

Contents

Preface	<i>XV</i>
About the Author	<i>XVII</i>
Acknowledgements	<i>XIX</i>

1	Introduction	<i>1</i>
1.1	From the Colloidal State to Nanotechnology	<i>1</i>
1.1.1	Microscience, Colloids, Nanoscience and Nanotechnology	<i>4</i>
1.2	Classification of Emulsions, Foams, Suspensions and Aerosols	<i>6</i>
1.2.1	Emulsions	<i>6</i>
1.2.2	Foams	<i>9</i>
1.2.3	Suspensions	<i>11</i>
1.2.4	Aerosols	<i>14</i>
1.2.5	Hybrids	<i>17</i>
1.3	Characterization and Stability	<i>17</i>
	References	<i>18</i>
2	Dispersion and Dispersed Species Characterization	<i>23</i>
2.1	Introduction	<i>23</i>
2.2	Surface Area, Surfaces, Porosity and Permeability	<i>23</i>
2.2.1	Surface Area	<i>23</i>
2.2.2	Surfaces	<i>27</i>
2.2.3	Porosity	<i>28</i>
2.2.4	Permeability	<i>29</i>
2.3	Size and Size Distribution	<i>30</i>
2.3.1	Microscopy	<i>31</i>
2.3.2	Filtration and Sieving	<i>36</i>
2.3.3	Radiation Scattering	<i>38</i>
2.3.4	Ultramicroscopy	<i>42</i>
2.3.5	Other Techniques	<i>42</i>
2.4	Conductivity	<i>43</i>
2.4.1	Dispersed Phase Identification	<i>43</i>
2.4.2	Sensing Zone Techniques	<i>44</i>
2.4.3	Conductivity of Dispersions	<i>45</i>

2.5	Sedimentation, Creaming and Centrifugation	46
2.5.1	Sedimentation and Creaming	46
2.5.2	Centrifugation and Ultracentrifugation	53
2.6	Characterization of Emulsions	56
2.6.1	Appearance and Emulsion Type	56
2.6.2	Experimental Assessment of Emulsion Stability	58
2.6.3	Composition	59
2.7	Characterization of Foams	60
2.7.1	Appearance and Foam Type	60
2.7.2	Experimental Assessment of Foam Stability	62
2.8	Characterization of Suspensions	66
2.8.1	Chemical and Surface Analysis	66
2.8.2	Experimental Assessment of Suspension Stability	66
2.9	Characterization of Aerosols	67
2.9.1	Aerosol Composition, Concentration, Size and Charge	67
2.9.2	Aerosol Processes and Stability	74
	References	78
3	Interfacial Energetics	85
3.1	Surface Area	85
3.2	Surface and Interfacial Tensions	86
3.2.1	Principles	86
3.2.2	Equation of Young–Laplace	94
3.2.3	Measurement	94
3.2.3.1	Capillary Rise	95
3.2.3.2	Wilhelmy Plate	96
3.2.3.3	du Noüy Ring	97
3.2.3.4	Drop Weight and Volume Methods	98
3.2.3.5	Drop Shape Methods	98
3.2.3.6	Oscillating Jet Method	98
3.2.3.7	Spinning Drop Method	101
3.2.3.8	Maximum Bubble or Droplet Pressure Method	102
3.2.3.9	Microfluidic Methods	103
3.2.4	Experimental Results for Dispersions	103
3.3	Pressure and Curved Surfaces	106
3.4	Contact Angle and Wettability	107
3.5	Surfactants and Micelles	114
3.5.1	Surface Activity	114
3.5.1.1	Retardation of Evaporation by Monolayers	117
3.5.2	Classification and Analysis of Surfactants	118
3.5.3	Micelles	120
3.5.4	Surface Elasticity	126
3.5.5	Polymeric Surfactants	129
3.6	Applications of Surface Activity	129
3.6.1	Surfactants and Emulsification	129

