

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

AFFINITY CHROMATOGRAPHY and RELATED TECHNIQUES

Ziad El Rassi
Adil Denizli
Editors



**HACETTEPE
UNIVERSITY
2018**

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

AFFINITY CHROMATOGRAPHY and RELATED TECHNIQUES

Ziad El Rassi
Adil Denizli
Editors

HACETTEPE UNIVERSITY PRESS
ANKARA - 2019

AFFINITY CHROMATOGRAPHY AND RELATED TECHNIQUES

Adil Denizli and Ziad El Rassi, Editors
Adil Denizli, Series Editor

ISBN: 978-975-491-468-9

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

Yayınevi Sertifika No: 14142

Baskı: Step Repro Dijital

Copyright 2019 by Hacettepe University. All rights reserved.

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.

Adil Denizli, Ph.D
Series Editor

PREFACE

It is my great pleasure to contribute to the Hacettepe Book Series published on the occasion of the 50th anniversary of the foundation of the Hacettepe University. I am very honored to co-edit this book on “Affinity Chromatography and Related Techniques” with Dr. Adil Denizli.

A full credit for the editing of this book goes to Dr. Denizli who assembled 11 solid chapter contributions on the various aspects of bioaffinity chromatography and related techniques from worldwide prominent scientists in the field. The topics of the chapters span over a wide spectrum of bioaffinity and related techniques including histidine-based affinity approach, nano-scale separation techniques in proteomics, magnetic based affinity separations, immobilized metal ion chromatography, boronate affinity chromatography, monolithic affinity columns, two-dimensional chromatography, membrane technologies and molecularly imprinted polymer nanoparticles for solid phase synthesis and MIP assays. In the closing, I would like to wish the Hacettepe University and its Faculty and Staffs continuous flourishing and progress over the coming years.

