

**TABLE OF CONTENTS**

**1 INTRODUCTION..... 41**

- 1.1 Aims and objectives of the study..... 41
- 1.2 Market definition..... 41
  - 1.2.1 Properties of nanomaterials..... 41
  - 1.2.2 Categorization..... 42

**2 RESEARCH METHODOLOGY..... 43**

**3 EXECUTIVE SUMMARY..... 44**

- 3.1 High performance coatings..... 45
- 3.2 Nanocoatings..... 45
- 3.3 Market drivers and trends..... 46
- 3.4 Global market size and opportunity to 2030..... 48
  - 3.4.1 End user market for nanocoatings..... 48
  - 3.4.2 Global revenues for nanocoatings 2010-2030..... 51
  - 3.4.3 Global revenues for nanocoatings, by market..... 52
    - 3.4.3.1 The market in 2017..... 52
    - 3.4.3.2 The market in 2018..... 54
    - 3.4.3.3 The market in 2030..... 55
  - 3.4.4 Global revenues by nanocoatings, by type..... 57
  - 3.4.5 Regional demand for nanocoatings..... 61
- 3.5 Market and technical challenges..... 63

**4 NANOCOATINGS TECHNICAL ANALYSIS..... 64**

- 4.1 Properties of nanocoatings..... 64
- 4.2 Benefits of using nanocoatings..... 66
  - 4.2.1 Types of nanocoatings..... 66
- 4.3 Production and synthesis methods..... 66
  - 4.3.1 Film coatings techniques analysis..... 68
  - 4.3.2 Superhydrophobic coatings on substrates..... 69
  - 4.3.3 Electrospray and electrospinning..... 70
  - 4.3.4 Chemical and electrochemical deposition..... 71
    - 4.3.4.1 Chemical vapor deposition (CVD)..... 71
    - 4.3.4.2 Physical vapor deposition (PVD)..... 72
    - 4.3.4.3 Atomic layer deposition (ALD)..... 72
    - 4.3.4.4 Aerosol coating..... 73
    - 4.3.4.5 Layer-by-layer Self-assembly (LBL)..... 73
    - 4.3.4.6 Sol-gel process..... 74







- 7.2.2 Benefits of anti-bacterial nanocoatings..... 131
- 7.2.3 Applications..... 134
- 7.2.4 Global market size..... 135
  - 7.2.4.1 Nanocoatings opportunity..... 135
  - 7.2.4.2 Global revenues 2010-2030..... 137
- 7.2.5 Companies..... 138
- 7.3 ANTI-CORROSION NANOCOATINGS..... 140
  - 7.3.1 Market drivers and trends..... 141
  - 7.3.2 Benefits of anti-corrosion nanocoatings..... 142
    - 7.3.2.1 Smart self-healing coatings..... 144
    - 7.3.2.2 Superhydrophobic coatings..... 144
    - 7.3.2.3 Graphene..... 145
  - 7.3.3 Applications..... 145
  - 7.3.4 Global market size..... 146
    - 7.3.4.1 Nanocoatings opportunity..... 146
    - 7.3.4.2 Global revenues 2010-2030..... 148
  - 7.3.5 Companies..... 149
- 7.4 ABRASION & WEAR-RESISTANT NANOCOATINGS..... 151
  - 7.4.1 Market drivers and trends..... 152
  - 7.4.2 Benefits of abrasion and wear-resistant nanocoatings..... 153
  - 7.4.3 Markets..... 153
  - 7.4.4 Global market size..... 154
    - 7.4.4.1 Nanocoatings opportunity..... 154
    - 7.4.4.2 Global revenues 2010-2030..... 156
  - 7.4.5 Companies..... 157
- 7.5 BARRIER NANOCOATINGS..... 159
  - 7.5.1 Market drivers and trends..... 159
  - 7.5.2 Benefits of barrier nanocoatings..... 159
    - 7.5.2.1 Increased shelf life..... 159
    - 7.5.2.2 Graphene..... 160
    - 7.5.2.3 Moisture protection..... 160
  - 7.5.3 Global market size..... 161
    - 7.5.3.1 Nanocoatings opportunity..... 161
    - 7.5.3.2 Global revenues 2010-2030..... 163
  - 7.5.4 Companies..... 164
- 7.6 ANTI-FOULING AND EASY-TO-CLEAN NANOCOATINGS..... 165
  - 7.6.1 Market drivers and trends..... 166
  - 7.6.2 Benefits of anti-fouling and easy-to-clean nanocoatings..... 167
  - 7.6.3 Applications..... 167
    - 7.6.3.1 Anti-graffiti..... 167
  - 7.6.4 Global market size..... 168
    - 7.6.4.1 Nanocoatings opportunity..... 168
    - 7.6.4.2 Global revenues 2010-2030..... 170
  - 7.6.5 Companies..... 171
- 7.7 SELF-CLEANING (BIONIC) NANOCOATINGS..... 173



