

Contents

List of contributing authors — IX

Mark Benvenuto

1 Incorporating green chemistry into education — 1

- 1.1 Introduction — 1
- 1.2 This volume — 2
 - 1.2.1 The quadruple bottom line — 2
 - 1.2.2 Green chemistry in the Middle East — 3
 - 1.2.3 Virtually green chemistry — 3
 - 1.2.4 Greening the teaching lab — 3
 - 1.2.5 Surfactants versus solvents — 3
 - 1.2.6 Bio-sources and energy production — 4
 - 1.2.7 The green chemistry growth mindset — 4
- 1.3 Summary — 4
- References — 5

George M. Bodner

2 The quadruple bottom line: the advantages of incorporating Green Chemistry into the undergraduate chemistry major — 7

- 2.1 Introduction — 7
- 2.2 The Green Chemistry movement as a community of practice — 8
- 2.3 Differentiating between Green Chemistry and Sustainable Development — 8
- 2.4 Genesis of the Green Chemistry movement — 9
 - 2.4.1 12 principles of Green Chemistry — 10
 - 2.4.2 12 principles of Green Engineering — 12
 - 2.4.3 Implications of the use of the term “design” in the guiding principles — 13
- 2.5 The ACS Green Chemistry Institute (ACS GCI®) — 14
- 2.6 Green Chemistry in the classroom — 16
 - 2.6.1 Beyond benign — 16
 - 2.6.2 The Green Chemistry commitment — 18
- 2.7 The “triple bottom line” in academics — 19
- 2.8 Reflections on the evolution of Green Chemistry in academics — 21
- 2.9 Why there might be a “quadruple bottom line” in academics — 23
- 2.10 A new way of looking at “relevance” — 23
- References — 25

Larry Kolopajlo

3 Green chemistry education in the Middle East — 29

- 3.1 Introduction — 29
- 3.2 Background — 30
 - 3.2.1 Estidama — 30
 - 3.2.2 Geography — 31
 - 3.2.3 Population — 31
 - 3.2.4 Pollution and waste — 31
 - 3.2.5 Water — 32
 - 3.2.6 Economics — 33
 - 3.2.7 Organizations — 33
 - 3.2.8 Education — 33
 - 3.2.9 Academia — 34
- 3.3 GCE contributions in the middle east — 34
 - 3.3.1 Types of green chemical educators — 34
 - 3.3.2 Organizations — 34
 - 3.3.3 Egypt — 37
 - 3.3.4 Malta — 39
 - 3.3.5 Israel — 40
 - 3.3.6 Iran — 41
 - 3.3.7 Saudi Arabia — 42
 - 3.3.8 UAE — 44
 - 3.3.9 Bahrain — 45
 - 3.3.10 Turkey — 45
 - 3.3.11 Palestine — 46
 - 3.3.12 ChemRAWN — 46
 - 3.3.13 ME outreach in GC — 47
- 3.4 Summary — 47
- References — 47

Jonathan Stevens

4 Virtually going green: The role of quantum computational chemistry in reducing pollution and toxicity in chemistry — 53

- 4.1 Introduction — 53
- 4.2 Greening catalysis – enzyme design — 54
- 4.3 Greening catalysis – “in silico” experiments — 55
- 4.4 Toward greener solvents — 57
- 4.5 Polymer production from CO₂ emissions — 58
- 4.6 Conclusion — 62
- References — 62

Serenity Desmond, Christian Ray and José G. Andino Martínez

5 Educational benefits of green chemistry — 67

- 5.1 Introduction — 67
- 5.2 Safety — 69
 - 5.2.1 Prevention — 70
 - 5.2.2 Inherently safer chemistry for accident prevention — 71
 - 5.2.3 Less hazardous chemical syntheses/use of renewable feedstocks/
reduce derivatives — 71
- 5.3 Economic reasons — 71
 - 5.3.1 What are the costs that go into our laboratories? — 72
 - 5.3.2 What are the costs that students incur from our laboratories? — 73
- 5.4 Educational advantages — 74
- 5.5 Conclusions and future work — 77
- References — 77

Daniel Y. Pharr

6 Green analytical chemistry – the use of surfactants as a replacement of organic solvents in spectroscopy — 79

- 6.1 Introduction — 79
- 6.2 General aspects of surfactants — 79
 - 6.2.1 Determination of the CMC — 83
 - 6.2.2 The Krafft and cloud points — 84
 - 6.2.3 Probing the micelle environment — 85
 - 6.2.4 Catalysis — 87
- 6.3 How environmentally safe are they? Concerns and beneficial uses — 89
 - 6.3.1 Biodegradation — 90
 - 6.3.2 Reclamation — 91
 - 6.3.3 Linear alkylbenzenesulfonates in the environment — 91
 - 6.3.4 Perfluorooctanesulfonate in the environment — 93
 - 6.3.5 Cationic surfactants in the environment — 95
- 6.4 Surfactants in analytical chemistry — 96
 - 6.4.1 UV–Visible spectroscopy — 96
 - 6.4.2 Cationic surfactants — 97
 - 6.4.3 Nonionic surfactants — 98
 - 6.4.4 Anionic surfactants — 99
 - 6.4.5 Fluorescence spectroscopy — 99
 - 6.4.6 Phosphorescence spectroscopy — 102
 - 6.4.7 Atomic spectroscopy — 103
 - 6.4.8 Chromatography — 104
 - 6.4.9 Micellar electrokinetic chromatography — 104

6.4.10	Electrochemistry —	105
6.4.11	Extractions —	106
6.4.12	Titrations —	107
6.4.13	Flow injection analysis —	108
6.5	Conclusions —	111
	References —	112

David Consiglio

7	Biofuels, fossil energy ratio, and the future of energy production —	123
7.1	Introduction —	123
7.1.1	What are biofuels? —	123
7.1.2	The transition to fossil fuels —	124
7.1.3	Fossil carbon versus atmospheric carbon —	125
7.2	Solid biofuels —	125
7.3	Liquid biofuels —	126
7.3.1	Gasoline substitutes —	126
7.3.2	Diesel substitutes —	127
7.4	Gaseous biofuels —	127
7.4.1	Biomethane and methane substitutes —	128
7.5	Fuel energy ratio —	129
7.5.1	Energy output —	129
7.5.2	Energy input —	130
7.5.3	FER values —	130
7.6	Problems with biofuels —	131
7.7	Potential for future improvements in biofuels —	132
	References —	133

Steven Kosmas

8	Growing your green chemistry mindset —	137
8.1	Introduction —	137
8.2	Principle #5 Safer Solvents & Auxiliaries —	138
8.3	Principle #4 Designing safer chemicals —	139
8.4	Principle #12 Safer Chemistry for Accident Prevention —	141
8.5	Conclusions —	142
	References —	143

Index — 145