

# The Global Market for Bio-based and Sustainable Materials 2023-2033

<https://marketpublishers.com/r/G48FE818378FEN.html>

Date: April 2023

Pages: 1248

Price: US\$ 1,500.00 (Single User License)

ID: G48FE818378FEN

## Abstracts

With the need to supplement global plastics production with sustainable alternatives, and the dearth of available recycled plastic (~9% of the world's plastic is recycled), many producers are turning to bio-based alternatives. Bio-based materials refer to products that mainly consist of a substance (or substances) derived from living matter (biomass) and either occur naturally or are synthesized, or it may refer to products made by processes that use biomass. Materials from biomass sources include bulk chemicals, platform chemicals, solvents, polymers, and biocomposites. The many processes to convert biomass components to value-added products and fuels can be classified broadly as biochemical or thermochemical. In addition, biotechnological processes that rely mainly on plant breeding, fermentation, and conventional enzyme isolation also are used. New bio-based materials that may compete with conventional materials are emerging continually, and the opportunities to use them in existing and novel products are explored in this publication.

There is growing consumer demand and regulatory push for bio-based chemicals, materials, polymers, plastics, paints, coatings and fuels with high performance, good recyclability and biodegradable properties to underpin transition towards more sustainable manufacturing and products.

The Global Market for Bio-based and Sustainable Materials 2023-2033 presents a complete picture of the current market and future outlooks, covering bio-based chemicals and feedstocks, materials, polymers, bio-plastics, bio-fuels and bio-based paints and coatings. Contents include:

In depth market analysis of bio-based chemical feedstocks, biopolymers, bioplastics, natural fibers and lignin, biofuels and bio-based coatings and paints.

Global production capacities, market volumes and trends, current and forecast to 2033.

Analysis of bio-based chemical including 11-Aminoundecanoic acid (11-AA), 1,4-Butanediol (1,4-BDO), Dodecanedioic acid (DDDA), Epichlorohydrin (ECH), Ethylene, Furan derivatives, 5-Chloromethylfurfural (5-CMF), 2,5-Furandicarboxylic acid (2,5-FDCA), Furandicarboxylic methyl ester (FDME), Isosorbide, Itaconic acid, 5 Hydroxymethyl furfural (HMF), Lactic acid (D-LA), Lactic acid – L-lactic acid (L-LA), Lactide, Levoglucosenone, Levulinic acid, Monoethylene glycol (MEG), Monopropylene glycol (MPG), Muconic acid, Naphtha, 1,5-Pentametylenediamine (DN5), 1,3-Propanediol (1,3-PDO), Sebacic acid and Succinic acid.

Analysis of synthetic bio-polymers and bio-plastics market including Polylactic acid (Bio-PLA), Polyethylene terephthalate (Bio-PET), Polytrimethylene terephthalate (Bio-PTT), Polyethylene furanoate (Bio-PEF), Polyamides (Bio-PA), Poly(butylene adipate-co-terephthalate) (Bio-PBAT), Polybutylene succinate (PBS) and copolymers, Polyethylene (Bio-PE), Polypropylene (Bio-PP) and Starch.

Analysis of naturally produced bio-based polymers including Polyhydroxyalkanoates (PHA), Polysaccharides, Microfibrillated cellulose (MFC), Cellulose nanocrystals, Cellulose nanofibers, Protein-based bioplastics, Chitosan, Algal and fungal materials.

Analysis of market for bio-fuels.

Analysis of types of natural fibers including plant fibers, animal fibers including alternative leather, wool, silk fiber and down and polysaccharides.

Markets for natural fibers, including composites, aerospace, automotive, construction & building, sports & leisure, textiles (including biobased leather), consumer products and packaging.

Production capacities of lignin producers.

In depth analysis of biorefinery lignin production.

Analysis of the market for bio-based, sustainable paints and coatings.

Analysis of types of bio-coatings and paints market including Alkyd coatings, Polyurethane coatings, Epoxy coatings, Acrylate resins, Polylactic acid (Bio-PLA), Polyhydroxyalkanoates (PHA), Cellulose, Rosins, Biobased carbon black, Lignin, Edible coatings, Protein-based biomaterials for coatings, Alginate etc.

Profiles of over 850 companies. Companies profiled include Aisti Corporation Oy, Algal Bio, AMSilk GmbH, Arkema, Avantium, BASF, Bioform Technologies, Biotic, Bolt Threads, Borealis, Braskem, B'ZEOS, Cathay, CJ Biomaterials, Danimer Scientific, DMC Biotechnologies, Dupont, Ecovative, EnginZyme, Full Cycle Bioplastics, Genecis, Humble Bee Bio, Indorama, Loliware, Keel Labs, Kraig Biocraft Laboratories, Mitsubishi Chemicals, Mycel, MycoWorks, Natrify, NatureWorks, Notpla, Novamont, PeriSkin, PILI, Plastus, Prometheus Materials, Silvis Materials, Smartfiber, Spiber, Stora Enso Oyj, Traceless Materials GmbH, Total Corbion and Venvirotech.

## Contents

### 1 RESEARCH METHODOLOGY

### 2 BIO-BASED AND SUSTAINABLE CHEMICALS AND FEEDSTOCKS

#### 2.1 Types

#### 2.2 Production capacities

#### 2.3 Bio-based adipic acid

##### 2.3.1 Applications and production

#### 2.4 11-Aminoundecanoic acid (11-AA)

##### 2.4.1 Applications and production

#### 2.5 1,4-Butanediol (1,4-BDO)

##### 2.5.1 Applications and production

#### 2.6 Dodecanedioic acid (DDDA)

##### 2.6.1 Applications and production

#### 2.7 Epichlorohydrin (ECH)

##### 2.7.1 Applications and production

#### 2.8 Ethylene

##### 2.8.1 Applications and production

#### 2.9 Furfural

##### 2.9.1 Applications and production

#### 2.10 5-Hydroxymethylfurfural (HMF)

##### 2.10.1 Applications and production

#### 2.11 5-Chloromethylfurfural (5-CMF)

##### 2.11.1 Applications and production

#### 2.12 2,5-Furandicarboxylic acid (2,5-FDCA)

##### 2.12.1 Applications and production

#### 2.13 Furandicarboxylic methyl ester (FDME)

#### 2.14 Isosorbide

##### 2.14.1 Applications and production

#### 2.15 Itaconic acid

##### 2.15.1 Applications and production

#### 2.16 3-Hydroxypropionic acid (3-HP)

##### 2.16.1 Applications and production

#### 2.17 5 Hydroxymethyl furfural (HMF)

##### 2.17.1 Applications and production

#### 2.18 Lactic acid (D-LA)

##### 2.18.1 Applications and production

## 2.19 Lactic acid – L-lactic acid (L-LA)

### 2.19.1 Applications and production

## 2.20 Lactide

### 2.20.1 Applications and production

## 2.21 Levoglucosenone

### 2.21.1 Applications and production

## 2.22 Levulinic acid

### 2.22.1 Applications and production

## 2.23 Monoethylene glycol (MEG)

### 2.23.1 Applications and production

## 2.24 Monopropylene glycol (MPG)

### 2.24.1 Applications and production

## 2.25 Muconic acid

### 2.25.1 Applications and production

## 2.26 Bio-Naphtha

### 2.26.1 Applications and production

### 2.26.2 Production capacities

### 2.26.3 Bio-naptha producers

## 2.27 Pentamethylene diisocyanate

### 2.27.1 Applications and production

## 2.28 1,3-Propanediol (1,3-PDO)

### 2.28.1 Applications and production

## 2.29 Sebacic acid

### 2.29.1 Applications and production

## 2.30 Succinic acid (SA)

### 2.30.1 Applications and production

## **3 BIO-BASED AND SUSTAINABLE MATERIALS, PLASTICS AND POLYMERS**

### 3.1 Global production of plastics

### 3.2 The importance of plastic

### 3.3 Issues with plastics use

### 3.4 Policy and regulations

### 3.5 The circular economy

### 3.6 Bio-based or renewable plastics

#### 3.6.1 Drop-in bio-based plastics

#### 3.6.2 Novel bio-based plastics

### 3.7 Biodegradable and compostable plastics

#### 3.7.1 Biodegradability

- 3.7.2 Compostability
- 3.8 Advantages and disadvantages
- 3.9 Biocomposites
  - 3.9.1 Natural Fibers
    - 3.9.1.1 Plant
    - 3.9.1.2 Animal
    - 3.9.1.3 Mineral
  - 3.9.2 Matrices
    - 3.9.2.1 Thermoplastic polymers
    - 3.9.2.2 Thermosetting polymers
- 3.10 Types of Bio-based and/or Biodegradable Plastics
- 3.11 Market leaders by biobased and/or biodegradable plastic types
- 3.12 Regional/country production capacities, by main types
  - 3.12.1 Bio-based Polyethylene (Bio-PE) production capacities, by country
  - 3.12.2 Bio-based Polyethylene terephthalate (Bio-PET) production capacities, by country
  - 3.12.3 Bio-based polyamides (Bio-PA) production capacities, by country
  - 3.12.4 Bio-based Polypropylene (Bio-PP) production capacities, by country
  - 3.12.5 Bio-based Polytrimethylene terephthalate (Bio-PTT) production capacities, by country
  - 3.12.6 Bio-based Poly(butylene adipate-co-terephthalate) (PBAT) production capacities, by country
  - 3.12.7 Bio-based Polybutylene succinate (PBS) production capacities, by country
  - 3.12.8 Bio-based Polylactic acid (PLA) production capacities, by country
  - 3.12.9 Polyhydroxyalkanoates (PHA) production capacities, by country
  - 3.12.10 Starch blends production capacities, by country
- 3.13 SYNTHETIC BIO-BASED POLYMERS
  - 3.13.1 Polylactic acid (Bio-PLA)
    - 3.13.1.1 Market analysis
    - 3.13.1.2 Production
      - 3.13.1.3 Producers and production capacities, current and planned
        - 3.13.1.3.1 Lactic acid producers and production capacities
        - 3.13.1.3.2 PLA producers and production capacities
        - 3.13.1.3.3 Polylactic acid (Bio-PLA) production capacities 2019-2033 (1,000 tons)
  - 3.13.2 Polyethylene terephthalate (Bio-PET)
    - 3.13.2.1 Market analysis
    - 3.13.2.2 Producers and production capacities
    - 3.13.2.3 Polyethylene terephthalate (Bio-PET) production capacities 2019-2033 (1,000 tons)