- 7.7.1 Market drivers and trends..... 174
- 7.7.2 Market drivers and trends..... 174
- 7.7.3 Benefits of self-cleaning nanocoatings..... 174
- 7.7.4 Global market size..... 175
  - 7.7.4.1 Nanocoatings opportunity..... 176
  - 7.7.4.2 Global revenues 2010-2030..... 177
- 7.7.5 Companies..... 179
- 7.8 SELF-CLEANING (PHOTOCATALYTIC) NANOCOATINGS..... 180
  - 7.8.1 Market drivers and trends..... 181
  - 7.8.2 Benefits of photocatalytic self-cleaning nanocoatings..... 181
  - 7.8.3 Applications..... 181
    - 7.8.3.1 Self-Cleaning Coatings..... 181
    - 7.8.3.2 Indoor Air Pollution and Sick Building Syndrome..... 182
    - 7.8.3.3 Outdoor Air Pollution..... 182
    - 7.8.3.4 Water Treatment..... 182
  - 7.8.4 Global market size..... 183
    - 7.8.4.1 Nanocoatings opportunity..... 183
    - 7.8.4.2 Global revenues 2010-2030..... 185
  - 7.8.5 Companies..... 186
- 7.9 UV-RESISTANT NANOCOATINGS..... 188
  - 7.9.1 Market drivers and trends..... 189
  - 7.9.2 Benefits of UV-resistant nanocoatings..... 189
    - 7.9.2.1 Textiles..... 189
    - 7.9.2.2 Wood coatings..... 189
  - 7.9.3 Global market size..... 190
    - 7.9.3.1 Nanocoatings opportunity..... 190
    - 7.9.3.2 Global revenues 2010-2030..... 192
  - 7.9.4 Companies..... 193
- 7.10 THERMAL BARRIER AND FLAME RETARDANT NANOCOATINGS..... 194
  - 7.10.1 Market drivers and trends..... 195
  - 7.10.2 Benefits of thermal barrier and flame retardant nanocoatings..... 195
  - 7.10.3 Applications..... 196
  - 7.10.4 Global market size..... 196
    - 7.10.4.1 Nanocoatings opportunity..... 197
    - 7.10.4.2 Global revenues 2010-2030..... 198
  - 7.10.5 Companies..... 200
- 7.11 ANTI-ICING AND DE-ICING..... 201
  - 7.11.1 Market drivers and trends..... 201
  - 7.11.2 Benefits of nanocoatings..... 203
    - 7.11.2.1 Hydrophobic and superhydrophobic coatings (HSH)..... 203
    - 7.11.2.2 SLIPS..... 204
    - 7.11.2.3 Heatable coatings..... 204
    - 7.11.2.4 Anti-freeze protein coatings..... 205
  - 7.11.3 Global market size..... 206







▪	8.5.2.2	Food preparation and processing.....	264
▪	8.5.2.3	Indoor pollutants and air quality.....	264
○	8.5.3	Global market size.....	265
▪	8.5.3.1	Nanocoatings opportunity.....	265
▪	8.5.3.2	Global revenues 2010-2030.....	266
○	8.5.4	Companies.....	268
●	8.6	MARINE.....	269
○	8.6.1	Market drivers and trends.....	269
○	8.6.2	Applications.....	270
○	8.6.3	Global market size.....	271
▪	8.6.3.1	Nanocoatings opportunity.....	271
▪	8.6.3.2	Global revenues 2010-2030.....	272
○	8.6.4	Companies.....	273
●	8.7	MEDICAL & HEALTHCARE.....	275
○	8.7.1	Market drivers and trends.....	275
○	8.7.2	Applications.....	276
▪	8.7.2.1	Anti-fouling.....	277
▪	8.7.2.2	Anti-microbial and infection control.....	277
▪	8.7.2.3	Nanosilver.....	277
▪	8.7.2.4	Medical device coatings.....	277
○	8.7.3	Global market size.....	279
▪	8.7.3.1	Nanocoatings opportunity.....	279
▪	8.7.3.2	Global revenues 2010-2030.....	280
○	8.7.4	Companies.....	281
●	8.8	MILITARY AND DEFENCE.....	283
○	8.8.1	Market drivers and trends.....	283
○	8.8.2	Applications.....	284
▪	8.8.2.1	Textiles.....	284
▪	8.8.2.2	Military equipment.....	284
▪	8.8.2.3	Chemical and biological protection.....	285
▪	8.8.2.4	Decontamination.....	285
▪	8.8.2.5	Thermal barrier.....	285
▪	8.8.2.6	EMI/ESD Shielding.....	285
▪	8.8.2.7	Anti-reflection.....	285
○	8.8.3	Global market size.....	286
▪	8.8.3.1	Nanocoatings opportunity.....	286
▪	8.8.3.2	Global market revenues 2010-2030.....	286
○	8.8.4	Companies.....	288
●	8.9	PACKAGING.....	289
○	8.9.1	Market drivers and trends.....	289
○	8.9.2	Applications.....	289
▪	8.9.2.1	Nanoclays.....	290
▪	8.9.2.2	Nanosilver.....	291





