

MARKETS AND PROFITABILITY

Market Insights: Polyhydroxyalkanoates (PHAs) - 2024

April 2024



This Report was prepared by NexantECA, the Energy and Chemicals Advisory company ("NexantECA"). Except where specifically stated in this Report, the information contained herein is prepared on the basis of information that is publicly available, and contains no confidential third party technical information to the best knowledge and belief of NexantECA. The information has not been independently verified or otherwise examined to determine its accuracy, completeness or financial feasibility. Neither NexantECA, Subscriber nor any person acting on behalf of either shall have any liabilities for any loss or damage arising from or connected to the use of any information contained in this Report. NexantECA does not represent or warrant that any assumed conditions will come to pass.

The Report is for Subscriber's internal use only and shall be kept strictly confidential. The Report should not be otherwise reproduced, distributed or used without first obtaining prior written consent by NexantECA. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Copyright © by NexantECA (BV) Ltd. 2024. All rights reserved.



Contents

1	Executive Summary	1
2	Introduction	7
2.1	Bioplastic Classification	7
2.2	Overview of Polyhydroxyalkanoates (PHAs)	8
2.2.1	Production Summary	10
2.2.1.1	Nutrient Limitation	10
2.2.1.2	Fermentation Configuration	10
2.2.1.3	Extraction Methods	11
2.2.2	Biodegradability of PHAs	13
2.2.2.1	Industrial Composting	13
2.2.2.2	Home Composting	13
2.2.2.3	Marine Biodegradability	14
2.2.3	PHA Properties	15
2.3	Key End Use Markets	17
2.3.1	Flexible and Rigid Packaging	18
2.3.2	Agricultural and Horticulture	19
2.3.3	Coatings & Adhesives	20
2.3.4	Consumer Products	21
2.3.5	Others	22
3	Market Outlook	24
3.1	Global	24
3.1.1	Market Overview	24
3.1.1.1	Flexible and Rigid Packaging	26
3.1.1.2	Agriculture and Horticulture	26
3.1.1.3	Coatings and Adhesives	26
3.1.1.4	Consumer Products	27
3.1.1.5	Others	27
3.1.2	Market Drivers	28
3.1.3	Market Constraints	31
3.1.4	Competitive Landscape	32
3.1.5	Supply and Demand	35
3.2	Asia Pacific (excluding China)	37
3.2.1	Market Overview	37
3.2.2	Market Drivers	37
3.2.3	Market Constraints	40
3.2.4	Competitive Landscape	42
3.2.5	Supply and Demand	43
3.3	China	45
3.3.1	Market Overview	45
3.3.2	Market Drivers	45
3.3.3	Market Constraints	45



3.3.4	Competitive Landscape.....	46
3.3.5	Supply and Demand.....	49
3.4	North America	51
3.4.1	Market Overview	51
3.4.2	Market Drivers	51
3.4.2.1	Composting Infrastructure.....	51
3.4.2.2	California Recycling and Plastics Pollution Act.....	51
3.4.2.3	Agricultural Mulch Films.....	52
3.4.2.4	Corporate Social Responsibility (CSR) – Sustainability Targets.....	52
3.4.2.5	USDA BioPreferred Program	52
3.4.2.6	Single Use Plastics Ban – Canada	53
3.4.3	Market Constraints	53
3.4.3.1	Single Use Plastics Ban – Mexico City	53
3.4.4	Competitive Landscape.....	54
3.4.5	Supply and Demand.....	60
3.5	South America.....	62
3.5.1	Market Overview	62
3.5.2	Market Drivers	62
3.5.3	Market Constraints	62
3.5.4	Competitive Landscape.....	63
3.5.5	Supply and Demand.....	63
3.6	Western Europe	65
3.6.1	Market Overview	65
3.6.2	Market Drivers	65
3.6.2.1	Taxation on Plastic Packaging	66
3.6.2.2	EU Taxonomy Regulations	67
3.6.2.3	Corporate Sustainability Goals	67
3.6.3	Market Constraints	67
3.6.3.1	Single Use Plastics Directive (SUPD).....	67
3.6.4	Competitive Landscape.....	70
3.6.5	Supply and Demand.....	72
3.7	Central Europe	74
3.7.1	Market Overview	74
3.7.2	Market Drivers	74
3.7.3	Market Constraints	75
3.7.4	Competitive Landscape.....	75
3.7.5	Supply and Demand.....	76
3.8	Eastern Europe	78
3.8.1	Market Overview	78
3.8.2	Market Drivers	78
3.8.3	Market Constraints	78
3.8.4	Competitive Landscape.....	79
3.8.5	Supply and Demand.....	79