### 3.13.3 Polytrimethylene terephthalate (Bio-PTT)

#### 3.13.3.1 Market analysis

#### 3.13.3.2 Producers and production capacities

#### 3.13.3.3 Polytrimethylene terephthalate (PTT) production capacities 2019-2033

(1,000 tons)

### 3.13.4 Polyethylene furanoate (Bio-PEF)

#### 3.13.4.1 Market analysis

#### 3.13.4.2 Comparative properties to PET

#### 3.13.4.3 Producers and production capacities

##### 3.13.4.3.1 FDCA and PEF producers and production capacities

##### 3.13.4.3.2 Polyethylene furanoate (Bio-PEF) production capacities 2019-2033

(1,000 tons).

### 3.13.5 Polyamides (Bio-PA)

#### 3.13.5.1 Market analysis

#### 3.13.5.2 Producers and production capacities

#### 3.13.5.3 Polyamides (Bio-PA) production capacities 2019-2033 (1,000 tons)

### 3.13.6 Poly(butylene adipate-co-terephthalate) (Bio-PBAT)

#### 3.13.6.1 Market analysis

#### 3.13.6.2 Producers and production capacities

#### 3.13.6.3 Poly(butylene adipate-co-terephthalate) (Bio-PBAT) production capacities

2019-2033 (1,000 tons)

### 3.13.7 Polybutylene succinate (PBS) and copolymers

#### 3.13.7.1 Market analysis

#### 3.13.7.2 Producers and production capacities

#### 3.13.7.3 Polybutylene succinate (PBS) production capacities 2019-2033 (1,000 tons)

### 3.13.8 Polyethylene (Bio-PE)

#### 3.13.8.1 Market analysis

#### 3.13.8.2 Producers and production capacities

#### 3.13.8.3 Polyethylene (Bio-PE) production capacities 2019-2033 (1,000 tons).

### 3.13.9 Polypropylene (Bio-PP)

#### 3.13.9.1 Market analysis

#### 3.13.9.2 Producers and production capacities

#### 3.13.9.3 Polypropylene (Bio-PP) production capacities 2019-2033 (1,000 tons)

### 3.13.10 Starch

#### 3.13.10.1 Market analysis

#### 3.13.10.2 Producers and production capacities

## 3.14 NATURAL BIO-BASED POLYMERS

### 3.14.1 Polyhydroxyalkanoates (PHA)

#### 3.14.1.1 Technology description



- 3.14.1.2 Types
  - 3.14.1.2.1 PHB
  - 3.14.1.2.2 PHBV
- 3.14.1.3 Synthesis and production processes
- 3.14.1.4 Market analysis
- 3.14.1.5 Commercially available PHAs
- 3.14.1.6 Markets for PHAs
  - 3.14.1.6.1 Packaging
  - 3.14.1.6.2 Cosmetics
    - 3.14.1.6.2.1 PHA microspheres
  - 3.14.1.6.3 Medical
    - 3.14.1.6.3.1 Tissue engineering
    - 3.14.1.6.3.2 Drug delivery
  - 3.14.1.6.4 Agriculture
    - 3.14.1.6.4.1 Mulch film
    - 3.14.1.6.4.2 Grow bags
- 3.14.1.7 Producers and production capacities
- 3.14.1.8 PHA production capacities 2019-2033 (1,000 tons)
- 3.14.2 Cellulose
  - 3.14.2.1 Microfibrillated cellulose (MFC)
    - 3.14.2.1.1 Market analysis
    - 3.14.2.1.2 Producers and production capacities
  - 3.14.2.2 Nanocellulose
    - 3.14.2.2.1 Cellulose nanocrystals
      - 3.14.2.2.1.1 Synthesis
      - 3.14.2.2.1.2 Properties
      - 3.14.2.2.1.3 Production
      - 3.14.2.2.1.4 Applications
      - 3.14.2.2.1.5 Market analysis
      - 3.14.2.2.1.6 Producers and production capacities
    - 3.14.2.2.2 Cellulose nanofibers
      - 3.14.2.2.2.1 Applications
      - 3.14.2.2.2.2 Market analysis
      - 3.14.2.2.2.3 Producers and production capacities
  - 3.14.2.3 Bacterial Nanocellulose, Biocellulose (BNC)
    - 3.14.2.2.3.1 Production
    - 3.14.2.2.3.2 Applications
- 3.14.3 Protein-based bioplastics
  - 3.14.3.1 Types, applications and producers



### 3.14.4 Algal and fungal

#### 3.14.4.1 Algal

##### 3.14.4.1.1 Advantages

##### 3.14.4.1.2 Production

##### 3.14.4.1.3 Producers

#### 3.14.4.2 Mycelium

##### 3.14.4.2.1 Properties

##### 3.14.4.2.2 Applications

##### 3.14.4.2.3 Commercialization

### 3.14.5 Chitosan

#### 3.14.5.1 Technology description

## 3.15 PRODUCTION OF BIOBASED AND BIODEGRADABLE PLASTICS, BY REGION

### 3.15.1 North America

### 3.15.2 Europe

### 3.15.3 Asia-Pacific

#### 3.15.3.1 China

#### 3.15.3.2 Japan

#### 3.15.3.3 Thailand

#### 3.15.3.4 Indonesia

### 3.15.4 Latin America

## 3.16 GLOBAL MARKET DEMAND FOR BIOBASED AND SUSTAINABLE PLASTICS, 2019-2033

### 3.16.1 Packaging

#### 3.16.1.1 Processes for bioplastics in packaging

#### 3.16.1.2 Applications

#### 3.16.1.3 Flexible packaging

##### 3.16.1.3.1 Global demand 2019-2033

#### 3.16.1.4 Rigid packaging

##### 3.16.1.4.1 Global demand 2019-2033

### 3.16.2 Consumer products

#### 3.16.2.1 Applications

#### 3.16.2.2 Global market demand 2019-2033

### 3.16.3 Automotive

#### 3.16.3.1 Applications

#### 3.16.3.2 Global market demand 2019-2033

### 3.16.4 Building & construction

#### 3.16.4.1 Applications

#### 3.16.4.2 Global market demand 2019-2033

### 3.16.5 Textiles

- 3.16.5.1 Apparel
- 3.16.5.2 Footwear
- 3.16.5.3 Medical textiles
- 3.16.5.4 Biobased leather
- 3.16.5.5 Global market demand, 209-2033
- 3.16.6 Sports and leisure equipment
  - 3.16.6.1 Market overview
  - 3.16.6.2 Global market demand 2019-2033
- 3.16.7 Electronics
  - 3.16.7.1 Applications
  - 3.16.7.2 Global market demand 2019-2033
- 3.16.8 Agriculture and horticulture
  - 3.16.8.1 Global market demand 2019-2033
- 3.17 NATURAL FIBERS
  - 3.17.1 Manufacturing method, matrix materials and applications of natural fibers
  - 3.17.2 Advantages of natural fibers
  - 3.17.3 Commercially available natural fiber products
  - 3.17.4 Market drivers for next-gen natural fibers
  - 3.17.5 Challenges
  - 3.17.6 Plants (cellulose, lignocellulose)
    - 3.17.6.1 Seed fibers
      - 3.17.6.1.1 Cotton
        - 3.17.6.1.1.1 Production volumes 2018-2033
      - 3.17.6.1.2 Kapok
        - 3.17.6.1.2.1 Production volumes 2018-2033
      - 3.17.6.1.3 Luffa
    - 3.17.6.2 Bast fibers
      - 3.17.6.2.1 Jute
        - 3.17.6.2.2 Production volumes 2018-2033
          - 3.17.6.2.2.1 Hemp
            - 3.17.6.2.2.2 Production volumes 2018-2033
        - 3.17.6.2.3 Flax
          - 3.17.6.2.3.1 Production volumes 2018-2033
        - 3.17.6.2.4 Ramie
          - 3.17.6.2.4.1 Production volumes 2018-2033
        - 3.17.6.2.5 Kenaf
          - 3.17.6.2.5.1 Production volumes 2018-2033
      - 3.17.6.3 Leaf fibers
        - 3.17.6.3.1 Sisal