Ziad El Rassi, Ph.D.
Editor

CONTENTS

CHAPTER 1

HISTIDINE PSEUDOBIOAFFINITY SEPARATION TECHNOLOGY: A POWERFUL TOOL FOR LIFE SCIENCES APPLICATIONS

Assem Elkak..... 1

CHAPTER 2

NANO-SCALE SEPARATION TECHNIQUES AND THEIR APPLICATIONS IN PROTEOMICS-AN OVERVIEW

Cemil Aydoğan and Ziad El Rassi..... 19

CHAPTER 3

MAGNETIC AFFINITY SEPARATION OF ENZYMES

Ivo Safarik and Kristyna Pospiskova 41

CHAPTER 4

A COMPUTATIONAL APPROACH TO AFFINITY INTERACTIONS IN IMMOBILIZED METAL ION CHROMATOGRAPHY

Dima Salha, Müge Andaç and Adil Denizli 63

CHAPTER 5

BORONATE AFFINITY CHROMATOGRAPHY AND GLYCOPROTEIN ENRICHMENTS

Recep Üzek and Serap Şenel 79

CHAPTER 6

IMMOBILIZED METAL-ION AFFINITY CHROMATOGRAPHY

Ömür Acet, Demet Erdönmez and Mehmet Odabaşı 93

CHAPTER 7

AFFINITY CHROMATOGRAPHY ON MONOLITHIC SUPPORTS

Aslıhan Gökaltun, Cemil Aydoğan and Adil Denizli 109

CHAPTER 8

MOLECULARLY IMPRINTED POLYMER NANOPARTICLES: SOLID-PHASE SYNTHESIS AND MINA ASSAYS

Cem Esen and Sergey A. Piletsky 125

CHAPTER 9

TWO-DIMENSIONAL HPLC: GENERAL ASPECTS AND PRACTICAL CONSIDERATIONS

Mehmet Emin Çorman, Canan Armutcu and Engin Bayram 139

CHAPTER 10

MEMBRANE TECHNOLOGIES AND THEIR APPLICATIONS

Fatma Gürbüz, Ömür Acet and Mehmet Odabaşı 165

CHAPTER 11

THE USE OF BACTERIAL PROTEINS FOR ANTIBODY PURIFICATION IN AFFINITY CHROMATOGRAPHY

Sevgi Aslıyüce, Bo Mattiasson and Adil Denizli 185

SUBJECT INDEX 197

Professor Ziad El Rassi was born in Lebanon and received his early education in the school system of Lebanon. The B.S. degree in chemistry was earned at the Lebanese University, Beirut, in 1972, followed by an Education Degree at the same University in 1973. He matriculated to Claude-Bernard University in Lyon, France, for M.S. and Ph.D. degrees in analytical chemistry in 1974 and 1978, respectively. A visiting Assistant Professorship followed at Ecole Centrale de Lyon (Engineering School), France (1978-1980). He then joined the Chemical Engineering Department at Yale University, New Haven, CT, as an Associate Research Scientist (1980-1985) and was appointed to Research Scientist over the period of 1985-1988. An Assistant Professorship was accepted in 1988 at Oklahoma State University (OSU) in the Department of Chemistry. He rose through the ranks to become Full professor in 1998. In 2013, he got promoted to Regents Professor, which is considered the most prestigious rank that may be attained by faculty at Oklahoma State University. El Rassi's current research in separation science is focused on furthering the development of modern liquid phase separation techniques such as high performance liquid chromatography, capillary electrophoresis and capillary electrochromatography by (i) introducing novel separation schemes and principles of high resolving power for biological substances and natural products (ii) investigating the underlying physico-chemical phenomena, (iii) improving the methodology of the three separation techniques, (iv) developing column-based separation platforms for proteomics and (iv) introducing novel applications of general use in the life sciences. During El Rassi's tenure at OSU, he has directed the research of 10 undergraduates, 11 M.S. students, 22 Ph.D. students and 9 Postdoctoral fellows. The research has resulted in 200 peer-reviewed papers and book chapters, 250 presentations including 170 invited lectures at various locations around the world. Also, edited two books on Carbohydrate Analysis in 1995 and 2002. Prof. El Rassi is a member of the permanent scientific committees of The Asia Pacific International Symposium on Microscale Separations, The International Symposium on Capillary Electroseparation Techniques (ITP), and The Latin-American Symposium on Biotechnology, Biomedical, Biopharmaceutical and Industrial Applications of Capillary Electrophoresis and Microchip Technology. Besides serving on the editorial boards of several international journals, Prof. El Rassi is the Editor-In-Chief of the journal ELECTROPHORESIS. He also served as the Chairman of three international symposia, the 17th and 19th and 23rd International Symposium on Electro- and Liquid Phase-separation Techniques in 2010 (ITP 2010), 2012 (ITP 2012) and 2016 (ITP 2016). Prof. El Rassi has received the following research awards: Sigma Xi Lectureship Award in 2004, Regents Distinguished Research Award in 2005, Oklahoma Scientist of the Year Award in 2006 and Oklahoma Chemist of the Year Award in 2007.

Prof. Dr. Adil Denizli completed elementary and high schools in Ankara. He graduated from Chemical Engineering Department of Hacettepe University in 1985. He completed his MSc in 1986 with the studies on "Controlled Delivery of Anticancer Drugs from Polymeric Matrices". He got his Ph.D. degree with the thesis on "Specific Sorbents for Hemoperfusion" in 1992. He became an Associate Professor of Chemical Technologies in 1994. Dr. Denizli is the Hacettepe University Department of Chemistry Professor since 2000. Dr. Denizli has written over 500 articles and 5 invited review articles and 25 book chapters. He published 42 research articles in national journals and 100 popular science articles. He has 2 patents. He is one of the most cited scientists in chemistry and engineering field (18000 citations, over 2500 citations in handbooks, encyclopedias, books and thesis, h-index of 68). He served as an associated member of the Turkish Academy of Sciences from 1999 to 2007, and as a full member since 2007. Dr. Denizli has received "TUBITAK Encouragement Award" in 1998 for his studies on "Biomedicine, Biotechnology and Environmental Applications of Polymeric Matrices". He also received TUBITAK Science Award and Basic Science Award of Popular Science Magazine in 2006. He elected as the most publishing scientist of Hacettepe University between 1995-2005 by COMSTECH. He is an editor of the Protein Chromatography and New Generation Polymeric Systems book (Pozitif Press, 2010) and Affinity-Based Biosensors I and II (Kukla Press, 2015-2016) books, translation editor of Stryer's Biochemistry (Palme Press, 2014) and Principles of Chemistry: A Molecular Approach (Nobel Press, 2015) books. He is the writer of Bioseparation and Polymeric Carriers book (Turkish Academy of Sciences Press, 2011). He is an Editorial Board Member of 25 journals (Honorary Editor: Current Analytical Chemistry and Associate Editor: Current Applied Polymer Science, Bentham Science Publishers). He has supervised 59 Master of Science and 45 PhD theses and 5 post Doctoral research up to now. He organized 18 Chromatography Congress and 12 Affinity Techniques congress, 5 Graduate Summer Schools and 4 Graduate Course. He is married to Dr. Fatma Denizli and has one child (Alp Denizli).