

PHOTOCATALYSTS: TECHNOLOGIES AND GLOBAL MARKETS



AVM069B
October 2015

Margareth Gagliardi
Project Analyst

ISBN: 1-62296-166-8



BCC Research
49 Walnut Park, Building 2
Wellesley, MA 02481 USA
866-285-7215 (toll-free within the USA),
or (+1) 781-489-7301
www.bccresearch.com
information@bccresearch.com

TABLE OF CONTENTS

TOPIC	PAGE NO.
CHAPTER 1 INTRODUCTION	2
STUDY GOALS AND OBJECTIVES	2
REASONS FOR DOING THIS STUDY	2
INTENDED AUDIENCE	3
SCOPE OF REPORT	4
METHODOLOGY AND INFORMATION SOURCES	5
RELATED BCC RESEARCH REPORTS	6
ANALYST'S CREDENTIALS	6
BCC RESEARCH WEBSITE	7
DISCLAIMER	8
CHAPTER 2 SUMMARY	10
<i>SUMMARY TABLE GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, THROUGH 2020 (\$ MILLIONS)</i>	11
<i>SUMMARY FIGURE GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, 2013-2020 (\$ MILLIONS)</i>	11
CHAPTER 3 OVERVIEW	13
PHOTOCATALYSTS AND THEIR BEHAVIOR	13
<i>TABLE 1 CAPABILITIES OF PHOTOCATALYSTS</i>	14
THE CATALYST AND PHOTOCATALYST INDUSTRY	14
<i>TABLE 2 THE CATALYST INDUSTRY: GLOBAL MARKET SHARE BY SEGMENT, 2015 (\$ MILLIONS/%)</i>	14
MILESTONES IN THE HISTORY OF PHOTOCATALYSTS AND RECENT EVENTS	15
<i>TABLE 3 PHOTOCATALYSTS - TECHNOLOGICAL MILESTONES</i>	15
<i>FIGURE 1 PHOTOCATALYSTS - WORLDWIDE PATENT APPLICATIONS AND PATENTS ISSUED SINCE 1970-2014 (NUMBER)</i>	16
APPLICATIONS OF PHOTOCATALYSTS	17
<i>TABLE 4 FIELDS OF APPLICATION FOR PHOTOCATALYSTS, 2015</i>	17
CONSTRUCTION	18
<i>TABLE 5 APPLICATIONS OF PHOTOCATALYSTS IN THE CONSTRUCTION SECTOR, 2015</i>	18
AUTOMOTIVE	19
<i>TABLE 6 APPLICATIONS OF PHOTOCATALYSTS IN THE AUTOMOTIVE SECTOR, 2015</i>	19
MEDICAL/DENTAL	19
<i>TABLE 7 APPLICATIONS OF PHOTOCATALYSTS IN THE MEDICAL/DENTAL SECTOR, 2015</i>	20
MECHANICAL/CHEMICAL	20
<i>TABLE 8 APPLICATIONS OF PHOTOCATALYSTS IN THE MECHANICAL/CHEMICAL SECTOR, 2015</i>	20
ENVIRONMENTAL	21
<i>TABLE 9 APPLICATIONS OF PHOTOCATALYSTS IN THE ENVIRONMENTAL SECTOR, 2015</i>	21
CONSUMER PRODUCTS	22
<i>TABLE 10 APPLICATIONS OF PHOTOCATALYSTS IN THE CONSUMER PRODUCTS SECTOR, 2015</i>	23
ENERGY	23

