current density generation, enhanced mass transport and rapid response times owing to their small sizes. The chapter involves a comprehensive understanding of UMEs in trace analysis of molecules electrocatalysis at nanoscale, electroanalysis in single cells and sensing of bio/neurochemicals.

Chapter 2 presents solar cells which have been considered as the latest sustainable sources and discussed about design factor. Electrochemical techniques for solar cell applications have also been put forward.

Chapter 3 includes electrochemical biosensors and representative applications of sensitive, selective and rapid analytical tools for the detection of various analytes such as nucleic acids DNA, whole cell or microorganisms, pollutants for food and environment.

Chapter 4 covers an overview of nanomotors/micromotors which converts chemical energy into the movement or forces acting as tiny machines. These man-made artificial nanoengines can effectively be used in the field of sensing of target molecules, monitoring or transportation/isolation in nanoscience. The recent advances on nanomotor technology, their synthesis methods, and their applications were also discussed.

Chapter 5 describes electrochromism and electrochromic materials especially electrochromic conjugated polymers because of easy structural design, easy synthesis, good film-forming properties, flexibility, high coloration efficiency and short switching times.

Chapter 6 focuses on spectroelectrochemistry which has been used for the characterization studies and the combination of electrochemistry and spectroscopy is particularly important because hybrid technique serves sensitive detection method. Some challenging analytical applications for Raman spectroelectrochemistry, UV-Visible spectroelectrochemistry, Infrared spectroelectrochemistry were presented.

Chapter 7 provides information on the UPD technique, which is one of the electrochemical surface-limited deposition techniques. Fundamentals and the mechanism of UPD were described in detail.

Chapter 8 functionalization of electrode surface with different strategies including chemical and physical methods together with electrochemistry. Combination of nanotechnology with electrochemical sensor technology was presented.

We hope this book will reach researchers, experts, professionalists and students in a variety of interdisciplinary fields including chemistry, physics, health, medicine, engineering etc.

Finally, I am deeply grateful to all authors and reviewers for their contribution, effort and time.

Serdar Abacı, PhD
Editor

Advanced Electrochemistry
Edited by Serdar Abacı

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Serdar Abaci was born in İskenderun, Turkey in 1971. He graduated from chemistry department of Hacettepe University. He was awarded with "İhsan Doğramacı Price" at the same year. Prof. Abaci got his MSc and PhD degrees at Hacettepe University, Department of Chemistry in 1997 and 2002, respectively. Postdoctoral fellow at Auburn University and was awarded as "Successful Young Researcher". In 2006, he was entitled as Associate Professor, four years later he won Hacettepe University Science Award'. In 2013, he became a Professor at Hacettepe University. He was assigned as the head of Hacettepe University Advanced Technologies Application and Research Center (HUNITEK) since April 2017. Prof. Abaci is an expert in the field of electrochemistry and he has a wide teaching statement includes chemistry, analytical chemistry, electrochemistry, electroanalytical chemistry, surface analysis methods, surface chemistry. He supervised 6 MSc and 4 PhD students. He has authored 48 research papers indexed by SCI-Expanded, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI and worked as a reviewer in approximately 10 journals. He presented in numerous national and international congresses. He managed more than 20 research projects supported by Hacettepe University, TUBITAK (Scientific and Technical Research Council of Turkey), TAGEM (General Directorate of Agricultural Research and Policies) and SANTEZ (Industrial Thesis Supporting Program) as the director and researcher. His current main research interest is the development of novel electrochemical surfaces using various materials including nanomaterials and conducting polymers. At the same time, different types of sensors such as ultramicroelectrodes, biosensors and thin films have been constructed for the detection of various analytes.