

Contents

Preface — V

1 Overview and introduction to the chemical industry — 1

1.1 Focus and depth — 1

1.2 Recycling — 2

2 Phosgene (carbonyl dichloride) — 5

2.1 Method of production — 5

2.2 Volume of production annually — 6

2.3 Sales — 6

2.4 Uses — 6

2.5 Recycling — 8

3 Butyraldehyde — 9

3.1 Method of production — 9

3.2 Volume of production annually — 9

3.3 Uses — 9

3.3.1 *n*-Butanol, production and uses — 9

3.3.2 Uses of 2-ethylhexanol — 10

3.3.3 Uses of polyvinyl butyral — 11

3.3.4 Uses of trimethylolpropane — 12

3.4 Recycling — 12

4 Acetic anhydride — 15

4.1 Method of production — 15

4.2 Production — 15

4.3 Uses — 17

4.4 Recycling and reuse — 18

5 Linear alpha olefins (LAO) — 19

5.1 Methods of production — 19

5.2 Uses of the different LAOs — 20

5.3 Recycling and reuse — 21

6 *n*-Butanol (1-butanol or *n*-butyl alcohol) — 23

6.1 Method of production — 23

6.2 Uses — 24

6.3 Recycling and reuse — 25

7	Methyl methacrylate — 27
7.1	Method of production — 27
7.1.1	The ACH method — 27
7.1.2	Production from isobutylene — 28
7.1.3	Production from isobutyric acid — 28
7.1.4	The methacrylonitrile process (MAN process) — 29
7.1.5	Production from methyl propionate (the BASF Route) — 29
7.1.6	Production from propionaldehyde — 30
7.1.7	Production from propyne (aka, methyl acetylene) — 30
7.2	Volume of production annually — 31
7.3	Uses — 31
7.4	Recycling and reuse — 32
8	Hexamethylene diamine (HMDA) — 33
8.1	Method of production — 33
8.2	Volume of production and uses — 34
8.3	Recycling and reuse — 35
9	Hydrogen cyanide (HCN) — 37
9.1	Method of production — 37
9.2	Volume of production annually — 38
9.3	Uses — 38
9.3.1	Mining — 38
9.3.2	Adiponitrile — 39
9.3.3	Acetone cyanohydrin — 39
9.3.4	Methionine — 39
9.3.5	Cyanuric chloride and cyanogen chloride — 39
9.3.6	Chelators — 40
9.4	Recycling and reuse — 40
10	Bisphenol A — 41
10.1	Method of production — 41
10.2	Volume of production annually — 42
10.3	Uses — 42
10.3.1	Polycarbonate production — 42
10.3.2	Epoxy resin production — 43
10.4	The controversy — 44
10.5	Recycling and reuse — 45

11	Food additives — 47
11.1	Categorizing food additives: organic and inorganic — 47
11.1.1	Food coloring — 47
11.1.2	Flavor enhancers — 50
11.1.3	Preserving freshness — 53
11.1.4	Enhancing mouth feel — 54
11.1.5	Inorganic additives — 54
11.2	Production — 56
11.3	Recycling — 56
12	Vitamins — 59
12.1	Sources and production — 59
12.1.1	Vitamin A — 59
12.1.2	Vitamin B ₁ — 60
12.1.3	Vitamin B ₂ — 60
12.1.4	Vitamin B ₃ — 61
12.1.5	Vitamin B ₅ — 61
12.1.6	Vitamin B ₆ — 62
12.1.7	Vitamin B ₇ — 63
12.1.8	Vitamin B ₉ — 63
12.1.9	Vitamin B ₁₂ — 65
12.1.10	Vitamin C — 65
12.1.11	Vitamin D — 65
12.1.12	Vitamin E — 67
12.1.13	Vitamin K — 67
12.1.14	Vitamin F — 68
12.2	Vitamin uses — 68
12.3	Recycling — 70
13	Hydrogen peroxide — 71
13.1	Production — 71
13.2	Uses of hydrogen peroxide — 72
13.3	Recycling and reuse — 73
14	Lithium — 75
14.1	Mining and sources — 75
14.2	Extraction chemistry — 76
14.3	Uses — 77
14.3.1	Ceramics and glass — 77
14.3.2	Lithium batteries — 77
14.3.3	Lubricating greases — 78
14.3.4	Air treatment — 79