TOPIC	PAGE NO.
Artificial Photosynthesis	23
Water Splitting	24
Decomposition of Carbon Dioxide	24
Decomposition of Hydrogen Sulfide	25
Decomposition of Biowaste	25
Photovoltaic Cells	25
<i>TABLE 11 APPLICATIONS OF PHOTOCATALYSTS IN THE ENERGY SECTOR, 2015</i>	26
CHAPTER 4 TECHNOLOGY	28
INTRODUCTION	28
PHOTOCATALYSTS: MATERIALS, TYPES, AND PRODUCTION TECHNOLOGIES	28
MATERIALS	28
Titanium Dioxide	28
Structure and Properties	28
Improvements in Photocatalytic Efficiency	29
Particle Size	29
Crystallinity	29
Doping	29
Morphology	30
Recent Developments in TiO ₂ Formulation	30
Tungsten Trioxide	30
Other Photocatalyst Materials	31
<i>TABLE 12 NEW PHOTOCATALYSTS WITH LOW BAND GAP</i>	31
TYPES AND PRODUCTION TECHNOLOGIES	32
Powders	32
Solutions	33
Films	33
<i>TABLE 13 THICK-FILM TECHNOLOGIES, 2015</i>	33
<i>TABLE 14 THIN FILM TECHNOLOGIES, 2015</i>	35
LATEST TECHNOLOGICAL DEVELOPMENTS, 2013 TO PRESENT	38
VISIBLE LIGHT PHOTOCATALYST BASED ON COPPER SUPPORTED ON TITANIUM OXIDE	38
GOLD/TITANIUM DIOXIDE PHOTOCATALYST WITH CORE- SHELL STRUCTURE	39
HIGH-EFFICIENCY PHOTOCATALYSTS USING HIGH-SURFACE- AREA SUBSTRATES	40
HETEROSTRUCTURED PHOTOCATALYST FOR CARBON DIOXIDE DECOMPOSITION	41
HYBRID PHOTOCATALYST FOR WASTEWATER TREATMENT	42
NIOBIUM NITRIDE PHOTOCATALYST FOR WATER SPLITTING	42
OTHER RELEVANT R&D ACTIVITIES	43
<i>TABLE 15 OTHER RELEVANT R & D ACTIVITIES</i>	44
CHAPTER 5 GLOBAL MARKET	47
ANALYSIS OUTLINE	47
GLOBAL MARKET SUMMARY	47
<i>TABLE 16 GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, THROUGH 2020 (\$ MILLIONS)</i>	48

TOPIC	PAGE NO.
<i>FIGURE 2 GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, 2013-2020 (\$ MILLIONS)</i>	48
CURRENT MARKET STATUS	49
CURRENT MARKET SUMMARY	49
<i>TABLE 17 CURRENT MARKET FOR PHOTOCATALYST PRODUCTS, THROUGH 2015 (\$ MILLIONS)</i>	49
<i>FIGURE 3 CURRENT MARKET FOR PHOTOCATALYST PRODUCTS, 2013-2015 (\$ MILLIONS)</i>	50
MARKET BY MATERIAL TYPE	50
<i>TABLE 18 PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY MATERIAL TYPE, 2015 (\$ MILLIONS/%)</i>	50
<i>FIGURE 4 PHOTOCATALYST PRODUCTS: MARKET SHARE BY MATERIAL TYPE, 2015 (%)</i>	51
MARKET BY APPLICATION	51
<i>TABLE 19 PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY APPLICATION, 2015 (\$ MILLIONS/%)</i>	52
<i>FIGURE 5 PHOTOCATALYST PRODUCTS: MARKET SHARE BY APPLICATION, 2015 (%)</i>	52
MARKET BY REGION	53
<i>TABLE 20 PHOTOCATALYST PRODUCTS: REVENUES BY REGION, THROUGH 2015 (\$ MILLIONS)</i>	53
<i>FIGURE 6 PHOTOCATALYST PRODUCTS: MARKET SHARE BY REGION, 2015 (%)</i>	53
MARKET GROWTH TRENDS	54
CONSTRUCTION	54
Paints and Coatings	54
<i>TABLE 21 FORECAST - PAINTS AND COATINGS: GLOBAL REVENUES BY TYPE, 2015 THROUGH 2020 (\$ BILLIONS)</i>	55
Ceramic Tiles	55
Flat Glass	55
Flat Glass Market by Sector	55
<i>TABLE 22 FORECAST - FLAT GLASS: GLOBAL REVENUES BY SECTOR, THROUGH 2020 (\$ BILLIONS)</i>	56
<i>FIGURE 7 FORECAST - FLAT GLASS: MARKET SHARE BY SECTOR, 2020 (%)</i>	56
Flat Glass Market by Region	57
<i>TABLE 23 FORECAST - FLAT GLASS: GLOBAL REVENUES BY REGION, THROUGH 2020 (\$ BILLIONS)</i>	57
<i>FIGURE 8 FORECAST - FLAT GLASS: MARKET SHARE BY REGION, 2015 AND 2020 (%)</i>	58
Other Construction Materials	58
Technological Trends within the Construction Sector	59
Green Building	59
Sunlight Optimization	59
Energy Savings	59
Individual Health and Well-Being	60
Reduced Maintenance	60
Global Construction and Green Building Markets	60
CONSUMER PRODUCTS	60
<i>TABLE 24 FORECAST - CONSUMER PRODUCTS: GLOBAL REVENUES BY INDUSTRY SEGMENT, THROUGH 2020 (\$ BILLIONS)</i>	60
<i>TABLE 25 FORECAST - OTHER APPLICATIONS WITHIN THE CONSUMER PRODUCTS SECTOR: GLOBAL REVENUES BY SEGMENT, THROUGH 2020 (\$ BILLIONS)</i>	61

