

CELLULOSE NANOPARTICLES: PROCESSING, APPLICATIONS AND GLOBAL MARKETS



AVM120A
June 2015

Alessandro Varotto
Project Analyst

ISBN: 1-62296-105-6



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 OBJECTIVE	2
REASON FOR DOING THE REPORT	2
SCOPE OF THE REPORT	2
INTENDED AUDIENCE	3
METHODOLOGY AND INFORMATION SOURCE	3
ANALYST'S CREDENTIALS	3
RELATED BCC RESEARCH REPORTS	3
BCC RESEARCH WEBSITE	4
DISCLAIMER	4
CHAPTER 2 SUMMARY	6
<i>SUMMARY TABLE GLOBAL NANOCELLULOSE MARKET BY MATERIAL, THROUGH 2019 (\$ MILLIONS)</i>	6
<i>SUMMARY FIGURE GLOBAL NANOCELLULOSE MARKET, BY MATERIAL, 2013-2019 (\$ MILLIONS)</i>	6
CHAPTER 3 OVERVIEW	9
LIFE CYCLE ASSESSMENT OF NANOCELLULOSES	9
NANOCELLULOSES	9
Types of Nanocelluloses Considered	10
LCA OF MFC NANOCELLULOSE	11
Production Procedure of MFC	11
LCA Scope and Functional Unit Definition	12
Nanocellulose (MFC) Fabrication Process Description	12
Chemical and Mechanical Processes Descriptions	13
Chemical Modification Process, TEMPO Oxidation (TO)	13
Chemical Modification Process of Chloroacetic Acid Etherification (CE)	13
Mechanical Disintegration Process by Homogenization (HO)	13
Mechanical Disintegration Process by Sonication (SO)	13
Life Cycle Impact Assessment (LCIA)	14
Scenario Analysis	15
Results and Deductions of LCA of MFC Nanocellulose	15
LCA OF NCC NANOCELLULOSE	16
Production of Nanocrystalline Cellulose (NCC)	16
Life Cycle Assessment (LCA)	17
Nanowhiskers Extraction Processes	17
Extraction of Nanowhiskers from Unripe Coconut Fiber	18
Extraction of Nanowhiskers from Cotton Fibers	18
Systems Boundaries	19
Functional Unit	19
Life Cycle Impact Assessment (LCIA)	19
Results and Conclusions	20
<i>TABLE 1 CUMULATIVE ENERGY DEMAND (CED) AND GLOBAL WARMING POTENTIAL (GWP) FOR 10 GRAMS OF NANOCELLULOSE PRODUCTION</i>	21

TOPIC	PAGE NO.
CHAPTER 4 THE GLOBAL NANOCELLULOSE MARKET	23
TABLE 2 GLOBAL NANOCELLULOSE MARKET BY REGION, THROUGH 2019 (\$ MILLIONS)	23
TABLE 3 GLOBAL NANOCELLULOSE MARKET SHARE BY REGION, 2013-2019 (%)	23
FIGURE 1 GLOBAL NANOCELLULOSE MARKET SHARE BY REGION, 2013-2019 (%)	23
TABLE 4 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY REGION, THROUGH 2019 (TONS)	24
TABLE 5 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY TYPE, THROUGH 2019 (TONS)	25
TABLE 6 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY TYPE, THROUGH 2019 (%)	25
FIGURE 2 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY TYPE, 2013-2019 (%)	25
TABLE 7 GLOBAL NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	26
TABLE 8 GLOBAL NANOCELLULOSE MARKET SHARE BY APPLICATION, 2013-2019 (%)	27
FIGURE 3 GLOBAL NANOCELLULOSE MARKET SHARE BY APPLICATION, 2013-2019 (%)	27
TABLE 9 NORTH AMERICAN NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	28
TABLE 10 EUROPEAN NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	29
TABLE 11 ASIAN NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	29
TABLE 12 GLOBAL NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	30
TABLE 13 NORTH AMERICAN NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	31
TABLE 14 EUROPEAN NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	31
TABLE 15 ASIAN NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	31
TABLE 16 ROW NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	32
TABLE 17 GLOBAL NANOCELLULOSE COMPOSITES MARKET SHARE BY PRODUCTION PROCESSING, THROUGH 2019 (%)	32
FIGURE 4 GLOBAL NANOCELLULOSE COMPOSITES MARKET SHARE BY PRODUCTION PROCESSING, 2013-2019 (%)	32
CHAPTER 5 STATE-OF-THE-ART RESEARCH AND DEVELOPMENT	35
INTRODUCTION	35
CELLULOSE NANOPARTICLES (CNS)	36
Microfibrillated Celluloses (MFCs)	36
Cellulose Nanoparticles (CNs)	36
PREPARATION OF CELLULOSE NANOPARTICLES (CNS)	37
First Stage: Pre-treatment	37
Second Stage: Fibrillation Step	38
Mechanical Treatments	38
Refining and High-Pressure Homogenization	38
Grinding	39