3.9	Middle East.....	80
3.9.1	Market Overview	80
3.9.2	Market Drivers	80
3.9.3	Market Constraints	80
3.9.4	Competitive Landscape.....	81
3.9.5	Supply and Demand.....	81
3.10	Africa	82
3.10.1	Market Overview	82
3.10.2	Market Drivers and Constraints.....	82
3.10.3	Competitive Landscape.....	82
3.10.4	Supply and Demand.....	82
4	Pricing	83
5	Cost Competitiveness.....	87
5.1	Cost Structure and Assumptions.....	87
5.1.1	Variable Costs	88
5.1.1.1	Feedstock Costs	88
5.1.1.2	Utility Costs	89
5.1.2	Direct Fixed Costs	89
5.1.3	Allocated Fixed Costs	90
5.1.4	Plant Capacity	91
5.1.5	Other Considerations	91
5.2	Cost Competitiveness	91

Figures

Figure 1	Example Structure of a PHA	9
Figure 2	Example High Level Block Flow Diagram for Commercial Production of PHAs	12
Figure 3	Current and Future PHA Applications by Market Segment.....	17
Figure 4	Compostable Snack Bag made from PHA Composite	19
Figure 5	Phade Compostable PHA-lined Hot Beverage Cups	21
Figure 6	Phasix™ Surgical Mesh (P4HB material) for Inguinal Hernia Repair.....	23
Figure 7	Global PHA Demand by End Use, 2023	25
Figure 8	Global PHA Demand by Region, 2023.....	26
Figure 9	Global PHAs Capacity Share by Producer (2023)	32
Figure 10	Global PHA Capacity by Region (2023)	33
Figure 11	Global Capacity by Region (2015-2028)	33
Figure 12	Global PHA Supply, Demand and Trade.....	35
Figure 13	Global PHA Net Trade.....	36
Figure 14	Asia Pacific (excluding China) PHA Supply, Demand and Trade	44
Figure 15	China PHA Supply, Demand and Trade.....	50
Figure 16	North America PHA Supply, Demand and Trade	61
Figure 17	South America PHA Supply, Demand and Trade	64
Figure 18	Western Europe PHA Supply, Demand and Trade	73
Figure 19	Central Europe PHA Supply, Demand and Trade.....	76