TOPIC	PAGE NO.
AUTOMOTIVE	61
Windows and Sunroofs	61
Side Mirrors	62
Automotive Coatings	62
<i>TABLE 26 FORECAST - AUTOMOTIVE: GLOBAL REVENUES BY INDUSTRY SEGMENT, THROUGH 2020 (\$ BILLIONS)</i>	63
ENVIRONMENTAL	63
Wastewater Treatment and Recycling	63
Air Pollution and Other Applications	63
ENERGY	63
Photovoltaic Cells and Modules	64
<i>TABLE 27 FORECAST - PHOTOVOLTAIC MODULES: GLOBAL PRODUCTION BY TYPE, THROUGH 2020 (MW)</i>	64
<i>FIGURE 9 PHOTOVOLTAIC MODULES: PRODUCTION SHARE BY TYPE, 2020 (%)</i>	65
MEDICAL/DENTAL	65
<i>TABLE 28 FORECAST - MEDICAL/DENTAL SECTOR: GLOBAL REVENUES BY INDUSTRY SEGMENT, THROUGH 2020 (\$ BILLIONS)</i>	65
MECHANICAL/CHEMICAL	66
OTHER TECHNOLOGICAL TRENDS	66
Nanotechnology	66
<i>TABLE 29 THE NANOTECHNOLOGY INDUSTRY, 2015</i>	67
<i>TABLE 30 NANOTECHNOLOGY: GLOBAL REVENUES BY SEGMENT, THROUGH 2020 (\$ BILLIONS)</i>	68
<i>FIGURE 10 NANOTECHNOLOGY: GLOBAL MARKET SHARE BY SEGMENT, 2020 (%)</i>	69
Other Trends	69
REGIONAL TRENDS	70
MARKET FORECAST	70
MARKET BY MATERIAL TYPE	70
<i>TABLE 31 FORECAST - PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	71
<i>FIGURE 11 FORECAST - PHOTOCATALYST PRODUCTS: MARKET SHARE BY TYPE, 2020 (%)</i>	71
MARKET BY APPLICATION	72
<i>TABLE 32 FORECAST - PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY APPLICATION, THROUGH 2020 (\$ MILLIONS)</i>	73
<i>FIGURE 12 FORECAST - PHOTOCATALYST PRODUCTS: MARKET SHARE BY APPLICATION, 2020 (%)</i>	73
MARKET BY REGION	74
<i>TABLE 33 FORECAST - PHOTOCATALYST PRODUCTS: REVENUES BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	74
<i>FIGURE 13 FORECAST - PHOTOCATALYST PRODUCTS: MARKET SHARE BY REGION, 2020 (%)</i>	74
CHAPTER 6 GLOBAL INDUSTRY STRUCTURE	77
LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS	77
<i>TABLE 34 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS, 2015</i>	77
<i>TABLE 35 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS BY SECTOR, 2015</i>	83
<i>TABLE 36 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS, BY SECTOR AND REGION, 2015</i>	87