TOPIC	PAGE NO.
Cryocrushing	39
Chemical Treatments	39
Acid Hydrolysis	39
Enzymatic Hydrolysis	41
Chemical Oxidation	42
Electrospinning	42
PROPERTIES OF NANOCELLULOSES	43
Structural and Molecular Properties	43
Mechanical Properties	43
Thermal Properties	43
Rheological Properties	43
<i>TABLE 18 MAJOR GLOBAL MANUFACTURERS OF NANOCELLULOSE</i>	44
<i>TABLE 19 GEOMETRICAL DIMENSIONS OF NC OBTAINED FROM DIFFERENT SOURCES (NM)</i>	44
<i>TABLE 20 CRYSTALLINITY OF VARIOUS NC (%)</i>	44
<i>TABLE 21 MECHANICAL PROPERTIES OF VARIOUS NC COMPARED TO WOOD</i>	45
<i>TABLE 22 COMPARISON OF PHYSICAL PROPERTIES OF NANOCELLULOSE VERSUS OTHER COMMON MATERIALS</i>	45
Surface Modifications of Nanocelluloses	46
Surface Modification During Extraction of Cellulose Nanoparticles	46
Surface Modification by Adsorption	46
Surface Modification by Chemical Reactions	47
Esterification	47
Ionization	47
Silylation	48
Fluorescent Labeling	48
Polymer Grafting	48
NANOCELLULOSE-BASED MATERIALS	49
Preparation of Nanocellulose Films	49
Preparation of Nanocomposites	50
Casting-Evaporation Process	50
Electrospinning Process	51
Melt-Compounding Processes	51
Impregnation Process	51
APPLICATIONS OF NANOCELLULOSES	52
CONCLUSIONS	52
CHAPTER 6 NANOCELLULOSE MARKET APPLICATIONS	55
HIGH-VOLUME APPLICATIONS	55
AUTOMOTIVE-BODY COMPONENTS	55
AUTOMOTIVE-INTERIORS	55
CONSTRUCTION-CEMENT; PRE-STRESSED AND PRE-CAST CONCRETE	55
PACKAGING-FIBER/PLASTIC REPLACEMENT	55
PACKAGING-FILLER	56
PACKAGING-COATING	56
PACKAGING-FILM	56
PAPER-FILLER	56

TOPIC	PAGE NO.
PAPER-COATINGS	56
PERSONAL CARE-HYGIENE AND ABSORBENT PRODUCTS	57
TEXTILES-CLOTHING	57
LOW-VOLUME APPLICATIONS	57
AEROGELS-OIL AND GAS INDUSTRY	57
AEROSPACE-STRUCTURAL	57
AEROSPACE-INTERIORS	58
CONSTRUCTION-AIR AND WATER FILTRATION	58
CONSTRUCTION-GYPSUM WALLBOARD FACING	58
CONSTRUCTION-INSULATION AND SOUNDPROOFING	58
INDUSTRIAL-VISCOSITY MODIFIERS	59
INDUSTRIAL-WATER PURIFICATION	59
PAINT	59
PERSONAL CARE-COSMETICS	59
PHARMACEUTICALS-EXCIPIENTS	59
SENSORS—MEDICAL, ENVIRONMENTAL AND INDUSTRIAL	59
NOVEL APPLICATIONS	60
ELECTRONICS-ORGANIC LIGHT-EMITTING DIODES (OLEDs)	60
PHOTONIC STRUCTURES-FILMS	60
INDUSTRIAL AND MEDICAL-ADDITIVE MANUFACTURING	60
<i>TABLE 23 NANOCELLULOSE POTENTIAL APPLICATIONS</i>	61
CHAPTER 7 BACTERIAL NANOCELLULOSE: PROPERTIES AND APPLICATIONS	63
INTRODUCTION	63
SYNTHESIS OF BACTERIAL CELLULOSE	63
BIOSYNTHESIS MECHANISM	64
PRODUCTION AND PURIFICATION OF BACTERIAL CELLULOSES	65
Production Process	65
Using Additives to Modify Nature of BC Product	66
Lignosulfonate	67
Hemicellulose	67
Carboxymethyl Cellulose (CMC)	67
2,6 - Dichloronitrobenzotrile (DCB)	67
Purification	67
PROPERTIES OF BACTERIAL CELLULOSE	68
NANOCOMPOSITES OF BACTERIAL CELLULOSE	68
APPLICATIONS OF BACTERIAL CELLULOSE	71
Medical Applications	71
Skin Therapy	71
Artificial Blood Vessels	72
Tissue Engineering Applications	73
Wound Care Products	73
Dental Care Products	74
Veterinary Medicine	74
Non-medical Applications of Bacterial Cellulose	75
Tablet Excipients	75
Paper Industry	75