14.4 Potential uses — 80

14.5 Recycling — 80

15 Tungsten — 83

15.1 Mining and sources — 83

15.2 Extraction chemistry — 84

15.3 Uses — 85

15.4 Recycling and reuse — 85

16 Sodium — 87

16.1 Sources — 87

16.2 Extraction chemistry — 87

16.3 Uses — 88

16.4 Other, heavy alkali metal production and uses — 89

16.5 Recycling — 90

17 Lead — 91

17.1 Sources — 91

17.2 Extraction chemistry — 92

17.3 Uses — 93

17.4 Recycling — 93

18 Rare earth elements — 95

18.1 Sources — 96

18.2 Extraction chemistry — 96

18.2.1 Separation and isolation — 96

18.2.2 Refining to pure rare earth elements — 99

18.3 Uses — 100

18.4 Recycling — 101

19 Thorium — 103

19.1 Sources — 103

19.2 Extraction chemistry — 103

19.3 Uses — 105

19.4 Potential uses for power — 105

19.5 Recycling — 106

20 Catalysts — 107

20.1 Uses — 107

20.2 Syntheses — 107

20.2.1 Metallocenes — 109

20.2.2 Zeolites — 109

20.3 Recycling — 109

- 21 Bromine — 111**
 - 21.1 Mining and sources — 111**
 - 21.2 Extraction chemistry — 112**
 - 21.3 Uses — 113**
 - 21.3.1 Flame retardants — 113**
 - 21.3.2 Halons — 114**
 - 21.3.3 Fumigants — 115**
 - 21.3.4 Drilling fluids — 116**
 - 21.3.5 Vegetable oil — 116**
 - 21.4 Reuse and recycling — 117**
- 22 Fluorine — 119**
 - 22.1 Isolation and production — 119**
 - 22.2 Hydrogen fluoride — 120**
 - 22.3 Cryolite — 121**
 - 22.4 Teflon — 122**
 - 22.5 Fluorinated fibers — 123**
 - 22.6 Dental fluoride and fluoridated water — 123**
 - 22.7 Recycling and reuse — 124**
- 23 Glass — 125**
 - 23.1 Raw materials — 125**
 - 23.1.1 Compositions — 125**
 - 23.1.2 Colors — 127**
 - 23.2 Production — 127**
 - 23.3 Uses — 128**
 - 23.4 Reuse and recycling — 129**
- 24 Cement — 131**
 - 24.1 Sources — 131**
 - 24.2 Production and formulation chemistry — 132**
 - 24.2.1 Hydraulic cement chemistry — 132**
 - 24.2.2 Nonhydraulic cement chemistry — 133**
 - 24.2.3 Other types of cement — 134**
 - 24.3 Uses — 134**
 - 24.4 Recycling — 135**
- 25 Asphalt — 137**
 - 25.1 Source material — 137**
 - 25.2 Formulations and production — 137**
 - 25.3 Uses — 138**
 - 25.4 Reuse and recycling — 138**

26	Biofuels and bioplastics — 141
26.1	Corn for bioethanol — 141
26.2	Sugar cane for bioethanol — 142
26.3	Soybeans for biodiesel — 142
26.4	Algae as a fuel source — 144
26.5	Cellulosic bioethanol — 144
26.6	Production of bioplastics — 145
26.6.1	Bio-polylactic acid — 145
26.6.2	Bio-poly-starch — 146
26.7	Recycling and reuse — 146

Index — 149