TOPIC	PAGE NO.
<i>FIGURE 14 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS: DISTRIBUTION BY SIZE AND REGION, 2015 (NUMBER OF COMPANIES)</i>	88
OTHER PLAYERS IN THE PHOTOCATALYST INDUSTRY	89
<i>TABLE 37 OTHER RELEVANT PLAYERS IN THE PHOTOCATALYST INDUSTRY</i>	89
COMPANY PROFILES	90
AOINN ENVIRONMENTAL TECHNOLOGY	90
ASAHI GLASS	91
CARDINAL GLASS INDUSTRIES	91
DAIKIN INDUSTRIES	92
GC CORP.	93
ITOCHU CORP.	94
JSR CORP.	94
KAWASAKI HEAVY INDUSTRIES	95
MARUSYO SANGYO	96
MITSUBISHI CHEMICAL	97
MITSUBISHI MATERIALS CORP.	98
MURAKAMI	99
NIPPON SHEET GLASS	100
NIPPON SODA	101
OKITSUMO	102
PANASONIC CORP.	102
PPG INDUSTRIES	104
SAINT-GOBAIN	105
SHOWA DENKO	106
TOTO	107
CHAPTER 7 PATENT ANALYSIS	110
INTRODUCTION	110
SUMMARY OF PATENTS AWARDED DURING THE PERIOD 2013 THROUGH 2015	110
<i>TABLE 38 PHOTOCATALYSTS - U.S. PATENTS, 2015</i>	110
<i>TABLE 39 U.S. PATENTS RELATED TO PHOTOCATALYSTS, 2014</i>	114
<i>TABLE 40 PHOTOCATALYSTS - U.S. PATENTS, 2013</i>	119
GENERAL TRENDS	123
<i>TABLE 41 PHOTOCATALYSTS: U.S. PATENT TRENDS, 2013-2015 (NO. OF PATENTS)</i>	124
<i>FIGURE 15 PHOTOCATALYSTS: U.S. PATENT TRENDS, 2013- 2015 (NUMBER OF PATENTS)</i>	124
TRENDS BY COUNTRY AND REGION	125
<i>FIGURE 16 SHARE OF U.S. PATENTS RELATED TO PHOTOCATALYSTS BY REGION, 2013-2015 (%)</i>	125
<i>FIGURE 17 PHOTOCATALYSTS: PATENTS BY COUNTRY, 2013-2015 (%)</i>	126
TRENDS BY ASSIGNEE	127
<i>TABLE 42 ASSIGNEES OF U.S. PATENTS RELATED TO PHOTOCATALYSTS, 2013-2015 (NUMBER)</i>	128
<i>FIGURE 18 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY ORGANIZATION TYPE, 2013-2015 (%)</i>	130
TRENDS BY PATENT CATEGORY	131
<i>FIGURE 19 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY CATEGORY, 2013-2015 (%)</i>	131
TRENDS BY APPLICATION	132

TOPIC	PAGE NO.
<i>FIGURE 20 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY APPLICATION, 2013-2015 (%)</i>	134
TRENDS BY MATERIAL TYPE	135
<i>FIGURE 21 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY MATERIAL TYPE, 2013-2015 (%)</i>	136