3.6.2	Surfactants and Foaming	132
3.6.3	Surfactants and Flotation	133
3.6.4	Surfactants and Suspensions	134
3.6.5	Surfactants and Wetting	134
3.6.6	Surfactants and Detergency	135
3.7	Other Lyophilic Colloids: Microemulsions	138
	References	142
4	Electrokinetics	147
4.1	Charged Interfaces	147
4.2	Electric Double Layer	149
4.3	Electrokinetic Phenomena	151
4.3.1	Electrophoresis	154
4.3.2	Point of Zero Charge and Isoelectric Point	158
4.3.3	Electrodialysis	159
4.4	Electrostatic Properties in Non-aqueous Media	160
	References	161
5	Colloid Stability	163
5.1	Introduction	163
5.2	Electrostatic and Dispersion Forces	165
5.2.1	Repulsive Forces	165
5.2.2	Dispersion Forces	167
5.3	DLVO Theory and Practice	168
5.3.1	Theory	168
5.3.2	Practical Guidelines	174
5.3.3	Schulze-Hardy Rule	176
5.3.4	Peptization	178
5.4	Hydration and Steric Effects	178
5.4.1	Steric Stabilization	180
5.5	Additional Stabilizing Influences	183
5.5.1	Other Stabilizing Influences for Suspension Stability	183
5.5.2	Other Influences on Emulsion Stability	184
5.5.3	Other Influences on Foam Stability	187
5.6	Kinetics	189
5.7	Destabilization of Colloids	195
5.7.1	Aggregation and Flocculation	195
5.7.2	Structures in Flocculation	196
5.7.3	Bridging Flocculation	198
5.7.4	Agglomeration Flocculation	200
5.7.5	Depletion Flocculation	200
5.7.6	Filtration	200
5.7.7	Foam Stability in the Presence of Oil	201
5.7.7.1	Adsorption of Stabilizing and Destabilizing Components	202
5.7.7.2	Spreading and Entering Coefficients	202

5.7.7.3	Emulsification and Imbibition Models	202
5.7.7.4	Pseudoemulsion Film Model	203
	References	204
6	Colloid Rheology	209
6.1	Introduction	209
6.2	Principles	210
6.3	Measurement	213
6.3.1	Tube Methods	215
6.3.2	Rotational Methods	219
6.3.3	Other Methods	222
6.4	Non-Newtonian Flow Properties	224
6.4.1	Pseudoplasticity	225
6.4.2	Dilatancy	229
6.4.3	Plasticity/Pseudoplasticity with Yield Stress	229
6.4.4	Thixotropy	230
6.4.5	Rheopexy	232
6.4.6	Viscoelasticity	233
6.4.7	Rheomalaxis	233
6.4.8	Summary	234
6.5	Other Viscosity Nomenclature and Parameters	234
6.5.1	Viscosity Nomenclature	234
6.5.2	Other Viscosity Parameters	234
6.5.3	Experimental Considerations	237
6.6	Dispersion Rheology	238
6.6.1	Einstein's Equation	238
6.6.2	Virial Expansions	241
6.6.3	Other Empirical Equations	243
6.6.4	Dispersed Phase Size and Polydispersity	243
6.6.5	Additional Considerations for Emulsions and Foams	244
6.6.6	Other Equations	247
6.7	Surface Rheology	248
6.8	Flow in Pipelines and Constraining Media	250
6.8.1	Applications in Pipeline Flow	250
6.8.2	Applications in Porous Media	252
	References	254
7	Preparation, Inhibition and Destruction of Dispersions	259
7.1	Introduction	259
7.2	Preparation	260
7.2.1	Preparation of Emulsions	260
7.2.2	Preparation of Foams	269
7.2.3	Preparation of Suspensions	271
7.2.4	Preparation of Aerosols	275
7.2.5	Ostwald Ripening	277