- 3.17.6.3.1.1 Production volumes 2018-2033
- 3.17.6.3.2 Abaca
  - 3.17.6.3.2.1 Production volumes 2018-2033
- 3.17.6.4 Fruit fibers
  - 3.17.6.4.1 Coir
    - 3.17.6.4.1.1 Production volumes 2018-2033
  - 3.17.6.4.2 Banana
    - 3.17.6.4.2.1 Production volumes 2018-2033
  - 3.17.6.4.3 Pineapple
- 3.17.6.5 Stalk fibers from agricultural residues
  - 3.17.6.5.1 Rice fiber
  - 3.17.6.5.2 Corn
- 3.17.6.6 Cane, grasses and reed
  - 3.17.6.6.1 Switch grass
  - 3.17.6.6.2 Sugarcane (agricultural residues)
  - 3.17.6.6.3 Bamboo
    - 3.17.6.6.3.1 Production volumes 2018-2033
  - 3.17.6.6.4 Fresh grass (green biorefinery)
- 3.17.6.7 Modified natural polymers
  - 3.17.6.7.1 Mycelium
  - 3.17.6.7.2 Chitosan
  - 3.17.6.7.3 Alginate
- 3.17.7 Animal (fibrous protein)
  - 3.17.7.1 Wool
    - 3.17.7.1.1 Alternative wool materials
    - 3.17.7.1.2 Producers
  - 3.17.7.2 Silk fiber
    - 3.17.7.2.1 Alternative silk materials
      - 3.17.7.2.1.1 Producers
  - 3.17.7.3 Leather
    - 3.17.7.3.1 Alternative leather materials
      - 3.17.7.3.1.1 Producers
  - 3.17.7.4 Fur
    - 3.17.7.4.1 Producers
  - 3.17.7.5 Down
    - 3.17.7.5.1 Alternative down materials
      - 3.17.7.5.1.1 Producers
- 3.17.8 Markets for natural fibers
  - 3.17.8.1 Composites

- 3.17.8.2 Applications
- 3.17.8.3 Natural fiber injection moulding compounds
  - 3.17.8.3.1 Properties
  - 3.17.8.3.2 Applications
- 3.17.8.4 Non-woven natural fiber mat composites
  - 3.17.8.4.1 Automotive
  - 3.17.8.4.2 Applications
- 3.17.8.5 Aligned natural fiber-reinforced composites
- 3.17.8.6 Natural fiber biobased polymer compounds
- 3.17.8.7 Natural fiber biobased polymer non-woven mats
  - 3.17.8.7.1 Flax
  - 3.17.8.7.2 Kenaf
- 3.17.8.8 Natural fiber thermoset bioresin composites
- 3.17.8.9 Aerospace
  - 3.17.8.9.1 Market overview
- 3.17.8.10 Automotive
  - 3.17.8.10.1 Market overview
  - 3.17.8.10.2 Applications of natural fibers
- 3.17.8.11 Building/construction
  - 3.17.8.11.1 Market overview
  - 3.17.8.11.2 Applications of natural fibers
- 3.17.8.12 Sports and leisure
  - 3.17.8.12.1 Market overview
- 3.17.8.13 Textiles
  - 3.17.8.13.1 Market overview
  - 3.17.8.13.2 Consumer apparel
  - 3.17.8.13.3 Geotextiles
- 3.17.8.14 Packaging
  - 3.17.8.14.1 Market overview
- 3.17.9 Natural fibers global production
  - 3.17.9.1 Overall global fibers market
  - 3.17.9.2 Plant-based fiber production
  - 3.17.9.3 Animal-based natural fiber production
- 3.18 LIGNIN
  - 3.18.1 Introduction
    - 3.18.1.1 What is lignin?
      - 3.18.1.1.1 Lignin structure
    - 3.18.1.2 Types of lignin
      - 3.18.1.2.1 Sulfur containing lignin

- 3.18.1.2.2 Sulfur-free lignin from biorefinery process
- 3.18.1.3 Properties
- 3.18.1.4 The lignocellulose biorefinery
- 3.18.1.5 Markets and applications
- 3.18.1.6 Challenges for using lignin
- 3.18.2 Lignin production processes
  - 3.18.2.1 Lignosulphonates
  - 3.18.2.2 Kraft Lignin
    - 3.18.2.2.1 LignoBoost process
    - 3.18.2.2.2 LignoForce method
    - 3.18.2.2.3 Sequential Liquid Lignin Recovery and Purification
    - 3.18.2.2.4 A-Recovery+
  - 3.18.2.3 Soda lignin
  - 3.18.2.4 Biorefinery lignin
    - 3.18.2.4.1 Commercial and pre-commercial biorefinery lignin production facilities and processes
  - 3.18.2.5 Organosolv lignins
  - 3.18.2.6 Hydrolytic lignin
- 3.18.3 Market for lignin
  - 3.18.3.1 Market drivers and trends for lignin
  - 3.18.3.2 Production capacities
    - 3.18.3.2.1 Technical lignin availability (dry ton/y)
    - 3.18.3.2.2 Biomass conversion (Biorefinery)
  - 3.18.3.3 Estimated consumption of lignin
  - 3.18.3.4 Prices
  - 3.18.3.5 Heat and power energy
  - 3.18.3.6 Pyrolysis and syngas
  - 3.18.3.7 Aromatic compounds
    - 3.18.3.7.1 Benzene, toluene and xylene
    - 3.18.3.7.2 Phenol and phenolic resins
    - 3.18.3.7.3 Vanillin
  - 3.18.3.8 Plastics and polymers
  - 3.18.3.9 Hydrogels
  - 3.18.3.10 Carbon materials
    - 3.18.3.10.1 Carbon black
    - 3.18.3.10.2 Activated carbons
    - 3.18.3.10.3 Carbon fiber
  - 3.18.3.11 Concrete
  - 3.18.3.12 Rubber

- 3.18.3.13 Biofuels
- 3.18.3.14 Bitumen and Asphalt
- 3.18.3.15 Oil and gas
- 3.18.3.16 Energy storage
  - 3.18.3.16.1 Supercapacitors
  - 3.18.3.16.2 Anodes for lithium-ion batteries
  - 3.18.3.16.3 Gel electrolytes for lithium-ion batteries
  - 3.18.3.16.4 Binders for lithium-ion batteries
  - 3.18.3.16.5 Cathodes for lithium-ion batteries
  - 3.18.3.16.6 Sodium-ion batteries
- 3.18.3.17 Binders, emulsifiers and dispersants
- 3.18.3.18 Chelating agents
- 3.18.3.19 Ceramics
- 3.18.3.20 Automotive interiors
- 3.18.3.21 Fire retardants
- 3.18.3.22 Antioxidants
- 3.18.3.23 Lubricants
- 3.18.3.24 Dust control

### 3.19 BIO-BASED AND SUSTAINABLE MATERIALS, PLASTICS AND POLYMERS COMPANY PROFILES 336 (538 company profiles)

## 4 BIO-BASED FUELS

- 4.1 The global biofuels market
  - 4.1.1 Diesel substitutes and alternatives
  - 4.1.2 Gasoline substitutes and alternatives
- 4.2 Comparison of biofuel costs 2022, by type
- 4.3 Types
  - 4.3.1 Solid Biofuels
  - 4.3.2 Liquid Biofuels
  - 4.3.3 Gaseous Biofuels
  - 4.3.4 Conventional Biofuels
  - 4.3.5 Advanced Biofuels
- 4.4 Feedstocks
  - 4.4.1 First-generation (1-G)
    - 4.4.2 Second-generation (2-G)
      - 4.4.2.1 Lignocellulosic wastes and residues
      - 4.4.2.2 Biorefinery lignin
    - 4.4.3 Third-generation (3-G)

- 4.4.3.1 Algal biofuels
  - 4.4.3.1.1 Properties
  - 4.4.3.1.2 Advantages
- 4.4.4 Fourth-generation (4-G)
- 4.4.5 Advantages and disadvantages, by generation
- 4.5 HYDROCARBON BIOFUELS
  - 4.5.1 Biodiesel
    - 4.5.1.1 Biodiesel by generation
    - 4.5.1.2 Production of biodiesel and other biofuels
      - 4.5.1.2.1 Pyrolysis of biomass
      - 4.5.1.2.2 Vegetable oil transesterification
      - 4.5.1.2.3 Vegetable oil hydrogenation (HVO)
        - 4.5.1.2.3.1 Production process
      - 4.5.1.2.4 Biodiesel from tall oil
      - 4.5.1.2.5 Fischer-Tropsch BioDiesel
      - 4.5.1.2.6 Hydrothermal liquefaction of biomass
      - 4.5.1.2.7 CO<sub>2</sub> capture and Fischer-Tropsch (FT)
      - 4.5.1.2.8 Dimethyl ether (DME)
    - 4.5.1.3 Global production and consumption
  - 4.5.2 Renewable diesel
    - 4.5.2.1 Production
    - 4.5.2.2 Global consumption
  - 4.5.3 Bio-jet (bio-aviation) fuels
    - 4.5.3.1 Description
    - 4.5.3.2 Global market
    - 4.5.3.3 Production pathways
  - 4.5.4 Costs
    - 4.5.4.1 Biojet fuel production capacities
    - 4.5.4.2 Challenges
    - 4.5.4.3 Global consumption
  - 4.5.5 Syngas
  - 4.5.6 Biogas and biomethane
    - 4.5.6.1 Feedstocks
  - 4.5.7 Bio-naphtha
    - 4.5.7.1 Overview
    - 4.5.7.2 Markets and applications
    - 4.5.7.3 Production capacities, by producer, current and planned
    - 4.5.7.4 Production capacities, total (tonnes), historical, current and planned
- 4.6 ALCOHOL FUELS