TOPIC	PAGE NO.
Food Industry	75
<hr/>	
CHAPTER 8 INDUSTRY STRUCTURE	77
INDUSTRY LIFECYCLE	77
<i>TABLE 24 NANOCELLULOSE POTENTIAL APPLICATIONS</i>	77
<i>TABLE 25 NANOCELLULOSE POTENTIAL PRODUCTS</i>	78
<i>TABLE 26 NANOCELLULOSE MARKET POTENTIAL (TONS)</i>	78
MARKET DRIVERS AND CHALLENGES	78
<i>TABLE 27 JOB GROWTH RELATED TO THE NANOCELLULOSE MARKET, 2015-2020 (UNITS)</i>	78
<i>TABLE 28 GDP GROWTH RELATED TO THE NANOCELLULOSE MARKET, 2015-2020 (\$ MILLIONS)</i>	79
PRODUCTION CAPACITY GLOBAL SIZE	79
<i>TABLE 29 MAJOR KEY COMPANIES AND PRODUCTION CAPACITIES FOR THE NANOCELLULOSE MARKET</i>	79
STANDARDS	80
CELLULOSE FROM FORESTS	80
Optimal Use of Wood and Fibers	82
CELLULOSE FROM VEGETABLES	82
INDUSTRY AND APPLICATIONS	83
AUTOMOTIVE AND AEROSPACE	83
<i>TABLE 30 AUTO PARTS REQUIREMENTS</i>	83
<i>TABLE 31 LEADING SUPPLIERS OF BIO-BASED MATERIALS TO NORTH AMERICA AUTO MANUFACTURERS</i>	84
PACKAGING	84
<i>TABLE 32 NANOCELLULOSE FILM</i>	85
<i>TABLE 33 MICROFIBRILLATED CELLULOSE FILMS</i>	85
PAINT	85
<i>TABLE 34 BENEFITS OF NANOCELLULOSE AS ADDITIVE FOR VARNISHES AND PAINTS</i>	85
FLEXIBLE ELECTRONICS	86
Energy Storage with Conductive Paper	86
Transparent Nanocellulose Paper for Electronic and Optoelectronic Devices	87
<i>TABLE 35 COMPARISON OF CELLULOSE NANOFIBRILS PROPERTIES VERSUS OTHER COMMON MATERIALS</i>	87
MEDICAL APPLICATIONS	88
<i>TABLE 36 MAJOR MARKET COMPANIES IN BACTERIAL CELLULOSE</i>	88
<i>TABLE 37 NANOCELLULOSE COMPOSITES</i>	88
<i>TABLE 38 MICROFIBRILLATED CELLULOSE COMPOSITE</i>	89
NANOCELLULOSE-POLYMERS COMPOSITES AS OXYGEN AND MOISTURE BARRIERS FOR FOOD PACKAGING	89
Oxygen Permeability	89
Water Vapor Permeability	89
<i>TABLE 39 NANOCELLULOSE-POLYMERS COMPOSITED- EXPECTED PERFORMANCES</i>	90
Coating-Examples	90
<i>TABLE 40 NANOCELLULOSE COATING FOR POLYMERS USED IN FOOD PACKAGING-LITERATURE EXAMPLES</i>	91
Melt Compounding-Examples	93