LIST OF TABLES

TABLE HEADING	PAGE NO.
SUMMARY TABLE GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, THROUGH 2020 (\$ MILLIONS)	11
TABLE 1 CAPABILITIES OF PHOTOCATALYSTS	14
TABLE 2 THE CATALYST INDUSTRY: GLOBAL MARKET SHARE BY SEGMENT, 2015 (\$ MILLIONS/%)	14
TABLE 3 PHOTOCATALYSTS - TECHNOLOGICAL MILESTONES	15
TABLE 4 FIELDS OF APPLICATION FOR PHOTOCATALYSTS, 2015	17
TABLE 5 APPLICATIONS OF PHOTOCATALYSTS IN THE CONSTRUCTION SECTOR, 2015	18
TABLE 6 APPLICATIONS OF PHOTOCATALYSTS IN THE AUTOMOTIVE SECTOR, 2015	19
TABLE 7 APPLICATIONS OF PHOTOCATALYSTS IN THE MEDICAL/DENTAL SECTOR, 2015	20
TABLE 8 APPLICATIONS OF PHOTOCATALYSTS IN THE MECHANICAL/CHEMICAL SECTOR, 2015	20
TABLE 9 APPLICATIONS OF PHOTOCATALYSTS IN THE ENVIRONMENTAL SECTOR, 2015	21
TABLE 10 APPLICATIONS OF PHOTOCATALYSTS IN THE CONSUMER PRODUCTS SECTOR, 2015	23
TABLE 11 APPLICATIONS OF PHOTOCATALYSTS IN THE ENERGY SECTOR, 2015	26
TABLE 12 NEW PHOTOCATALYSTS WITH LOW BAND GAP	31
TABLE 13 THICK-FILM TECHNOLOGIES, 2015	33
TABLE 14 THIN FILM TECHNOLOGIES, 2015	35
TABLE 15 OTHER RELEVANT R & D ACTIVITIES	44
TABLE 16 GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, THROUGH 2020 (\$ MILLIONS)	48
TABLE 17 CURRENT MARKET FOR PHOTOCATALYST PRODUCTS, THROUGH 2015 (\$ MILLIONS)	49
TABLE 18 PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY MATERIAL TYPE, 2015 (\$ MILLIONS/%)	50
TABLE 19 PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY APPLICATION, 2015 (\$ MILLIONS/%)	52
TABLE 20 PHOTOCATALYST PRODUCTS: REVENUES BY REGION, THROUGH 2015 (\$ MILLIONS)	53
TABLE 21 FORECAST - PAINTS AND COATINGS: GLOBAL REVENUES BY TYPE, 2015 THROUGH 2020 (\$ BILLIONS)	55
TABLE 22 FORECAST - FLAT GLASS: GLOBAL REVENUES BY SECTOR, THROUGH 2020 (\$ BILLIONS)	56
TABLE 23 FORECAST - FLAT GLASS: GLOBAL REVENUES BY REGION, THROUGH 2020 (\$ BILLIONS)	57
TABLE 24 FORECAST - CONSUMER PRODUCTS: GLOBAL REVENUES BY INDUSTRY SEGMENT, THROUGH 2020 (\$ BILLIONS)	60
TABLE 25 FORECAST - OTHER APPLICATIONS WITHIN THE CONSUMER PRODUCTS SECTOR: GLOBAL REVENUES BY SEGMENT, THROUGH 2020 (\$ BILLIONS)	61
TABLE 26 FORECAST - AUTOMOTIVE: GLOBAL REVENUES BY INDUSTRY SEGMENT, THROUGH 2020 (\$ BILLIONS)	63
TABLE 27 FORECAST - PHOTOVOLTAIC MODULES: GLOBAL PRODUCTION BY TYPE, THROUGH 2020 (MW)	64
TABLE 28 FORECAST - MEDICAL/DENTAL SECTOR: GLOBAL REVENUES BY INDUSTRY SEGMENT, THROUGH 2020 (\$ BILLIONS)	65
TABLE 29 THE NANOTECHNOLOGY INDUSTRY, 2015	67