#### 4.6.1 Biomethanol

##### 4.6.1.1 Methanol-to gasoline technology

###### 4.6.1.1.1 Production processes

###### 4.6.1.1.1.1 Anaerobic digestion

###### 4.6.1.1.1.2 Biomass gasification

###### 4.6.1.1.1.3 Power to Methane

#### 4.6.2 Bioethanol

##### 4.6.2.1 Technology description

##### 4.6.2.2 1G Bio-Ethanol

##### 4.6.2.3 Ethanol to jet fuel technology

##### 4.6.2.4 Methanol from pulp & paper production

##### 4.6.2.5 Sulfite spent liquor fermentation

##### 4.6.2.6 Gasification

###### 4.6.2.6.1 Biomass gasification and syngas fermentation

##### 4.6.2.7 Biomass gasification and syngas thermochemical conversion

##### 4.6.2.8 CO<sub>2</sub> capture and alcohol synthesis

##### 4.6.2.9 Biomass hydrolysis and fermentation

###### 4.6.2.9.1 Separate hydrolysis and fermentation

###### 4.6.2.9.2 Simultaneous saccharification and fermentation (SSF)

###### 4.6.2.9.3 Pre-hydrolysis and simultaneous saccharification and fermentation (PSSF)

###### 4.6.2.9.4 Simultaneous saccharification and co-fermentation (SSCF)

###### 4.6.2.9.5 Direct conversion (consolidated bioprocessing) (CBP)

##### 4.6.2.10 Global ethanol consumption

#### 4.6.3 Biobutanol

##### 4.6.3.1 Production

#### 4.7 BIOFUEL FROM PLASTIC WASTE AND USED TIRES

##### 4.7.1 Plastic pyrolysis

##### 4.7.2 Used tires pyrolysis

###### 4.7.2.1 Conversion to biofuel

#### 4.8 ELECTROFUELS (E-FUELS)

##### 4.8.1 Introduction

###### 4.8.1.1 Benefits of e-fuels

##### 4.8.2 Feedstocks

###### 4.8.2.1 Hydrogen electrolysis

###### 4.8.2.2 CO<sub>2</sub> capture

##### 4.8.3 Production

###### 4.8.3.1 eFuel production facilities, current and planned

##### 4.8.4 Electrolysers

###### 4.8.4.1 Commercial alkaline electrolyser cells (AECs)

- 4.8.4.2 PEM electrolyzers (PEMEC)
- 4.8.4.3 High-temperature solid oxide electrolyser cells (SOECs)
- 4.8.5 Costs
- 4.8.6 Market challenges
- 4.8.7 Companies
- 4.9 ALGAE-DERIVED BIOFUELS
  - 4.9.1 Technology description
  - 4.9.2 Production
- 4.10 GREEN AMMONIA
  - 4.10.1 Production
    - 4.10.1.1 Decarbonisation of ammonia production
    - 4.10.1.2 Green ammonia projects
  - 4.10.2 Green ammonia synthesis methods
    - 4.10.2.1 Haber-Bosch process
    - 4.10.2.2 Biological nitrogen fixation
    - 4.10.2.3 Electrochemical production
      - 4.10.2.3.1 Chemical looping processes
  - 4.10.3 Blue ammonia
    - 4.10.3.1 Blue ammonia projects
  - 4.10.4 Markets and applications
    - 4.10.4.1 Chemical energy storage
      - 4.10.4.1.1 Ammonia fuel cells
    - 4.10.4.2 Marine fuel
  - 4.10.5 Costs
  - 4.10.6 Estimated market demand
  - 4.10.7 Companies and projects
- 4.11 BIOFUELS FROM CARBON CAPTURE
  - 4.11.1 Overview
  - 4.11.2 CO<sub>2</sub> capture from point sources
  - 4.11.3 Production routes
  - 4.11.4 Direct air capture (DAC)
    - 4.11.4.1 Description
    - 4.11.4.2 Deployment
    - 4.11.4.3 Point source carbon capture versus Direct Air Capture
    - 4.11.4.4 Technologies
      - 4.11.4.4.1 Solid sorbents
      - 4.11.4.4.2 Liquid sorbents
      - 4.11.4.4.3 Liquid solvents
      - 4.11.4.4.4 Airflow equipment integration

- 4.11.4.4.5 Passive Direct Air Capture (PDAC)
- 4.11.4.5 Direct conversion
  - 4.11.4.5.1 Co-product generation
  - 4.11.4.5.2 Low Temperature DAC
  - 4.11.4.5.3 Regeneration methods
- 4.11.4.6 Commercialization and plants
- 4.11.4.7 Metal-organic frameworks (MOFs) in DAC
- 4.11.4.8 DAC plants and projects-current and planned
- 4.11.4.9 Markets for DAC
- 4.11.4.10 Costs
- 4.11.4.11 Challenges
- 4.11.4.12 Players and production
- 4.11.5 Methanol
- 4.11.6 Algae based biofuels
- 4.11.7 CO<sub>2</sub>-fuels from solar
- 4.11.8 Companies
- 4.11.9 Challenges
- 4.12 BIO-BASED FUELS COMPANY PROFILES (164 company profiles)

## **5 BIO-BASED PAINTS AND COATINGS**

- 5.1 The global paints and coatings market
- 5.2 Bio-based paints and coatings
- 5.3 Challenges using bio-based paints and coatings
- 5.4 Types of bio-based coatings and materials
  - 5.4.1 Alkyd coatings
    - 5.4.1.1 Alkyd resin properties
    - 5.4.1.2 Biobased alkyd coatings
    - 5.4.1.3 Products
  - 5.4.2 Polyurethane coatings
    - 5.4.2.1 Properties
    - 5.4.2.2 Biobased polyurethane coatings
    - 5.4.2.3 Products
  - 5.4.3 Epoxy coatings
    - 5.4.3.1 Properties
    - 5.4.3.2 Biobased epoxy coatings
    - 5.4.3.3 Products
  - 5.4.4 Acrylate resins
    - 5.4.4.1 Properties

- 5.4.4.2 Biobased acrylates
- 5.4.4.3 Products
- 5.4.5 Polylactic acid (Bio-PLA)
  - 5.4.5.1 Properties
  - 5.4.5.2 Bio-PLA coatings and films
- 5.4.6 Polyhydroxyalkanoates (PHA)
  - 5.4.6.1 Properties
  - 5.4.6.2 PHA coatings
  - 5.4.6.3 Commercially available PHAs
- 5.4.7 Cellulose
  - 5.4.7.1 Microfibrillated cellulose (MFC)
    - 5.4.7.1.1 Properties
    - 5.4.7.1.2 Applications in paints and coatings
  - 5.4.7.2 Cellulose nanofibers
    - 5.4.7.2.1 Properties
    - 5.4.7.2.2 Product developers
  - 5.4.7.3 Cellulose nanocrystals
  - 5.4.7.4 Bacterial Nanocellulose (BNC)
- 5.4.8 Rosins
- 5.4.9 Biobased carbon black
  - 5.4.9.1 Lignin-based
  - 5.4.9.2 Algae-based
- 5.4.10 Lignin
  - 5.4.10.1 Application in coatings
- 5.4.11 Edible coatings
- 5.4.12 Protein-based biomaterials for coatings
  - 5.4.12.1 Plant derived proteins
  - 5.4.12.2 Animal origin proteins
- 5.4.13 Alginate
- 5.5 Market for bio-based paints and coatings
  - 5.5.1 Global market revenues to 2033, total
  - 5.5.2 Global market revenues to 2033, by market
- 5.6 BIO-BASED PAINTS AND COATINGS COMPANY PROFILES (130 company profiles)

## **6 REFERENCES**

## List Of Tables

### LIST OF TABLES

Table 1. List of Bio-based chemicals.

Table 2. Lactide applications.

Table 3. Biobased MEG producers capacities.

Table 4. Bio-naphtha market value chain.

Table 5. Bio-naphtha producers and production capacities.

Table 6. Issues related to the use of plastics.

Table 7. Type of biodegradation.

Table 8. Advantages and disadvantages of biobased plastics compared to conventional plastics.

Table 9. Mechanical properties of natural and man-made fibers.

Table 10. Properties of bio-based and synthetic resin systems.

Table 11. Properties of polymer matrices.

Table 12. Types of Bio-based and/or Biodegradable Plastics, applications.

Table 13. Market leader by Bio-based and/or Biodegradable Plastic types.

Table 14. Bioplastics regional production capacities, 1,000 tons, 2019-2033.

Table 15. Polylactic acid (PLA) market analysis-manufacture, advantages, disadvantages and applications.

Table 16. Lactic acid producers and production capacities.

Table 17. PLA producers and production capacities.

Table 18. Planned PLA capacity expansions in China.

Table 19. Bio-based Polyethylene terephthalate (Bio-PET) market analysis-manufacture, advantages, disadvantages and applications.

Table 20. Bio-based Polyethylene terephthalate (PET) producers and production capacities (tons).

Table 21. Polytrimethylene terephthalate (PTT) market analysis-manufacture, advantages, disadvantages and applications.

Table 22. Production capacities of Polytrimethylene terephthalate (PTT), by leading producers.

Table 23. Polyethylene furanoate (PEF) market analysis-manufacture, advantages, disadvantages and applications.