	▪ 8.9.2.3 Nanocellulose.....	292
○ 8.9.3	Global market size.....	292
	▪ 8.9.3.1 Nanocoatings opportunity.....	292
	▪ 8.9.3.2 Global market revenues 2010-2030.....	293
○ 8.9.4	Companies.....	294
• 8.10	TEXTILES AND APPAREL.....	295
○ 8.10.1	Market drivers and trends.....	295
○ 8.10.2	Applications.....	296
	▪ 8.10.2.1 Protective textiles.....	296
	▪ 8.10.2.2 UV-resistant textile coatings.....	300
	▪ 8.10.2.3 Conductive coatings.....	300
○ 8.10.3	Global market size.....	302
	▪ 8.10.3.1 Nanocoatings opportunity.....	302
	▪ 8.10.3.2 Global market revenues 2010-2030.....	304
○ 8.10.4	Companies.....	305
• 8.11	ENERGY.....	307
○ 8.11.1	Market drivers and trends.....	307
○ 8.11.2	Applications.....	307
	▪ 8.11.2.1 Wind energy.....	307
	▪ 8.11.2.2 Solar.....	308
	▪ 8.11.2.3 Anti-reflection.....	309
	▪ 8.11.2.4 Gas turbine coatings.....	309
○ 8.11.3	Global market size.....	309
	▪ 8.11.3.1 Nanocoatings opportunity.....	310
	▪ 8.11.3.2 Global market revenues 2010-2030.....	311
○ 8.11.4	Companies.....	312
• 8.12	OIL AND GAS.....	314
○ 8.12.1	Market drivers and trends.....	314
○ 8.12.2	Applications.....	315
	▪ 8.12.2.1 Anti-corrosion pipelines.....	317
	▪ 8.12.2.2 Drilling in sub-zero climates.....	317
○ 8.12.3	Global market size.....	317
	▪ 8.12.3.1 Nanocoatings opportunity.....	318
	▪ 8.12.3.2 Global market revenues 2010-2030.....	319
○ 8.12.4	Companies.....	320
• 8.13	TOOLS AND MACHINING.....	322
○ 8.13.1	Market drivers and trends.....	322
○ 8.13.2	Applications.....	322
○ 8.13.3	Global market size.....	322
	▪ 8.13.3.1 Global market revenues 2010-2030.....	322
○ 8.13.4	Companies.....	324
• 8.14	ANTI-COUNTERFEITING.....	325
○ 8.14.1	Market drivers and trends.....	325
○ 8.14.2	Applications.....	325
○ 8.14.3	Global market size.....	326
	▪ 8.14.3.1 Global market revenues 2010-2030.....	326
○ 8.14.4	Companies.....	327



<b>9 NANOCOATINGS COMPANIES.....</b>	<b>329</b>
• 9.1 UNITED STATES..... COMPANY PROFILES)	329 (137)
• 9.2 CANADA..... COMPANY PROFILES)	396 (15)
• 9.3 EUROPE..... COMPANY PROFILES)	403 (153)
• 9.4 AUSTRALIA..... COMPANY PROFILES)	479 (6)
• 9.5 ASIA..... COMPANY PROFILES)	481 (53)
<b>10 REFERENCES.....</b>	<b>508</b>

## TABLES

• Table 1: Categorization of nanomaterials.....	42
• Table 2: Properties of nanocoatings.....	46
• Table 3: Market drivers and trends in nanocoatings.....	46
• Table 4: End user markets for nanocoatings.....	48
• Table 5: Global revenues for nanocoatings, 2010-2030, millions USD.....	51
• Table 6: Global revenues for nanocoatings, 2017, millions USD, by market.....	52
• Table 7: Estimated revenues for nanocoatings, 2018, millions USD, by market.....	54
• Table 8: Estimated revenues for nanocoatings, 2030, millions USD, by market.....	55
• Table 9: Global revenues for nanocoatings, 2017, millions USD, by type.....	57
• Table 10: Estimated global revenues for nanocoatings, 2018, millions USD, by type.....	59
• Table 11: Estimated revenues for nanocoatings, 2030, millions USD, by type.....	60
• Table 12: Market and technical challenges for nanocoatings.....	63
• Table 13: Technology for synthesizing nanocoatings agents.....	66
• Table 14: Film coatings techniques.....	68
• Table 15: Contact angles of hydrophilic, super hydrophilic, hydrophobic and superhydrophobic surfaces..... 77	
• Table 16: Disadvantages of commonly utilized superhydrophobic coating methods.....	79
• Table 17: Applications of oleophobic & omniphobic coatings.....	81
• Table 18: Nanomaterials used in nanocoatings and applications.....	83
• Table 19: Graphene properties relevant to application in coatings.....	85
• Table 20: Uncoated vs. graphene coated (right) steel wire in corrosive environment solution after 30 days..... 87	
• Table 21: Nanocellulose applications timeline in the coatings and paints markets.....	104
• Table 22: Applications of cellulose nanofibers(CNF).....	105
• Table 23: Applications of bacterial cellulose (BC).....	109
• Table 24: Companies developing cellulose nanofibers products in coatings.....	111
• Table 25: Nanocoatings market structure.....	114
• Table 26: Anti-fingerprint nanocoatings-Nanomaterials used, principles, properties and applications..... 117	
• Table 27: Market assessment for anti-fingerprint nanocoatings.....	122
• Table 28: Potential addressable market for anti-fingerprint nanocoatings.....	122
• Table 29: Revenues for anti-fingerprint nanocoatings, 2010-2030, millions USD.....	123
• Table 30: Anti-fingerprint coatings product and application developers.....	125
• Table 31: Anti-bacterial nanocoatings-Nanomaterials used, principles, properties and applications..... 127	
• Table 32: Nanomaterials utilized in Anti-bacterial coatings-benefits and applications.....	133
• Table 33: Anti-bacterial nanocoatings markets and applications.....	134
• Table 35: Market assessment of Anti-bacterial nanocoatings.....	136
• Table 36: Opportunity for Anti-bacterial nanocoatings.....	136
• Table 37: Revenues for Anti-bacterial nanocoatings, 2010-2030, US\$.....	137
• Table 38: Anti-bacterial nanocoatings product and application developers.....	138