TABLE HEADING	PAGE NO.
TABLE 30 NANOTECHNOLOGY: GLOBAL REVENUES BY SEGMENT, THROUGH 2020 (\$ BILLIONS)	68
TABLE 31 FORECAST - PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY TYPE, THROUGH 2020 (\$ MILLIONS)	71
TABLE 32 FORECAST - PHOTOCATALYST PRODUCTS: GLOBAL REVENUES BY APPLICATION, THROUGH 2020 (\$ MILLIONS)	73
TABLE 33 FORECAST - PHOTOCATALYST PRODUCTS: REVENUES BY REGION, THROUGH 2020 (\$ MILLIONS)	74
TABLE 34 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS, 2015	77
TABLE 35 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS BY SECTOR, 2015	83
TABLE 36 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS, BY SECTOR AND REGION, 2015	87
TABLE 37 OTHER RELEVANT PLAYERS IN THE PHOTOCATALYST INDUSTRY	89
TABLE 38 PHOTOCATALYSTS - U.S. PATENTS, 2015	110
TABLE 39 U.S. PATENTS RELATED TO PHOTOCATALYSTS, 2014	114
TABLE 40 PHOTOCATALYSTS - U.S. PATENTS, 2013	119
TABLE 41 PHOTOCATALYSTS: U.S. PATENT TRENDS, 2013-2015 (NO. OF PATIENTS)	124
TABLE 42 ASSIGNEES OF U.S. PATENTS RELATED TO PHOTOCATALYSTS, 2013-2015 (NUMBER)	128

LIST OF FIGURES

FIGURE TITLE	PAGE NO.
SUMMARY FIGURE GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, 2013-2020 (\$ MILLIONS)	11
FIGURE 1 PHOTOCATALYSTS - WORLDWIDE PATENT APPLICATIONS AND PATENTS ISSUED SINCE 1970-2014 (NUMBER)	16
FIGURE 2 GLOBAL MARKET FOR PHOTOCATALYST PRODUCTS, 2013-2020 (\$ MILLIONS)	48
FIGURE 3 CURRENT MARKET FOR PHOTOCATALYST PRODUCTS, 2013-2015 (\$ MILLIONS)	50
FIGURE 4 PHOTOCATALYST PRODUCTS: MARKET SHARE BY MATERIAL TYPE, 2015 (%)	51
FIGURE 5 PHOTOCATALYST PRODUCTS: MARKET SHARE BY APPLICATION, 2015 (%)	52
FIGURE 6 PHOTOCATALYST PRODUCTS: MARKET SHARE BY REGION, 2015 (%)	53
FIGURE 7 FORECAST - FLAT GLASS: MARKET SHARE BY SECTOR, 2020 (%)	56
FIGURE 8 FORECAST - FLAT GLASS: MARKET SHARE BY REGION, 2015 AND 2020 (%)	58
FIGURE 9 PHOTOVOLTAIC MODULES: PRODUCTION SHARE BY TYPE, 2020 (%)	65
FIGURE 10 NANOTECHNOLOGY: GLOBAL MARKET SHARE BY SEGMENT, 2020 (%)	69
FIGURE 11 FORECAST - PHOTOCATALYST PRODUCTS: MARKET SHARE BY TYPE, 2020 (%)	71
FIGURE 12 FORECAST - PHOTOCATALYST PRODUCTS: MARKET SHARE BY APPLICATION, 2020 (%)	73
FIGURE 13 FORECAST - PHOTOCATALYST PRODUCTS: MARKET SHARE BY REGION, 2020 (%)	74
FIGURE 14 LEADING SUPPLIERS OF PHOTOCATALYST PRODUCTS: DISTRIBUTION BY SIZE AND REGION, 2015 (NUMBER OF COMPANIES)	88
FIGURE 15 PHOTOCATALYSTS: U.S. PATENT TRENDS, 2013- 2015 (NUMBER OF PATENTS)	124
FIGURE 16 SHARE OF U.S. PATENTS RELATED TO PHOTOCATALYSTS BY REGION, 2013-2015 (%)	125
FIGURE 17 PHOTOCATALYSTS: PATENTS BY COUNTRY, 2013-2015 (%)	126
FIGURE 18 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY ORGANIZATION TYPE, 2013-2015 (%)	130
FIGURE 19 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY CATEGORY, 2013-2015 (%)	131
FIGURE 20 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY APPLICATION, 2013-2015 (%)	134
FIGURE 21 PHOTOCATALYSTS: SHARES OF U.S. PATENTS BY MATERIAL TYPE, 2013-2015 (%)	136