Table 24. PEF vs. PET.

Table 25. FDCA and PEF producers.

Table 26. Bio-based polyamides (Bio-PA) market analysis - manufacture, advantages, disadvantages and applications.

Table 27. Leading Bio-PA producers production capacities.

- Table 28. Poly(butylene adipate-co-terephthalate) (PBAT) market analysis-manufacture, advantages, disadvantages and applications.
- Table 29. Leading PBAT producers, production capacities and brands.
- Table 30. Bio-PBS market analysis-manufacture, advantages, disadvantages and applications.
- Table 31. Leading PBS producers and production capacities.
- Table 32. Bio-based Polyethylene (Bio-PE) market analysis- manufacture, advantages, disadvantages and applications.
- Table 33. Leading Bio-PE producers.
- Table 34. Bio-PP market analysis- manufacture, advantages, disadvantages and applications.
- Table 35. Leading Bio-PP producers and capacities.
- Table 36. Starch-based bioplastic producers.
- Table 37. Types of PHAs and properties.
- Table 38. Comparison of the physical properties of different PHAs with conventional petroleum-based polymers.
- Table 39. Polyhydroxyalkanoate (PHA) extraction methods.
- Table 40. Polyhydroxyalkanoates (PHA) market analysis.
- Table 41. Commercially available PHAs.
- Table 42. Markets and applications for PHAs.
- Table 43. Applications, advantages and disadvantages of PHAs in packaging.
- Table 44. Polyhydroxyalkanoates (PHA) producers.
- Table 45. Microfibrillated cellulose (MFC) market analysis-manufacture, advantages, disadvantages and applications.
- Table 46. Leading MFC producers and capacities.
- Table 47. Synthesis methods for cellulose nanocrystals (CNC).
- Table 48. CNC sources, size and yield.
- Table 49. CNC properties.
- Table 50. Mechanical properties of CNC and other reinforcement materials.
- Table 51. Applications of nanocrystalline cellulose (NCC).
- Table 52. Cellulose nanocrystals analysis.
- Table 53: Cellulose nanocrystal production capacities and production process, by producer.
- Table 54. Applications of cellulose nanofibers (CNF).
- Table 55. Cellulose nanofibers market analysis.
- Table 56. CNF production capacities (by type, wet or dry) and production process, by producer, metric tonnes.
- Table 57. Applications of bacterial nanocellulose (BNC).
- Table 58. Types of protein based-bioplastics, applications and companies.

Table 59. Types of algal and fungal based-bioplastics, applications and companies.

Table 60. Overview of alginate-description, properties, application and market size.

Table 61. Companies developing algal-based bioplastics.

Table 62. Overview of mycelium fibers-description, properties, drawbacks and applications.

Table 63. Companies developing mycelium-based bioplastics.

Table 64. Overview of chitosan-description, properties, drawbacks and applications.

Table 65. Global production capacities of biobased and sustainable plastics in 2019-2033, by region, tons.

Table 66. Biobased and sustainable plastics producers in North America.

Table 67. Biobased and sustainable plastics producers in Europe.

Table 68. Biobased and sustainable plastics producers in Asia-Pacific.

Table 69. Biobased and sustainable plastics producers in Latin America.

Table 70. Processes for bioplastics in packaging.

Table 71. Comparison of bioplastics' (PLA and PHAs) properties to other common polymers used in product packaging.

Table 72. Typical applications for bioplastics in flexible packaging.

Table 73. Types of bio-based packaging materials and price/kg.

Table 74. Typical applications for bioplastics in rigid packaging.

Table 75. Biocomposites in the automotive market, by manufacturer.

Table 76. Applications of natural fibers in the automotive industry.

Table 77. Natural fiber-reinforced polymer composite in the automotive market.

Table 78. Applications of natural fibers in the building/construction sector.

Table 79. Bio-based leather companies.

Table 80. Biocomposites in the sports and leisure sector-market drivers, applications and challenges for NF use.

Table 81. Types of next-gen natural fibers.

Table 82. Application, manufacturing method, and matrix materials of natural fibers.

Table 83. Typical properties of natural fibers.

Table 84. Commercially available natural fiber products.

Table 85. Market drivers for natural fibers.

Table 86. Overview of cotton fibers-description, properties, drawbacks and applications.

Table 87. Overview of kapok fibers-description, properties, drawbacks and applications.

Table 88. Overview of luffa fibers-description, properties, drawbacks and applications.

Table 89. Overview of jute fibers-description, properties, drawbacks and applications.

Table 90. Overview of hemp fibers-description, properties, drawbacks and applications.

Table 91. Overview of flax fibers-description, properties, drawbacks and applications.

Table 92. Overview of ramie fibers- description, properties, drawbacks and applications.

Table 93. Overview of kenaf fibers-description, properties, drawbacks and applications.



- Table 94. Overview of sisal leaf fibers-description, properties, drawbacks and applications.
- Table 95. Overview of abaca fibers-description, properties, drawbacks and applications.
- Table 96. Overview of coir fibers-description, properties, drawbacks and applications.
- Table 97. Overview of banana fibers-description, properties, drawbacks and applications.
- Table 98. Overview of pineapple fibers-description, properties, drawbacks and applications.
- Table 99. Overview of rice fibers-description, properties, drawbacks and applications.
- Table 100. Overview of corn fibers-description, properties, drawbacks and applications.
- Table 101. Overview of switch grass fibers-description, properties and applications.
- Table 102. Overview of sugarcane fibers-description, properties, drawbacks and application and market size.
- Table 103. Overview of bamboo fibers-description, properties, drawbacks and applications.
- Table 104. Overview of mycelium fibers-description, properties, drawbacks and applications.
- Table 105. Overview of chitosan fibers-description, properties, drawbacks and applications.
- Table 106. Overview of alginate-description, properties, application and market size.
- Table 107. Overview of wool fibers-description, properties, drawbacks and applications.
- Table 108. Alternative wool materials producers.
- Table 109. Overview of silk fibers-description, properties, application and market size.
- Table 110. Alternative silk materials producers.
- Table 111. Alternative leather materials producers.
- Table 112. Next-gen fur producers.
- Table 113. Alternative down materials producers.
- Table 114. Applications of natural fiber composites.
- Table 115. Typical properties of short natural fiber-thermoplastic composites.
- Table 116. Properties of non-woven natural fiber mat composites.
- Table 117. Properties of aligned natural fiber composites.
- Table 118. Properties of natural fiber-bio-based polymer compounds.
- Table 119. Properties of natural fiber-bio-based polymer non-woven mats.
- Table 120. Natural fibers in the aerospace sector-market drivers, applications and challenges for NF use.
- Table 121. Natural fiber-reinforced polymer composite in the automotive market.
- Table 122. Natural fibers in the aerospace sector- market drivers, applications and challenges for NF use.
- Table 123. Applications of natural fibers in the automotive industry.

Table 124. Natural fibers in the building/construction sector- market drivers, applications and challenges for NF use.

Table 125. Applications of natural fibers in the building/construction sector.

Table 126. Natural fibers in the sports and leisure sector-market drivers, applications and challenges for NF use.

Table 127. Natural fibers in the textiles sector- market drivers, applications and challenges for NF use.

Table 128. Natural fibers in the packaging sector-market drivers, applications and challenges for NF use.

Table 129. Technical lignin types and applications.

Table 130. Classification of technical lignins.

Table 131. Lignin content of selected biomass.

Table 132. Properties of lignins and their applications.

Table 133. Example markets and applications for lignin.

Table 134. Processes for lignin production.

Table 135. Biorefinery feedstocks.

Table 136. Comparison of pulping and biorefinery lignins.

Table 137. Commercial and pre-commercial biorefinery lignin production facilities and processes

Table 138. Market drivers and trends for lignin.

Table 139. Production capacities of technical lignin producers.

Table 140. Production capacities of biorefinery lignin producers.

Table 141. Estimated consumption of lignin, 2019-2033 (000 MT).

Table 142. Prices of benzene, toluene, xylene and their derivatives.

Table 143. Application of lignin in plastics and polymers.

Table 144. Lignin-derived anodes in lithium batteries.

Table 145. Application of lignin in binders, emulsifiers and dispersants.

Table 146. Lactips plastic pellets.

Table 147. Oji Holdings CNF products.

Table 148. Comparison of biofuel costs (USD/liter) 2022, by type.

Table 149. Categories and examples of solid biofuel.

Table 150. Comparison of biofuels and e-fuels to fossil and electricity.

Table 151. Classification of biomass feedstock.

Table 152. Biorefinery feedstocks.

Table 153. Feedstock conversion pathways.

Table 154. First-Generation Feedstocks.

Table 155. Lignocellulosic ethanol plants and capacities.

Table 156. Comparison of pulping and biorefinery lignins.

Table 157. Commercial and pre-commercial biorefinery lignin production facilities and

processes

Table 158. Operating and planned lignocellulosic biorefineries and industrial flue gas-to-ethanol.

Table 159. Properties of microalgae and macroalgae.

Table 160. Yield of algae and other biodiesel crops.

Table 161. Advantages and disadvantages of biofuels, by generation.

Table 162. Biodiesel by generation.

Table 163. Biodiesel production techniques.

Table 164. Summary of pyrolysis technique under different operating conditions.

Table 165. Biomass materials and their bio-oil yield.

Table 166. Biofuel production cost from the biomass pyrolysis process.