- Table 39: Anti-corrosion nanocoatings-Nanomaterials used, principles, properties and applications..... 140
- Table 40: Market drivers and trends in anti-corrosion nanocoatings..... 141
- Table 41: Superior corrosion protection using graphene-added epoxy coatings, right, as compared to a commercial zinc-rich epoxy primer, left..... 145
- Table 42: Anti-corrosion nanocoatings markets and applications..... 145
- Table 43: Market assessment for anti-corrosion nanocoatings..... 147
- Table 44: Opportunity for anti-corrosion nanocoatings by 2030..... 147
- Table 45: Revenues for anti-corrosion nanocoatings, 2010-2030..... 148
- Table 46: Anti-corrosion nanocoatings product and application developers..... 149
- Table 47: Abrasion & wear resistant nanocoatings-Nanomaterials used, principles, properties and applications..... 151
- Table 48: Market drivers and trends in abrasion & wear-resistant nanocoatings..... 152
- Table 49: Abrasion & wear resistant nanocoatings markets and applications..... 153
- Table 50: Abrasion and wear resistant nanocoatings markets, applications and potential revenues..... 154
- Table 51: Market assessment for abrasion and wear resistant nanocoatings..... 155
- Table 52: Revenues for abrasion and wear resistant nanocoatings, 2010-2030, US\$..... 156
- Table 53: Abrasion and wear resistant nanocoatings product and application developers..... 157
- Table 54: Market trends and drivers in barrier nanocoatings..... 159
- Table 55: Barrier nanocoatings markets, applications and potential addressable market..... 161
- Table 56: Market assessment for barrier nanocoatings and films..... 162
- Table 57: Revenues for barrier nanocoatings, 2010-2030, US\$..... 163
- Table 58: Barrier nanocoatings product and application developers..... 164
- Table 59: Anti-fouling and easy-to-clean nanocoatings-Nanomaterials used, principles, properties and applications. 165
- Table 60: Market drivers and trends in Anti-fouling and easy-to-clean nanocoatings..... 166
- Table 61: Anti-fouling and easy-to-clean nanocoatings markets, applications and potential addressable market..... 169
- Table 62: Market assessment for anti-fouling and easy-to-clean nanocoatings..... 169
- Table 63: Revenues for anti-fouling and easy-to-clean nanocoatings, 2010-2030, US\$..... 170
- Table 64: Anti-fouling and easy-to-clean nanocoatings product and application developers..... 171
- Table 65: Self-cleaning (bionic) nanocoatings-Nanomaterials used, principles, properties and applications..... 173
- Table 66: Market drivers and trends in Self-cleaning (bionic) nanocoatings..... 174
- Table 67: Self-cleaning (bionic) nanocoatings-Markets and applications..... 176
- Table 68: Market assessment for self-cleaning (bionic) nanocoatings..... 176
- Table 69: Revenues for self-cleaning nanocoatings, 2010-2030, US\$..... 177
- Table 70: Self-cleaning (bionic) nanocoatings product and application developers..... 179
- Table 71: Self-cleaning (photocatalytic) nanocoatings-Nanomaterials used, principles, properties and applications.. 180
- Table 72: Market drivers and trends in photocatalytic nanocoatings..... 181
- Table 73: Photocatalytic nanocoatings-Markets, applications and potential addressable market size by 2027..... 184
- Table 74: Market assessment for self-cleaning (photocatalytic) nanocoatings..... 184
- Table 75: Revenues for self-cleaning (photocatalytic) nanocoatings, 2010-2030, US\$..... 185
- Table 76: Self-cleaning (photocatalytic) nanocoatings product and application developers..... 186
- Table 77: UV-resistant nanocoatings-Nanomaterials used, principles, properties and applications..... 188
- Table 78: Market drivers and trends in UV-resistant nanocoatings..... 189
- Table 79: UV-resistant nanocoatings-Markets, applications and potential addressable market..... 191
- Table 80: Market assessment for UV-resistant nanocoatings..... 191
- Table 81: Revenues for UV-resistant nanocoatings, 2010-2030, US\$..... 192
- Table 82: UV-resistant nanocoatings product and application developers..... 193
- Table 83: Thermal barrier and flame retardant nanocoatings-Nanomaterials used, principles, properties and applications..... 194
- Table 84: Market drivers and trends in thermal barrier and flame retardant nanocoatings..... 195
- Table 85: Nanomaterials utilized in thermal barrier and flame retardant coatings and benefits thereof..... 196
- Table 86: Thermal barrier and flame retardant nanocoatings-Markets, applications and potential addressable markets..... 197
- Table 87: Market assessment for thermal barrier and flame retardant nanocoatings..... 198