TOPIC	PAGE NO.
<i>TABLE 41 NANOCELLULOSE POLYMERS MELT COMPOUNDING USED IN FOOD PACKAGING-LITERATURE EXAMPLES</i>	94
Stand-alone Films-Examples	96
<i>TABLE 42 NANOCELLULOSE STAND-ALONE FILMS USED IN FOOD PACKAGING-LITERATURE EXAMPLES</i>	97
CHAPTER 9 GOVERNMENT REGULATIONS	100
REGULATIONS AND SAFETY	100
<i>TABLE 43 TOXICOLOGICAL EVALUATION OF NANOCELLULOSE</i>	101
CHAPTER 10 PATENT STATUS	104
<i>TABLE 44 ASSIGNEES WITH AT LEAST TWO PATENTS WITHIN THE NANOCELLULOSE FIELD</i>	104
<i>TABLE 45 RELEVANT NANOCELLULOSE PATENTS</i>	104
CHAPTER 11 PRESS RELEASES	118
<i>TABLE 46 PRESS RELEASES</i>	118
CHAPTER 12 COMPANY PROFILES	124
ALBERTA INNOVATES-TECHNOLOGY FUTURES	124
ASAHI KASEI	125
ASAHI KASEI AMERICA	125
BASF CORP.	126
ABOUT BASF	127
ABOUT BASF'S PAPER CHEMICALS DIVISION	127
ABOUT ZELFO TECHNOLOGY	128
BC GENESIS LLC	128
BLUE GOOSE BIOREFINERIES INC.	128
BORREGAARD	129
RESEARCH AND DEVELOPMENT	129
BOWIL BIOTECH	129
CELLUCOMP LTD.	130
CURRAN PASTE/SLURRY	131
CURRAN POWDER	131
OTHER CURRAN POSSIBILITIES	131
CELLUFORCE	131
COCOSONG FOOD INDUSTRIES SDN. BHD.	132
COLORADO SCHOOL OF MINES	132
CP KELCO	133
DAICEL CORP.	133
EARTHRISE NUTRITIONALS LLC HEADQUARTERS	134
FMC BIOPOLYMER	134
FOREST PRODUCT LABORATORIES	134
PARTNERSHIPS	135
FPINNOVATIONS	135
GEA NIRO SOAVI	136
NAMICELL	136
THE PARTNERS	136

TOPIC	PAGE NO.
GRENCORE COMPOSITES	136
MOLDS ON CONVENTIONAL MACHINES, TOOLING, HOT-RUNNERS	137
ADVANCED INJECTION MOLDING PROCESSES	137
GRENOBLE INP-PAGORA	137
THE DEVELOPMENT OF BIO-BASED CHEMISTRY	138
ENERGY AND CHEMICAL PRODUCTS	139
APPLICATIONS IN VARIOUS FIELDS	139
INNVENTIA AB	140
BIOREFINING	140
MATERIAL PROCESSES	141
PACKAGING SOLUTIONS	141
INTECHFIBRES	142
KEYSER & MACKAY	142
KRAHN CHEMIE GMBH	142
LOHMANN & RAUSCHER INC.	143
LULEA UNIVERSITY OF TECHNOLOGY	143
MELODEA LTD.	143
NIPPON PAPER INDUSTRIES USA CO. LTD.	144
OJI PAPER	145
PT. SARI SEGAR HUSADA	145
SEALED AIR CORP.	145
SEIKO PMC CORP.	146
SONY CORP. OF AMERICA	146
STORA ENSO	147
TENNANTS DISTRIBUTION LTD	147
UPM	148
GLOBAL NETWORK OF RESEARCH CENTERS	149
UNIVERSITY OF MAINE	149
PILOT PLANT CAPABILITIES	150
UPGRADED REFINER LABORATORY	150
WONG COCO	151
ZELFO TECHNOLOGY	151