Table 167. Properties of vegetable oils in comparison to diesel.

Table 168. Main producers of HVO and capacities.

Table 169. Example commercial Development of BtL processes.

Table 170. Pilot or demo projects for biomass to liquid (BtL) processes.

Table 171. Global biodiesel consumption, 2010-2033 (M litres/year).

Table 172. Global renewable diesel consumption, to 2033 (M litres/year).

Table 173. Advantages and disadvantages of biojet fuel

Table 174. Production pathways for bio-jet fuel.

Table 175. Current and announced biojet fuel facilities and capacities.

Table 176. Global bio-jet fuel consumption to 2033 (Million litres/year).

Table 177. Biogas feedstocks.

Table 178. Bio-based naphtha markets and applications.

Table 179. Bio-naphtha market value chain.

Table 180. Bio-based Naphtha production capacities, by producer.

Table 181. Comparison of biogas, biomethane and natural gas.

Table 182. Processes in bioethanol production.

Table 183. Microorganisms used in CBP for ethanol production from biomass lignocellulosic.

Table 184. Ethanol consumption 2010-2033 (million litres).

Table 185. Applications of e-fuels, by type.

Table 186. Overview of e-fuels.

Table 187. Benefits of e-fuels.

Table 188. eFuel production facilities, current and planned.

Table 189. Main characteristics of different electrolyzer technologies.

Table 190. Market challenges for e-fuels.

Table 191. E-fuels companies.

Table 192. Green ammonia projects (current and planned).

Table 193. Blue ammonia projects.

Table 194.	Ammonia fuel cell technologies.
Table 195.	Market overview of green ammonia in marine fuel.
Table 196.	Summary of marine alternative fuels.
Table 197.	Estimated costs for different types of ammonia.
Table 198.	Main players in green ammonia.
Table 199.	Market overview for CO <sub>2</sub> derived fuels.
Table 200.	Point source examples.
Table 201.	Advantages and disadvantages of DAC.
Table 202.	Companies developing airflow equipment integration with DAC.
Table 203.	Companies developing Passive Direct Air Capture (PDAC) technologies.
Table 204.	Companies developing regeneration methods for DAC technologies.
Table 205.	DAC companies and technologies.
Table 206.	DAC technology developers and production.
Table 207.	DAC projects in development.
Table 208.	Markets for DAC.
Table 209.	Costs summary for DAC.
Table 210.	Cost estimates of DAC.
Table 211.	Challenges for DAC technology.
Table 212.	DAC companies and technologies.
Table 213.	Microalgae products and prices.
Table 214.	Main Solar-Driven CO <sub>2</sub> Conversion Approaches.
Table 215.	Companies in CO <sub>2</sub> -derived fuel products.
Table 216.	Granbio Nanocellulose Processes.
Table 217.	Types of alkyd resins and properties.
Table 218.	Market summary for biobased alkyd coatings-raw materials, advantages, disadvantages, applications and producers.
Table 219.	Biobased alkyd coating products.
Table 220.	Types of polyols.
Table 221.	Polyol producers.
Table 222.	Biobased polyurethane coating products.
Table 223.	Market summary for biobased epoxy resins.
Table 224.	Biobased polyurethane coating products.
Table 225.	Biobased acrylate resin products.
Table 226.	Polylactic acid (PLA) market analysis.
Table 227.	PLA producers and production capacities.
Table 228.	Polyhydroxyalkanoates (PHA) market analysis.
Table 229.	Types of PHAs and properties.
Table 230.	Polyhydroxyalkanoates (PHA) producers.
Table 231.	Commercially available PHAs.

Table 232. Properties of micro/nanocellulose, by type.

Table 233. Types of nanocellulose.

Table 234: MFC production capacities (by type, wet or dry) and production process, by producer, metric tonnes.

Table 235. Market overview for cellulose nanofibers in paints and coatings.

Table 236. Companies developing cellulose nanofibers products in paints and coatings.

Table 237. CNC properties.

Table 238: Cellulose nanocrystal capacities (by type, wet or dry) and production process, by producer, metric tonnes.

Table 239. Edible coatings market summary.

Table 240. Types of protein based-biomaterials, applications and companies.

Table 241. Overview of alginate-description, properties, application and market size.

Table 242. Global market revenues for biobased paints and coatings, 2018-2033 (billions USD).

Table 243. Market revenues for biobased paints and coatings, 2018-2033(billions USD), conservative estimate.

Table 244. Market revenues for biobased paints and coatings, 2018-2033 (billions USD), high estimate.

Table 245. Oji Holdings CNF products.

## List Of Figures

### LIST OF FIGURES

- Figure 1. Bio-based chemicals and feedstocks production capacities, 2018-2033.
- Figure 2. Overview of Toray process. Overview of process
- Figure 3. Production capacities for 11-Aminoundecanoic acid (11-AA)
- Figure 4. 1,4-Butanediol (BDO) production capacities, 2018-2033 (tonnes).
- Figure 5. Dodecanedioic acid (DDDA) production capacities, 2018-2033 (tonnes).
- Figure 6. Epichlorohydrin production capacities, 2018-2033 (tonnes).
- Figure 7. Ethylene production capacities, 2018-2033 (tonnes).
- Figure 8. Potential industrial uses of 3-hydroxypropanoic acid.
- Figure 9. L-lactic acid (L-LA) production capacities, 2018-2033 (tonnes).
- Figure 10. Lactide production capacities, 2018-2033 (tonnes).
- Figure 11. Bio-MEG production capacities, 2018-2033.
- Figure 12. Bio-MPG production capacities, 2018-2033 (tonnes).
- Figure 13. Biobased naphtha production capacities, 2018-2033 (tonnes).
- Figure 14. 1,3-Propanediol (1,3-PDO) production capacities, 2018-2033 (tonnes).
- Figure 15. Sebacic acid production capacities, 2018-2033 (tonnes).
- Figure 16. Global plastics production 1950-2021, million metric tons.
- Figure 17. The circular plastic economy.
- Figure 18. Coca-Cola PlantBottle.
- Figure 19. Interrelationship between conventional, bio-based and biodegradable plastics.
- Figure 20. Bioplastics regional production capacities, 1,000 tons, 2019-2033.
- Figure 21. Bio-based Polyethylene (Bio-PE), 1,000 tons, 2019-2033.
- Figure 22. Bio-based Polyethylene terephthalate (Bio-PET) production capacities, 1,000 tons, 2019-2033
- Figure 23. Bio-based polyamides (Bio-PA) production capacities, 1,000 tons, 2019-2033.
- Figure 24. Bio-based Polypropylene (Bio-PP) production capacities, 1,000 tons, 2019-2033.
- Figure 25. Bio-based Polytrimethylene terephthalate (Bio-PTT) production capacities, 1,000 tons, 2019-2033.
- Figure 26. Bio-based Poly(butylene adipate-co-terephthalate) (PBAT) production capacities, 1,000 tons, 2019-2033.
- Figure 27. Bio-based Polybutylene succinate (PBS) production capacities, 1,000 tons, 2019-2033.
- Figure 28. Bio-based Polylactic acid (PLA) production capacities, 1,000 tons,



2019-2033.

Figure 29. PHA production capacities, 1,000 tons, 2019-2033.

Figure 30. Starch blends production capacities, 1,000 tons, 2019-2033.

Figure 31. Polylactic acid (Bio-PLA) production capacities 2019-2033 (1,000 tons).

Figure 32. Polyethylene terephthalate (Bio-PET) production capacities 2019-2033 (1,000 tons)

Figure 33. Polytrimethylene terephthalate (PTT) production capacities 2019-2033 (1,000 tons).

Figure 34. Production capacities of Polyethylene furanoate (PEF) to 2025.

Figure 35. Polyethylene furanoate (Bio-PEF) production capacities 2019-2033 (1,000 tons).

Figure 36. Polyamides (Bio-PA) production capacities 2019-2033 (1,000 tons).

Figure 37. Poly(butylene adipate-co-terephthalate) (Bio-PBAT) production capacities 2019-2033 (1,000 tons).

Figure 38. Polybutylene succinate (PBS) production capacities 2019-2033 (1,000 tons).

Figure 39. Polyethylene (Bio-PE) production capacities 2019-2033 (1,000 tons).

Figure 40. Polypropylene (Bio-PP) production capacities 2019-2033 (1,000 tons).

Figure 41. PHA family.

Figure 42. PHA production capacities 2019-2033 (1,000 tons).

Figure 43. TEM image of cellulose nanocrystals.

Figure 44. CNC preparation.

Figure 45. Extracting CNC from trees.

Figure 46. CNC slurry.

Figure 47. CNF gel.

Figure 48. Bacterial nanocellulose shapes

Figure 49. BLOOM masterbatch from Algix.

Figure 50. Typical structure of mycelium-based foam.

Figure 51. Commercial mycelium composite construction materials.

Figure 52. Global production capacities of biobased and sustainable plastics 2022.

Figure 53. Global production capacities of biobased and sustainable plastics 2025.

Figure 54. Global production capacities for biobased and sustainable plastics by end user market 2019-2033, 1,000 tons.

Figure 55. Notpla water bottle.

Figure 56. PHA bioplastics products.

Figure 57. Global market demand for biobased and biodegradable plastics for flexible packaging 2019–2033 ('000 tonnes).

Figure 58. Sulupac packaging.

Figure 59. Shellworks packaging.