• Table 88: Revenues for thermal barrier and flame retardant nanocoatings, 2010-2030, US\$.....	199
• Table 89: Thermal barrier and flame retardant nanocoatings product and application developers.....	200
• Table 90: Anti-icing nanocoatings-Nanomaterials used, principles, properties, applications.....	201
• Table 91: Market drivers and trends in anti-icing and de-icing nanocoatings.....	201
• Table 92: Nanomaterials utilized in anti-icing coatings and benefits thereof.....	205
• Table 93: Anti-icing and de-icing nanocoatings-Markets, applications and potential addressable markets.....	206
• Table 94: Market assessment for anti-icing and de-icing nanocoatings.....	207
• Table 95: Revenues for anti-icing and de-icing nanocoatings, 2010-2030, US\$, conservative and optimistic estimates.....	208
• Table 96: Anti-icing and de-icing nanocoatings product and application developers.....	209
• Table 97: Anti-reflective nanocoatings-Nanomaterials used, principles, properties and applications.....	211
• Table 98: Market drivers and trends in Anti-reflective nanocoatings.....	211
• Table 99: Market opportunity for anti-reflection nanocoatings.....	213
• Table 100: Revenues for anti-reflective nanocoatings, 2010-2030, US\$.....	213
• Table 101: Anti-reflective nanocoatings product and application developers.....	215
• Table 102: Types of self-healing coatings and materials.....	219
• Table 103: Comparative properties of self-healing materials.....	220
• Table 104: Types of self-healing nanomaterials.....	221
• Table 105: Self-healing nanocoatings product and application developers.....	221
• Table 106. Market drivers and trends for nanocoatings in aviation and aerospace.....	224
• Table 107: Types of nanocoatings utilized in aerospace and application.....	225
• Table 108: Revenues for nanocoatings in the aerospace industry, 2010-2030.....	229
• Table 109: Aerospace nanocoatings product developers.....	230
• Table 110: Market drivers and trends for nanocoatings in the automotive market.....	233
• Table 111: Anti-scratch automotive nanocoatings.....	234
• Table 112: Conductive automotive nanocoatings.....	234
• Table 113: Hydro- and oleophobic automotive nanocoatings.....	234
• Table 114: Anti-corrosion automotive nanocoatings.....	235
• Table 115: UV-resistance automotive nanocoatings.....	235
• Table 116: Thermal barrier automotive nanocoatings.....	235
• Table 117: Flame retardant automotive nanocoatings.....	235
• Table 118: Anti-fingerprint automotive nanocoatings.....	236
• Table 119: Anti-bacterial automotive nanocoatings.....	236
• Table 120: Self-healing automotive nanocoatings.....	236
• Table 121: Revenues for nanocoatings in the automotive industry, 2010-2030, US\$, conservative and optimistic estimate.....	238
• Table 122: Automotive nanocoatings product developers.....	239
• Table 123: Market drivers and trends for nanocoatings in the construction market.....	242
• Table 124: Nanocoatings applied in the construction industry-type of coating, nanomaterials utilized and benefits... 242	
• Table 125: Photocatalytic nanocoatings-Markets and applications.....	245
• Table 126: Revenues for nanocoatings in construction, architecture and exterior protection, 2010-2030, US\$..... 248	
• Table 127: Construction, architecture and exterior protection nanocoatings product developers.....	249
• Table 128: Market drivers for nanocoatings in electronics.....	253
• Table 129: Main companies in waterproof nanocoatings for electronics, products and synthesis methods..... 255	
• Table 130: Conductive electronics nanocoatings.....	256
• Table 131: Anti-fingerprint electronics nanocoatings.....	256
• Table 132: Anti-abrasion electronics nanocoatings.....	257
• Table 133: Conductive electronics nanocoatings.....	257
• Table 134: Revenues for nanocoatings in electronics, 2010-2030, US\$.....	260
• Table 135: Nanocoatings applications developers in electronics.....	261
• Table 136: Market drivers and trends for nanocoatings in household care and sanitary.....	263
• Table 137: Revenues for nanocoatings in household care, sanitary and indoor air quality, 2010-2030, US\$..... 266	
• Table 138: Household care, sanitary and indoor air quality nanocoatings product developers.....	268
• Table 139: Market drivers and trends for nanocoatings in the marine industry.....	269



- Table 140: Nanocoatings applied in the marine industry-type of coating, nanomaterials utilized and benefits..... 271
- Table 141: Revenues for nanocoatings in the marine sector, 2010-2030, US\$..... 272
- Table 142: Marine nanocoatings product developers..... 273
- Table 143: Market drivers and trends for nanocoatings in medicine and healthcare..... 275
- Table 144: Nanocoatings applied in the medical industry-type of coating, nanomaterials utilized, benefits and applications..... 276
- Table 145: Types of advanced coatings applied in medical devices and implants..... 278
- Table 146: Nanomaterials utilized in medical implants..... 278
- Table 147: Revenues for nanocoatings in medical and healthcare, 2010-2030, US\$..... 280
- Table 148: Medical and healthcare nanocoatings product developers..... 281
- Table 149: Market drivers and trends for nanocoatings in the military and defence industry..... 284
- Table 150: Revenues for nanocoatings in military and defence, 2010-2030, US\$..... 287
- Table 151: Military and defence nanocoatings product and application developers..... 288
- Table 152: Market drivers and trends for nanocoatings in the packaging industry..... 289
- Table 153: Revenues for nanocoatings in packaging, 2010-2030, US\$..... 293
- Table 154: Packaging nanocoatings companies..... 294
- Table 155: Market drivers and trends for nanocoatings in the textiles and apparel industry..... 295
- Table 156: Applications in textiles, by advanced materials type and benefits thereof..... 297
- Table 157: Nanocoatings applied in the textiles industry-type of coating, nanomaterials utilized, benefits and applications..... 298
- Table 158: Applications and benefits of graphene in textiles and apparel..... 301
- Table 159: Revenues for nanocoatings in textiles and apparel, 2010-2030, US\$..... 304
- Table 160: Textiles nanocoatings product developers..... 305
- Table 161: Market drivers and trends for nanocoatings in the energy industry..... 307
- Table 162: Revenues for nanocoatings in energy, 2010-2030, US\$..... 311
- Table 163: Renewable energy nanocoatings product developers..... 312
- Table 164: Market drivers and trends for nanocoatings in the oil and gas exploration industry..... 314
- Table 165: Desirable functional properties for the oil and gas industry afforded by nanomaterials in coatings..... 315
- Table 166: Revenues for nanocoatings in oil and gas exploration, 2010-2030, US\$..... 319
- Table 167: Oil and gas nanocoatings product developers..... 321
- Table 168: Market drivers and trends for nanocoatings in tools and machining..... 322
- Table 169: Revenues for nanocoatings in Tools and manufacturing, 2010-2030, US\$..... 322
- Table 170: Tools and manufacturing nanocoatings product and application developers..... 324
- Table 171: Revenues for nanocoatings in anti-counterfeiting, 2010-2030, US\$..... 326
- Table 172: Anti-counterfeiting nanocoatings product and application developers..... 327