LIST OF TABLES

TABLE HEADING	PAGE NO.
SUMMARY TABLE GLOBAL NANOCELLULOSE MARKET BY MATERIAL, THROUGH 2019 (\$ MILLIONS)	6
TABLE 1 CUMULATIVE ENERGY DEMAND (CED) AND GLOBAL WARMING POTENTIAL (GWP) FOR 10 GRAMS OF NANOCELLULOSE PRODUCTION	21
TABLE 2 GLOBAL NANOCELLULOSE MARKET BY REGION, THROUGH 2019 (\$ MILLIONS)	23
TABLE 3 GLOBAL NANOCELLULOSE MARKET SHARE BY REGION, 2013-2019 (%)	23
TABLE 4 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY REGION, THROUGH 2019 (TONS)	24
TABLE 5 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY TYPE, THROUGH 2019 (TONS)	25
TABLE 6 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY TYPE, THROUGH 2019 (%)	25
TABLE 7 GLOBAL NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	26
TABLE 8 GLOBAL NANOCELLULOSE MARKET SHARE BY APPLICATION, 2013-2019 (%)	27
TABLE 9 NORTH AMERICAN NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	28
TABLE 10 EUROPEAN NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	29
TABLE 11 ASIAN NANOCELLULOSE MARKET BY APPLICATION, THROUGH 2019 (\$ MILLIONS)	29
TABLE 12 GLOBAL NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	30
TABLE 13 NORTH AMERICAN NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	31
TABLE 14 EUROPEAN NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	31
TABLE 15 ASIAN NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	31
TABLE 16 ROW NANOCELLULOSE COMPOSITES MARKET BY NANOCOMPOSITE PRODUCTION PROCESSING, THROUGH 2019 (\$ MILLIONS)	32
TABLE 17 GLOBAL NANOCELLULOSE COMPOSITES MARKET SHARE BY PRODUCTION PROCESSING, THROUGH 2019 (%)	32
TABLE 18 MAJOR GLOBAL MANUFACTURERS OF NANOCELLULOSE	44
TABLE 19 GEOMETRICAL DIMENSIONS OF NC OBTAINED FROM DIFFERENT SOURCES (NM)	44
TABLE 20 CRYSTALLINITY OF VARIOUS NC (%)	44
TABLE 21 MECHANICAL PROPERTIES OF VARIOUS NC COMPARED TO WOOD	45
TABLE 22 COMPARISON OF PHYSICAL PROPERTIES OF NANOCELLULOSE VERSUS OTHER COMMON MATERIALS	45
TABLE 23 NANOCELLULOSE POTENTIAL APPLICATIONS	61
TABLE 24 NANOCELLULOSE POTENTIAL APPLICATIONS	77
TABLE 25 NANOCELLULOSE POTENTIAL PRODUCTS	78
TABLE 26 NANOCELLULOSE MARKET POTENTIAL (TONS)	78
TABLE 27 JOB GROWTH RELATED TO THE NANOCELLULOSE MARKET, 2015-2020 (UNITS)	78
TABLE 28 GDP GROWTH RELATED TO THE NANOCELLULOSE MARKET, 2015-2020 (\$ MILLIONS)	79

TABLE HEADING	PAGE NO.
TABLE 29 MAJOR KEY COMPANIES AND PRODUCTION CAPACITIES FOR THE NANOCELLULOSE MARKET	79
TABLE 30 AUTO PARTS REQUIREMENTS	83
TABLE 31 LEADING SUPPLIERS OF BIO-BASED MATERIALS TO NORTH AMERICA AUTO MANUFACTURERS	84
TABLE 32 NANOCELLULOSE FILM	85
TABLE 33 MICROFIBRILLATED CELLULOSE FILMS	85
TABLE 34 BENEFITS OF NANOCELLULOSE AS ADDITIVE FOR VARNISHES AND PAINTS	85
TABLE 35 COMPARISON OF CELLULOSE NANOFIBRILS PROPERTIES VERSUS OTHER COMMON MATERIALS	87
TABLE 36 MAJOR MARKET COMPANIES IN BACTERIAL CELLULOSE	88
TABLE 37 NANOCELLULOSE COMPOSITES	88
TABLE 38 MICROFIBRILLATED CELLULOSE COMPOSITE	89
TABLE 39 NANOCELLULOSE-POLYMERS COMPOSITED- EXPECTED PERFORMANCES	90
TABLE 40 NANOCELLULOSE COATING FOR POLYMERS USED IN FOOD PACKAGING-LITERATURE EXAMPLES	91
TABLE 41 NANOCELLULOSE POLYMERS MELT COMPOUNDING USED IN FOOD PACKAGING-LITERATURE EXAMPLES	94
TABLE 42 NANOCELLULOSE STAND-ALONE FILMS USED IN FOOD PACKAGING-LITERATURE EXAMPLES	97
TABLE 43 TOXICOLOGICAL EVALUATION OF NANOCELLULOSE	101
TABLE 44 ASSIGNEES WITH AT LEAST TWO PATENTS WITHIN THE NANOCELLULOSE FIELD	104
TABLE 45 RELEVANT NANOCELLULOSE PATENTS	104
TABLE 46 PRESS RELEASES	118

LIST OF FIGURES

FIGURE TITLE	PAGE NO.
SUMMARY FIGURE GLOBAL NANOCELLULOSE MARKET, BY MATERIAL, 2013-2019 (\$ MILLIONS)	6
FIGURE 1 GLOBAL NANOCELLULOSE MARKET SHARE BY REGION, 2013-2019 (%)	23
FIGURE 2 GLOBAL NANOCELLULOSE PRODUCTION CAPACITY BY TYPE, 2013-2019 (%)	25
FIGURE 3 GLOBAL NANOCELLULOSE MARKET SHARE BY APPLICATION, 2013-2019 (%)	27
FIGURE 4 GLOBAL NANOCELLULOSE COMPOSITES MARKET SHARE BY PRODUCTION PROCESSING, 2013-2019 (%)	32