Figure 60. Bioplastics for rigid packaging, 2019–2033 ('000 tonnes).



Figure 61. Global market demand for biobased and biodegradable plastics in consumer products 2019-2033, in 1,000 tons.

Figure 62. Car door produced from Hemp fiber.

Figure 63. Natural fiber composites in the BMW M4 GT4 racing car.

Figure 64. Mercedes-Benz components containing natural fibers.

Figure 65. Global market demand for biocomposites 2019-2033, in automotive, in 1,000 tons.

Figure 66. Global market demand for biocomposites 2019-2033, in building and construction, in 1,000 tons.

Figure 67. AlgiKicks sneaker, made with the Algiknit biopolymer gel.

Figure 68. Reebok's [REE]GROW running shoes.

Figure 69. Camper Runner K21.

Figure 70. Global market demand for biocomposites 2019-2033, in textiles, in 1,000 tons.

Figure 71. Lonely Mountain natural fiber snowboard.

Figure 72. Global market demand for biocomposites 2019-2033, in sports & leisure equipment, in 1,000 tons.

Figure 73. Global market demand for biobased and biodegradable plastics in electronics 2019-2033, in 1,000 tons.

Figure 74. Biodegradable mulch films.

Figure 75. Global market demand for biobased and biodegradable plastics in agriculture 2019-2033, in 1,000 tons.

Figure 76. Types of natural fibers.

Figure 77. Absolut natural based fiber bottle cap.

Figure 78. Adidas algae-ink tees.

Figure 79. Carlsberg natural fiber beer bottle.

Figure 80. Miratex watch bands.

Figure 81. Adidas Made with Nature Ultraboost 22.

Figure 82. PUMA RE:SUEDE sneaker

Figure 83. Cotton production volume 2018-2033 (Million MT).

Figure 84. Kapok production volume 2018-2033 (MT).

Figure 85. Luffa cylindrica fiber.

Figure 86. Jute production volume 2018-2033 (Million MT).

Figure 87. Hemp fiber production volume 2018-2033 ( MT).

Figure 88. Flax fiber production volume 2018-2033 (MT).

Figure 89. Ramie fiber production volume 2018-2033 (MT).

Figure 90. Kenaf fiber production volume 2018-2033 (MT).

Figure 91. Sisal fiber production volume 2018-2033 (MT).

Figure 92. Abaca fiber production volume 2018-2033 (MT).

- Figure 93. Coir fiber production volume 2018-2033 (MILLION MT).
- Figure 94. Banana fiber production volume 2018-2033 (MT).
- Figure 95. Pineapple fiber.
- Figure 96. A bag made with pineapple biomaterial from the H&M Conscious Collection 2019.
- Figure 97. Bamboo fiber production volume 2018-2033 (MILLION MT).
- Figure 98. Typical structure of mycelium-based foam.
- Figure 99. Commercial mycelium composite construction materials.
- Figure 100. Frayme Mylo?.
- Figure 101. BLOOM masterbatch from Algix.
- Figure 102. Conceptual landscape of next-gen leather materials.
- Figure 103. Hemp fibers combined with PP in car door panel.
- Figure 104. Car door produced from Hemp fiber.
- Figure 105. Mercedes-Benz components containing natural fibers.
- Figure 106. AlgiKicks sneaker, made with the Algiknit biopolymer gel.
- Figure 107. Coir mats for erosion control.
- Figure 108. Global fiber production in 2021, by fiber type, million MT and %.
- Figure 109. Global fiber production (million MT) to 2020-2033.
- Figure 110. Plant-based fiber production 2018-2033, by fiber type, MT.
- Figure 111. Animal based fiber production 2018-2033, by fiber type, million MT.
- Figure 112. High purity lignin.
- Figure 113. Lignocellulose architecture.
- Figure 114. Extraction processes to separate lignin from lignocellulosic biomass and corresponding technical lignins.
- Figure 115. The lignocellulose biorefinery.
- Figure 116. LignoBoost process.
- Figure 117. LignoForce system for lignin recovery from black liquor.
- Figure 118. Sequential liquid-lignin recovery and purification (SLPR) system.
- Figure 119. A-Recovery+ chemical recovery concept.
- Figure 120. Schematic of a biorefinery for production of carriers and chemicals.
- Figure 121. Organosolv lignin.
- Figure 122. Hydrolytic lignin powder.
- Figure 123. Estimated consumption of lignin, 2019-2033 (000 MT).
- Figure 124. Schematic of WISA plywood home.
- Figure 125. Lignin based activated carbon.
- Figure 126. Lignin/cellulose precursor.
- Figure 127. Pluumo.
- Figure 128. ANDRITZ Lignin Recovery process.
- Figure 129. Anpoly cellulose nanofiber hydrogel.

Figure 130. MEDICELLU.

Figure 131. Asahi Kasei CNF fabric sheet.

Figure 132. Properties of Asahi Kasei cellulose nanofiber nonwoven fabric.

Figure 133. CNF nonwoven fabric.

Figure 134. Roof frame made of natural fiber.

Figure 135. Beyond Leather Materials product.

Figure 136. BIOLO e-commerce mailer bag made from PHA.

Figure 137. Reusable and recyclable foodservice cups, lids, and straws from Joinease Hong Kong Ltd., made with plant-based NuPlastiQ BioPolymer from BioLogiQ, Inc.

Figure 138. Fiber-based screw cap.

Figure 139. formicobio technology.

Figure 140. nanoforest-S.

Figure 141. nanoforest-PDP.

Figure 142. nanoforest-MB.

Figure 143. sunliquid production process.

Figure 144. CuanSave film.

Figure 145. Celish.

Figure 146. Trunk lid incorporating CNF.

Figure 147. ELLEX products.

Figure 148. CNF-reinforced PP compounds.

Figure 149. Kirekira! toilet wipes.

Figure 150. Color CNF.

Figure 151. Rheocrysta spray.

Figure 152. DKS CNF products.

Figure 153. Domsjo process.

Figure 154. Mushroom leather.

Figure 155. CNF based on citrus peel.

Figure 156. Citrus cellulose nanofiber.

Figure 157. Filler Bank CNC products.

Figure 158. Fibers on kapok tree and after processing.

Figure 159. TMP-Bio Process.

Figure 160. Flow chart of the lignocellulose biorefinery pilot plant in Leuna.

Figure 161. Water-repellent cellulose.

Figure 162. Cellulose Nanofiber (CNF) composite with polyethylene (PE).

Figure 163. PHA production process.

Figure 164. Fungi Solutions packaging.

Figure 165. CNF products from Furukawa Electric.

Figure 166. AVAPTM process.

Figure 167. GreenPower+ process.

- Figure 168. Cutlery samples (spoon, knife, fork) made of nano cellulose and biodegradable plastic composite materials.
- Figure 169. Non-aqueous CNF dispersion 'Senaf' (Photo shows 5% of plasticizer).
- Figure 170. CNF gel.
- Figure 171. Block nanocellulose material.
- Figure 172. CNF products developed by Hokuetsu.
- Figure 173. Marine leather products.
- Figure 174. Inner Mettle Milk products.
- Figure 175. Kami Shoji CNF products.
- Figure 176. Dual Graft System.
- Figure 177. Engine cover utilizing Kao CNF composite resins.
- Figure 178. Acrylic resin blended with modified CNF (fluid) and its molded product (transparent film), and image obtained with AFM (CNF 10wt% blended).
- Figure 179. Kel Labs yarn.
- Figure 180. 0.3% aqueous dispersion of sulfated esterified CNF and dried transparent film (front side).
- Figure 181. Lignin gel.
- Figure 182. BioFlex process.
- Figure 183. Nike Algae Ink graphic tee.
- Figure 184. LX Process.
- Figure 185. Made of Air's HexChar panels.
- Figure 186. TransLeather.
- Figure 187. Chitin nanofiber product.
- Figure 188. Marusumi Paper cellulose nanofiber products.
- Figure 189. FibriMa cellulose nanofiber powder.
- Figure 190. METNIN Lignin refining technology.
- Figure 191. IPA synthesis method.
- Figure 192. MOGU-Wave panels.
- Figure 193. CNF slurries.
- Figure 194. Range of CNF products.
- Figure 195. Reishi.
- Figure 196. Compostable water pod.
- Figure 197. Leather made from leaves.
- Figure 198. Nike shoe with beLEAF.
- Figure 199. CNF clear sheets.
- Figure 200. Oji Holdings CNF polycarbonate product.
- Figure 201. Enfinity cellulosic ethanol technology process.
- Figure 202. Fabric consisting of 70 per cent wool and 30 per cent Qmilk.
- Figure 203. XCNF.