7.2.6	Size Fractionation	278
7.3	Destruction and/or Inhibition	279
7.3.1	Demulsification	279
7.3.2	Antifoaming and Defoaming	283
	References	285
8	Introduction to Practical and Industrial Applications	291
8.1	General Uses	291
8.2	Emulsions	292
8.3	Foams	295
8.4	Suspensions	297
8.5	Aerosols	297
8.6	Hazards	300
	References	303
9	Applications in the Environment	307
9.1	Introduction	307
9.2	Rocks, Sediments and Soils	307
9.2.1	Magmas	307
9.2.2	Aquatic Suspensions	307
9.2.3	Soils	310
9.3	Environmental Soil Remediation	311
9.4	Water and Wastewater Treatment	313
9.5	Spills and Other Hazards	315
9.6	Environmental Foam Blankets	318
9.7	Environmental Aerosols	319
9.7.1	Clouds	321
9.7.2	Atmospheric Aerosols and Climate	323
9.7.3	Aerosol Treatment	324
	References	324
10	Mining and Mineral Processing Applications	329
10.1	Introduction	329
10.2	Hydraulic Mining and Hydrotransport	329
10.3	Mineral Flotation	331
10.3.1	Carrier, Emulsion and Floc Flotation	343
10.4	Tailings and Tailings Ponds	344
10.5	Dust-Suppressing Foam Blankets	348
	References	348
11	Petroleum Industry Applications	351
11.1	Introduction	351
11.2	Oilwells, Gas Wells and Near Wells	353
11.2.1	Drilling and Completion Fluids	353
11.2.2	Well Stimulation: Fracturing and Acidizing	355

11.2.3	Gas Well Unloading	357
11.3	Reservoirs	358
11.3.1	Primary and Secondary Oil Recovery	358
11.3.2	Enhanced (Tertiary) Oil Recovery	360
11.3.2.1	Chemical, Microemulsion and Macroemulsion Flooding	361
11.3.2.2	Foam Injection Processes	365
11.4	Surface Operations	368
11.4.1	Surface Treatment	368
11.4.2	Oil Sands Processing	370
11.4.3	Pipeline Transportation	372
11.4.4	Upgraders and Refineries	374
	References	374
12	Manufacturing and Materials Science Applications	383
12.1	Introduction	383
12.2	Wood Processing and Papermaking	383
12.3	Inks and Printing	386
12.4	Emulsions for Road Paving	387
12.5	Metalworking	388
12.6	Cleaning Processes	389
12.6.1	Detergency	389
12.6.2	De-inking	392
12.7	Surface Coatings Including Paints	394
12.8	Polymer Synthesis	397
12.9	Ceramics Manufacture	398
12.9.1	Aerogels and Xerogels	398
12.10	Firefighting Foams	399
12.11	Other Applications	401
	References	401
13	Food Product and Agricultural Applications	405
13.1	Introduction to Food Colloids	405
13.2	Stabilizing Agents	406
13.3	Preparation	408
13.4	Stability	409
13.5	Protein-Stabilized Emulsions	410
13.5.1	Ice Cream	414
13.5.2	Cream Liqueurs	416
13.6	Non-protein-Stabilized Emulsions	416
13.6.1	Carbonated Soft Drinks	418
13.7	Foam Food Products	419
13.7.1	Baked Products	420
13.7.2	Foam Toppings	421
13.7.3	Champagne and Beer Foams	422
13.7.4	Coffee Beverage Foam	423

13.7.5	Undesirable Food Foams	424
13.8	Other Food Colloids	425
13.8.1	Food Suspensions	425
13.8.2	Food Aerosols	425
13.8.3	Mixed Food Colloids	426
13.9	Introduction to Agricultural Colloids	427
	References	429
14	Biological and Medical Applications	433
14.1	Introduction	433
14.2	Vesicle Carriers	438
14.3	Polymer Coatings	439
14.4	Emulsion Carriers	441
14.5	Colloids in Diagnostics	444
14.6	Smart Materials in Medicine	445
	References	446
15	Personal Care Product Applications	449
15.1	Introduction	449
15.2	Detergents, Shampoos and Conditioners	449
15.3	Cosmetic Skin Care Products	452
15.4	Other Personal Care Products	458
15.4.1	Aerosol Sprays and Foams	459
	References	461
16	Emerging Areas in Emulsions, Foams, Suspensions and Aerosols	463
16.1	Introduction	463
16.2	Microscopy, Supermicroscopy and Nanoscopy	463
16.3	Combatting Terror Agents	465
16.4	Smart Colloids and Smart Materials	467
16.5	Nanomaterials and Nanodispersions	471
16.5.1	Nanosheets, Nanotubes and Nanowires	472
16.5.2	Other “Nano” Applications	474
16.6	Nanoscience Phenomenology and Biomimetics	477
16.6.1	Reflective and Antireflective Surfaces	477
16.6.2	Adhesive Surfaces	477
16.6.3	Wetting and Slip on Surfaces	478
16.6.4	Nanomechanics	478
	References	479
	Index	483