**FIGURES**

- Figure 1: Global revenues for nanocoatings, 2010-2030, millions USD..... 52
- Figure 2: Global market revenues for nanocoatings 2017, millions USD, by market..... 53
- Figure 3: Markets for nanocoatings 2017, %..... 54
- Figure 4: Estimated market revenues for nanocoatings 2018, millions USD, by market..... 55
- Figure 5: Estimated market revenues for nanocoatings 2030, millions USD, by market..... 56
- Figure 6: Markets for nanocoatings 2030, %..... 57
- Figure 7: Global revenues for nanocoatings, 2017, millions USD, by type..... 58
- Figure 8: Markets for nanocoatings 2017, by nanocoatings type, %..... 58
- Figure 9: Estimated global revenues for nanocoatings, 2018, millions USD, by type..... 59
- Figure 10: Market for nanocoatings 2030, by nanocoatings type, US\$..... 60
- Figure 11: Market for nanocoatings 2030, by nanocoatings type, %..... 61
- Figure 12: Regional demand for nanocoatings, 2017..... 62
- Figure 13: Regional demand for nanocoatings, 2018..... 62
- Figure 14: Regional demand for nanocoatings, 2030..... 63
- Figure 15: Hydrophobic fluoropolymer nanocoatings on electronic circuit boards..... 65
- Figure 16: Nanocoatings synthesis techniques..... 67
- Figure 17: Techniques for constructing superhydrophobic coatings on substrates..... 69
- Figure 18: Electrospray deposition..... 71



- Figure 19: CVD technique..... 71
- Figure 20: Schematic of ALD..... 73
- Figure 21: SEM images of different layers of TiO<sub>2</sub> nanoparticles in steel surface..... 74
- Figure 22: The coating system is applied to the surface. The solvent evaporates..... 75
- Figure 23: A first organization takes place where the silicon-containing bonding component (blue dots in figure 2) bonds covalently with the surface and cross-links with neighbouring molecules to form a strong three-dimensional..... 75
- Figure 24: During the curing, the compounds or- ganise themselves in a nanoscale monolayer. The fluorine-containing repellent component (red dots in figure 3) on top makes the glass hydro- phobic and oleophobic..... 76
- Figure 25: (a) Water drops on a lotus leaf..... 77
- Figure 26: A schematic of (a) water droplet on normal hydrophobic surface with contact angle greater than 90° and (b) water droplet on a superhydrophobic surface with a contact angle > 150°..... 78
- Figure 27: Contact angle on superhydrophobic coated surface..... 78
- Figure 28: Self-cleaning nanocellulose dishware..... 80
- Figure 29: SLIPS repellent coatings..... 81
- Figure 30: Omniphobic coatings..... 82
- Figure 31: Graphair membrane coating..... 85
- Figure 32: Antimicrobial activity of Graphene oxide (GO)..... 87
- Figure 33: Conductive graphene coatings for rotor blades..... 88
- Figure 34: Water permeation through a brick without (left) and with (right) “graphene paint” coating..... 88
- Figure 35: Graphene heat transfer coating..... 89
- Figure 36 Carbon nanotube cable coatings..... 91
- Figure 37 Formation of a protective CNT-based char layer during combustion of a CNT-modified coating..... 91
- Figure 38: Hydrophobic easy-to-clean coating..... 92
- Figure 39: Anti-fogging nanocoatings on protective eyewear..... 93
- Figure 40: Silica nanoparticle anti-reflection coating on glass..... 93
- Figure 41 Anti-bacterials mechanism of silver nanoparticle coating..... 95
- Figure 42: Mechanism of photocatalysis on a surface treated with TiO<sub>2</sub> nanoparticles..... 96
- Figure 43: Schematic showing the self-cleaning phenomena on superhydrophilic surface..... 96
- Figure 44: Titanium dioxide-coated glass (left) and ordinary glass (right)..... 97
- Figure 45: Self-Cleaning mechanism utilizing photooxidation..... 98
- Figure 46: Schematic of photocatalytic air purifying pavement..... 99
- Figure 47: Schematic of photocatalytic indoor air purification filter..... 99
- Figure 48: Schematic of photocatalytic water purification..... 100
- Figure 49: Types of nanocellulose..... 104
- Figure 50: CNF gel..... 105
- Figure 51: TEM image of cellulose nanocrystals..... 107
- Figure 52: Extracting CNC from trees..... 107
- Figure 53: An iridescent biomimetic cellulose multilayer film remains after water that contains cellulose nanocrystals evaporates..... 108
- Figure 54: CNC slurry..... 109
- Figure 55: Nanoclays structure. The dimensions of a clay platelet are typically 200-1000 nm in lateral dimension and 1 nm thick..... 112
- Figure 56: Schematic of typical commercialization route for nanocoatings producer..... 114
- Figure 57 Nanocoatings market by nanocoatings type, 2010-2030, USD..... 116
- Figure 58: Anti-fingerprint nanocoating on glass..... 117
- Figure 59: Market trends and drivers in anti-fingerprint nanocoatings..... 118
- Figure 60: Schematic of anti-fingerprint nanocoatings..... 120
- Figure 61: Toray anti-fingerprint film (left) and an existing lipophilic film (right)..... 120
- Figure 62: Types of anti-fingerprint coatings applied to touchscreens..... 121
- Figure 63: Anti-fingerprint nanocoatings markets and applications..... 121
- Figure 64: Current end user markets for anti-fingerprint nanocoatings, %, 2018..... 123
- Figure 65: Revenues for anti-fingerprint coatings, 2010-2030, US\$..... 124
- Figure 66: Market drivers and trends in anti-bacterial nanocoatings..... 129
- Figure 67: Mechanism of microbial inactivation and degradation with anti-microbial PhotoProtect nanocoatings..... 131
- Figure 68: Schematic of silver nanoparticles penetrating bacterial cell membrane..... 132