- Figure 204: Plantrose process.
- Figure 205. LOVR hemp leather.
- Figure 206. CNF insulation flat plates.
- Figure 207. Hansa lignin.
- Figure 208. Manufacturing process for STARCEL.
- Figure 209. Manufacturing process for STARCEL.
- Figure 210. Shellworks packaging.
- Figure 211. 3D printed cellulose shoe.
- Figure 212. Lyocell process.
- Figure 213. North Face Spiber Moon Parka.
- Figure 214. PANGAIA LAB NXT GEN Hoodie.
- Figure 215. Spider silk production.
- Figure 216. Stora Enso lignin battery materials.
- Figure 217. 2 wt.% CNF suspension.
- Figure 218. BiNFi-s Dry Powder.
- Figure 219. BiNFi-s Dry Powder and Propylene (PP) Complex Pellet.
- Figure 220. Silk nanofiber (right) and cocoon of raw material.
- Figure 221. Sulapac cosmetics containers.
- Figure 222. Sulzer equipment for PLA polymerization processing.
- Figure 223. Solid Novolac Type lignin modified phenolic resins.
- Figure 224. Teijin bioplastic film for door handles.
- Figure 225. Corbion FDCA production process.
- Figure 226. Comparison of weight reduction effect using CNF.
- Figure 227. CNF resin products.
- Figure 228. UPM biorefinery process.
- Figure 229. Vegea production process.
- Figure 230. The Proesa Process.
- Figure 231. Goldilocks process and applications.
- Figure 232. Visolis' Hybrid Bio-Thermocatalytic Process.
- Figure 233. HefCel-coated wood (left) and untreated wood (right) after 30 seconds flame test.
- Figure 234. Worn Again products.
- Figure 235. Zelfo Technology GmbH CNF production process.
- Figure 236. Diesel and gasoline alternatives and blends.
- Figure 237. Schematic of a biorefinery for production of carriers and chemicals.
- Figure 238. Hydrolytic lignin powder.
- Figure 239. Regional production of biodiesel (billion litres).
- Figure 240. Flow chart for biodiesel production.
- Figure 241. Global biodiesel consumption, 2010-2033 (M litres/year).

- Figure 242. Global renewable diesel consumption, to 2033 (M litres/year).
- Figure 243. Global bio-jet fuel consumption to 2033 (Million litres/year).
- Figure 244. Total syngas market by product in MM Nm<sup>3</sup>/h of Syngas, 2021.
- Figure 245. Overview of biogas utilization.
- Figure 246. Biogas and biomethane pathways.
- Figure 247. Bio-based naphtha production capacities, 2018-2033 (tonnes).
- Figure 248. Renewable Methanol Production Processes from Different Feedstocks.
- Figure 249. Production of biomethane through anaerobic digestion and upgrading.
- Figure 250. Production of biomethane through biomass gasification and methanation.
- Figure 251. Production of biomethane through the Power to methane process.
- Figure 252. Ethanol consumption 2010-2033 (million litres).
- Figure 253. Properties of petrol and biobutanol.
- Figure 254. Biobutanol production route.
- Figure 255. Waste plastic production pathways to (A) diesel and (B) gasoline
- Figure 256. Schematic for Pyrolysis of Scrap Tires.
- Figure 257. Used tires conversion process.
- Figure 258. Process steps in the production of electrofuels.
- Figure 259. Mapping storage technologies according to performance characteristics.
- Figure 260. Production process for green hydrogen.
- Figure 261. E-liquids production routes.
- Figure 262. Fischer-Tropsch liquid e-fuel products.
- Figure 263. Resources required for liquid e-fuel production.
- Figure 264. Levelized cost and fuel-switching CO<sub>2</sub> prices of e-fuels.
- Figure 265. Cost breakdown for e-fuels.
- Figure 266. Pathways for algal biomass conversion to biofuels.
- Figure 267. Algal biomass conversion process for biofuel production.
- Figure 268. Classification and process technology according to carbon emission in ammonia production.
- Figure 269. Green ammonia production and use.
- Figure 270. Schematic of the Haber Bosch ammonia synthesis reaction.
- Figure 271. Schematic of hydrogen production via steam methane reformation.
- Figure 272. Estimated production cost of green ammonia.
- Figure 273. Projected annual ammonia production, million tons.
- Figure 274. CO<sub>2</sub> capture and separation technology.
- Figure 275. Conversion route for CO<sub>2</sub>-derived fuels and chemical intermediates.
- Figure 276. Conversion pathways for CO<sub>2</sub>-derived methane, methanol and diesel.
- Figure 277. CO<sub>2</sub> captured from air using liquid and solid sorbent DAC plants, storage, and reuse.
- Figure 278. Global CO<sub>2</sub> capture from biomass and DAC in the Net Zero Scenario.



- Figure 279. DAC technologies.
- Figure 280. Schematic of Climeworks DAC system.
- Figure 281. Climeworks' first commercial direct air capture (DAC) plant, based in Hinwil, Switzerland.
- Figure 282. Flow diagram for solid sorbent DAC.
- Figure 283. Direct air capture based on high temperature liquid sorbent by Carbon Engineering.
- Figure 284. Global capacity of direct air capture facilities.
- Figure 285. Global map of DAC and CCS plants.
- Figure 286. Schematic of costs of DAC technologies.
- Figure 287. DAC cost breakdown and comparison.
- Figure 288. Operating costs of generic liquid and solid-based DAC systems.
- Figure 289. CO<sub>2</sub> feedstock for the production of e-methanol.
- Figure 290. Schematic illustration of (a) biophotosynthetic, (b) photothermal, (c) microbial-photoelectrochemical, (d) photosynthetic and photocatalytic (PS/PC), (e) photoelectrochemical (PEC), and (f) photovoltaic plus electrochemical (PV+EC) approaches for CO<sub>2</sub> c
- Figure 291. Audi synthetic fuels.
- Figure 292. ANDRITZ Lignin Recovery process.
- Figure 293. FBPO process
- Figure 294. Direct Air Capture Process.
- Figure 295. CRI process.
- Figure 296. Colyser process.
- Figure 297. ECFORM electrolysis reactor schematic.
- Figure 298. Dioxycle modular electrolyzer.
- Figure 299. Domsjo process.
- Figure 300. FuelPositive system.
- Figure 301. INERATEC unit.
- Figure 302. Infinitree swing method.
- Figure 303. Enfinity cellulosic ethanol technology process.
- Figure 304: Plantrose process.
- Figure 305. O12 Reactor.
- Figure 306. Sunglasses with lenses made from CO<sub>2</sub>-derived materials.
- Figure 307. CO<sub>2</sub> made car part.
- Figure 308. The Velocys process.
- Figure 309. The Proesa Process.
- Figure 310. Goldilocks process and applications.
- Figure 311. Paints and coatings industry by market segmentation 2019-2020.
- Figure 312. PHA family.



Figure 313: Schematic diagram of partial molecular structure of cellulose chain with numbering for carbon atoms and  $n$ = number of cellobiose repeating unit.

Figure 314: Scale of cellulose materials.

Figure 315: Nanocellulose preparation methods and resulting materials.

Figure 316: Relationship between different kinds of nanocelluloses.

Figure 317: Hefcel-coated wood (left) and untreated wood (right) after 30 seconds flame test.

Figure 318: CNC slurry.

Figure 319: High purity lignin.

Figure 320: BLOOM masterbatch from Algix.

Figure 321: Global market revenues for biobased paints and coatings, 2018-2033 (billions USD).

Figure 322: Market revenues for biobased paints and coatings, 2018-2033 (billions USD), conservative estimate.

Figure 323: Market revenues for biobased paints and coatings, 2018-2033 (billions USD), high

Figure 324: Dulux Better Living Air Clean Biobased.

Figure 325: NCCTM Process.

Figure 326: CNC produced at Tech Futures' pilot plant; cloudy suspension (1 wt.%), gel-like (10 wt.%), flake-like crystals, and very fine powder. Product advantages include

Figure 327: Cellugy materials.

Figure 328: EcoLine 3690 (left) vs Solvent-Based Competitor Coating (right).

Figure 329: Rheocrysta spray.

Figure 330: DKS CNF products.

Figure 331: Domsjo process

Figure 332: CNF gel.

Figure 333: Block nanocellulose material.

Figure 334: CNF products developed by Hokuetsu.

Figure 335: BioFlex process.

Figure 336: Marusumi Paper cellulose nanofiber products.

Figure 337: Fluorene cellulose powder.

Figure 338: XCNF.

Figure 339: Spider silk production.

Figure 340: CNF dispersion and powder from Starlite.

Figure 341: 2 wt.% CNF suspension.

Figure 342: BiNF-i-s Dry Powder.

Figure 343: BiNF-i-s Dry Powder and Propylene (PP) Complex Pellet.

Figure 344: Silk nanofiber (right) and cocoon of raw material.

Figure 345: HefCel-coated wood (left) and untreated wood (right) after 30 seconds

flame test.

Figure 346. Bio-based barrier bags prepared from Tempo-CNF coated bio-HDPE film.

Figure 347. Bioalkyd products.

## I would like to order

Product name: The Global Market for Bio-based and Sustainable Materials 2023-2033

Product link: <https://marketpublishers.com/r/G48FE818378FEN.html>

Price: US\$ 1,500.00 (Single User License / Electronic Delivery)

If you want to order Corporate License or Hard Copy, please, contact our Customer Service:

[info@marketpublishers.com](mailto:info@marketpublishers.com)

## Payment

To pay by Credit Card (Visa, MasterCard, American Express, PayPal), please, click button on product page <https://marketpublishers.com/r/G48FE818378FEN.html>

To pay by Wire Transfer, please, fill in your contact details in the form below:

First name:  
Last name:  
Email:  
Company:  
Address:  
City:  
Zip code:  
Country:  
Tel:  
Fax:  
Your message:

**\*\*All fields are required**

Customer signature \_\_\_\_\_

Please, note that by ordering from marketpublishers.com you are agreeing to our Terms & Conditions at <https://marketpublishers.com/docs/terms.html>

To place an order via fax simply print this form, fill in the information below and fax the completed form to +44 20 7900 3970