- Figure 69: Antibacterial mechanism of nanosilver particles..... 133
- Figure 70: Current end user markets for Anti-bacterial nanocoatings, %, based on nanocoatings company sales... 135
- Figure 71: Potential addressable market for Anti-bacterial nanocoatings by 2030..... 137
- Figure 72: Revenues for Anti-bacterial nanocoatings, 2010-2030, US\$..... 138
- Figure 73: Nanovate CoP coating..... 143
- Figure 74: 2000 hour salt fog results for Teslan nanocoatings..... 143
- Figure 75: AnCatt proprietary polyaniline nanodispersion and coating structure..... 143
- Figure 76: Hybrid self-healing sol-gel coating..... 144
- Figure 77: Schematic of anti-corrosion via superhydrophobic surface..... 144
- Figure 78: Current end user markets for anti-corrosion nanocoatings, %, 2018..... 146
- Figure 79: Potential addressable market for anti-corrosion nanocoatings by 2030..... 148
- Figure 80: Revenues for anti-corrosion nanocoatings, 2010-2030, US\$..... 149
- Figure 81: Potential addressable market for abrasion and wear resistant nanocoatings by 2030..... 155
- Figure 82: Revenues for abrasion and wear-resistant nanocoatings, 2010-2030, millions US\$..... 157
- Figure 83: Nanocomposite oxygen barrier schematic..... 160
- Figure 84: Schematic of barrier nanoparticles deposited on flexible substrates..... 160
- Figure 85: End user markets for barrier nanocoatings, %..... 161
- Figure 86: Potential addressable market for barrier nanocoatings and films by 2030..... 162
- Figure 87: Revenues for barrier nanocoatings, 2010-2030, US\$..... 164
- Figure 88: Anti-fouling treatment for heat-exchangers..... 167
- Figure 89: Removal of graffiti after application of nanocoating..... 168
- Figure 90: Markets for anti-fouling and easy clean nanocoatings, by %..... 168
- Figure 91: Potential addressable market for anti-fouling and easy-to-clean nanocoatings by 2030..... 170
- Figure 92: Revenues for anti-fouling and easy-to-clean nanocoatings 2010-2030, millions USD..... 171
- Figure 93: Self-cleaning superhydrophobic coating schematic..... 175
- Figure 94: Markets for self-cleaning nanocoatings, %, 2018..... 176
- Figure 95: Potential addressable market for self-cleaning (bionic) nanocoatings by 2030..... 177
- Figure 96: Revenues for self-cleaning nanocoatings, 2010-2030, US\$..... 178
- Figure 97: Principle of superhydrophilicity..... 182
- Figure 98: Schematic of photocatalytic air purifying pavement..... 182
- Figure 99: Tokyo Station GranRoof. The titanium dioxide coating ensures long-lasting whiteness..... 183
- Figure 100: Markets for self-cleaning (photocatalytic) nanocoatings 2018, %..... 183
- Figure 101: Potential addressable market for self-cleaning (photocatalytic) nanocoatings by 2030..... 185
- Figure 102: Revenues for self-cleaning (photocatalytic) nanocoatings, 2010-2030, US\$..... 186
- Figure 103: Markets for UV-resistant nanocoatings, %, 2017..... 190
- Figure 104: Potential addressable market for UV-resistant nanocoatings..... 192
- Figure 105: Revenues for UV-resistant nanocoatings, 2010-2030, US\$..... 193
- Figure 106: Flame retardant nanocoating..... 196
- Figure 107: Markets for thermal barrier and flame retardant nanocoatings, %..... 197
- Figure 108: Potential addressable market for thermal barrier and flame retardant nanocoatings by 2030..... 198
- Figure 109: Revenues for thermal barrier and flame retardant nanocoatings, 2010-2030, US\$..... 200
- Figure 110: Nanocoated surface in comparison to existing surfaces..... 203
- Figure 111: NANOMYTE® SuperAi, a Durable Anti-ice Coating..... 204
- Figure 112: SLIPS coating schematic..... 204
- Figure 113: Carbon nanotube based anti-icing/de-icing device..... 205
- Figure 114: CNT anti-icing nanocoating..... 205
- Figure 115: Markets for anti-icing and de-icing nanocoatings, %, 2017..... 206
- Figure 116: Potential addressable market for anti-icing and de-icing nanocoatings by 2030..... 208
- Figure 117: Revenues for anti-icing and de-icing nanocoatings, 2010-2030, US\$, conservative and optimistic estimates. Conservative estimates in blue, optimistic in red..... 209
- Figure 118: Schematic of AR coating utilizing nanoporous coating..... 212
- Figure 119: Demo solar panels coated with nanocoatings..... 213
- Figure 120: Revenues for anti-reflective nanocoatings, 2010-2030, US\$..... 214



- Figure 121: Schematic of self-healing polymers. Capsule based (a), vascular (b), and intrinsic (c) schemes for self-healing materials. Red and blue colours indicate chemical species which react (purple) to heal damage..... 216
- Figure 122: Stages of self-healing mechanism..... 217
- Figure 123: Self-healing mechanism in vascular self-healing systems..... 217
- Figure 124: Comparison of self-healing systems..... 218
- Figure 125: Self-healing coating on glass..... 221
- Figure 126 Nanocoatings market by end user sector, 2010-2030, USD..... 223
- Figure 127: Nanocoatings in the aerospace industry, by nanocoatings type %, 2018..... 228
- Figure 128: Potential addressable market for nanocoatings in aerospace by 2030..... 229
- Figure 129: Revenues for nanocoatings in the aerospace industry, 2010-2030, US\$..... 230
- Figure 130: Nanocoatings in the automotive industry, by coatings type % 2018..... 237
- Figure 131: Potential addressable market for nanocoatings in the automotive sector by 2030..... 237
- Figure 132: Revenues for nanocoatings in the automotive industry, 2010-2030, US\$..... 239
- Figure 133: Mechanism of photocatalytic NOx oxidation on active concrete road..... 244
- Figure 134: Jubilee Church in Rome, the outside coated with nano photocatalytic TiO2 coatings..... 244
- Figure 135: FN® photocatalytic coating, applied in the Project of Ecological Sound Barrier, in Prague..... 245
- Figure 136 Smart window film coatings based on indium tin oxide nanocrystals..... 246
- Figure 137: Nanocoatings in construction, architecture and exterior protection, by coatings type %, 2018..... 247
- Figure 138: Potential addressable market for nanocoatings in the construction, architecture and exterior coatings sector by 2030..... 247
- Figure 139: Revenues for nanocoatings in construction, architecture and exterior protection, 2010-2030, US\$..... 249
- Figure 140: Reflection of light on anti-glare coating for display..... 254
- Figure 141: Nanocoating submerged in water..... 255
- Figure 142: Phone coated in WaterBlock submerged in water tank..... 255
- Figure 143: Self-healing patent schematic..... 258
- Figure 144: Self-healing glass developed at the University of Tokyo..... 258
- Figure 145: Royole flexible display..... 259
- Figure 146: Potential addressable market for nanocoatings in electronics by 2030..... 260
- Figure 147: Revenues for nanocoatings in electronics, 2010-2030, US\$, conservative and optimistic estimates..... 261
- Figure 148: Nanocoatings in household care, sanitary and indoor air quality, by coatings type %, 2018..... 266
- Figure 149: Potential addressable market for nanocoatings in household care, sanitary and indoor air filtration by 2030..... 266
- Figure 150: Revenues for nanocoatings in household care, sanitary and indoor air quality, 2010-2030, US\$..... 267
- Figure 151: Potential addressable market for nanocoatings in the marine sector by 2030..... 272
- Figure 152: Revenues for nanocoatings in the marine sector, 2010-2030, US\$..... 273
- Figure 153: Nanocoatings in medical and healthcare, by coatings type %, 2018..... 279
- Figure 154: Potential addressable market for nanocoatings in medical & healthcare by 2030..... 280
- Figure 155: Revenues for nanocoatings in medical and healthcare, 2010-2030, US\$..... 281
- Figure 156: Nanocoatings in military and defence, by nanocoatings type %, 2018..... 286
- Figure 157: Potential addressable market nanocoatings in military and defence by 2030..... 286
- Figure 158: Revenues for nanocoatings in military and defence, 2010-2030, US\$..... 287
- Figure 159: Nanocomposite oxygen barrier schematic..... 291
- Figure 160: Oso fresh food packaging incorporating antimicrobial silver..... 291
- Figure 161: Potential addressable market for nanocoatings in packaging by 2030..... 293
- Figure 162: Revenues for nanocoatings in packaging, 2010-2030, US\$..... 294
- Figure 163: Omniphobic-coated fabric..... 297
- Figure 164: Work out shirt incorporating ECG sensors, flexible lights and heating elements..... 302
- Figure 165: Nanocoatings in textiles and apparel, by coatings type %, 2018..... 303
- Figure 166: Potential addressable market for nanocoatings in textiles and apparel by 2030..... 304
- Figure 167: Revenues for nanocoatings in textiles and apparel, 2010-2030, US\$..... 305
- Figure 168: Self-Cleaning Hydrophobic Coatings on solar panels..... 309
- Figure 169: Znshine Graphene Series solar coatings..... 309
- Figure 170: Nanocoatings in renewable energy, by coatings type %..... 310





- Figure 171: Potential addressable market for nanocoatings in renewable energy by 2030..... 311
- Figure 172: Revenues for nanocoatings in energy, 2010-2030, US\$..... 312
- Figure 173: Oil-Repellent self-healing nanocoatings..... 317
- Figure 174: Nanocoatings in oil and gas exploration, by coatings type %..... 318
- Figure 175: Potential addressable market for nanocoatings in oil and gas exploration by 2030..... 319
- Figure 176: Revenues for nanocoatings in oil and gas exploration, 2010-2030, US\$..... 320
- Figure 177: Revenues for nanocoatings in Tools and manufacturing, 2010-2030, US\$..... 324
- Figure 178: Security tag developed by Nanotech Security..... 325
- Figure 179: Revenues for nanocoatings in anti-counterfeiting, 2010-2030, US\$..... 327