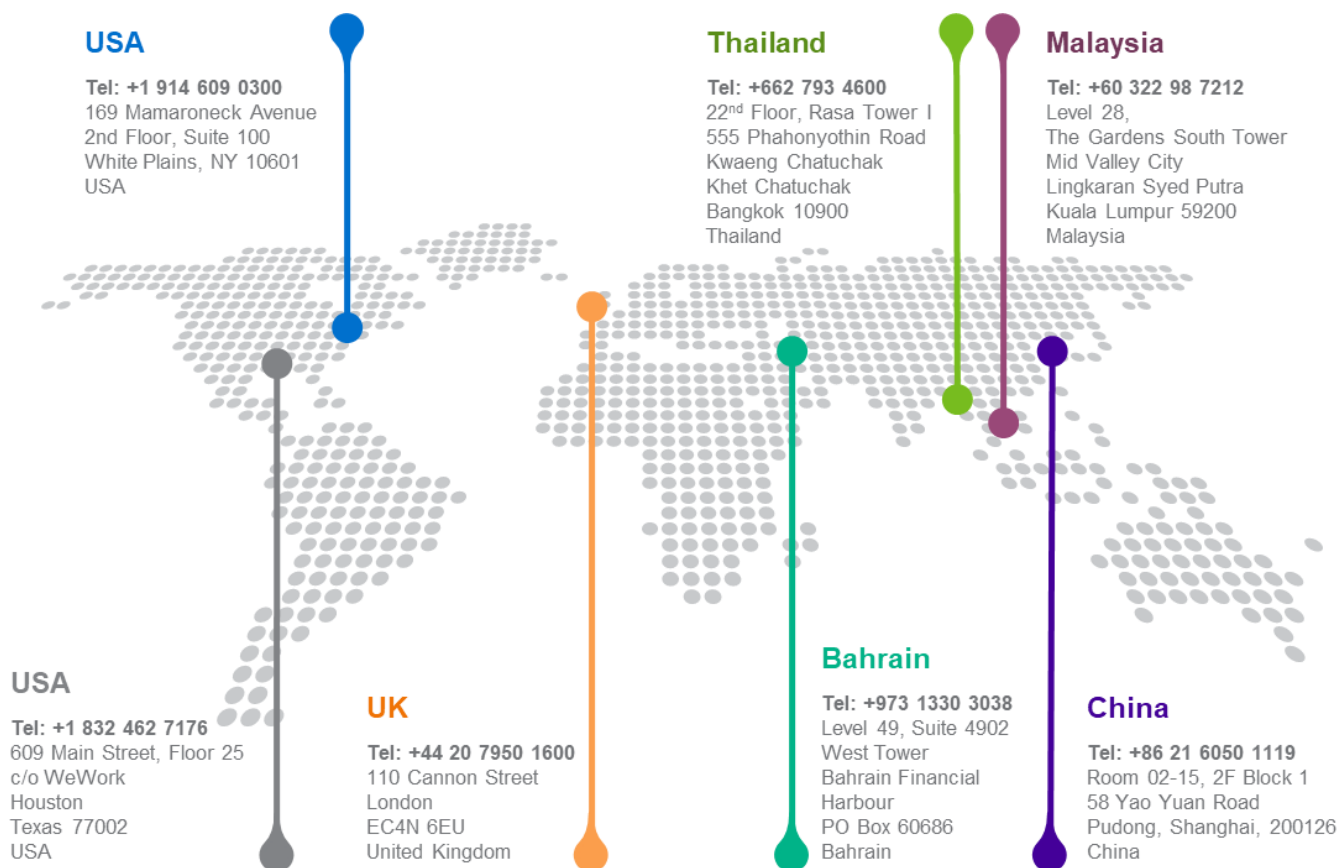
Figure 20	Regional PHA Prices	84
Figure 21	Regional PHA Feedstock Prices	84
Figure 22	PHA China Price, Cost and Margin	85
Figure 23	PHA US Price, Cost and Margin	85
Figure 24	PHA Southeast Price, Cost and Margin	86
Figure 25	Components of Delivered Cost to Market	87
Figure 26	PHA Cash Cost	92

Tables

Table 1	Biopolymer Classification	8
Table 2	Thermal and Mechanical Properties of Selected PHAs	16
Table 3	Market Drivers by Region	29
Table 4	Global PHA Supply, Demand and Trade	35
Table 5	Asia Pacific (excluding China) PHA Capacity	43
Table 6	Asia Pacific (excluding China) PHA Supply, Demand, and Trade	44
Table 7	China PHA Capacity	49
Table 8	China PHA Supply, Demand and Trade	50
Table 9	North America PHA Capacity	60
Table 10	North America PHA Supply, Demand and Trade	61
Table 11	South America PHA Supply, Demand and Trade	64
Table 12	Western Europe PHA Capacity	72
Table 13	Western Europe PHA Supply, Demand and Trade	73
Table 14	Central Europe PHA Capacity	76
Table 15	Central Europe Supply, Demand and Trade	77
Table 16	Feedstock Price Assumptions	88
Table 17	Utility Rates	89
Table 18	Wage Assumptions	90
Table 19	Capital Cost Location Factors	90



NexantECA partners with clients to help them navigate the big global energy, chemicals and materials issues of tomorrow. We provide independent advice through our consulting, subscriptions and reports, and training businesses using expertise developed in markets, economics and technology through our fifty years of operation. We are entirely dedicated to supporting sustainable development of the industry and provide expert advice with efficiency, speed, and agility.



Disclaimer

This Report was prepared by NexantECA, the Energy and Chemicals Advisory company. Except where specifically stated otherwise in this Report, the information contained here is prepared on the basis of information that is publicly available, and contains no confidential third-party technical information to the best knowledge of NexantECA. Aforesaid information has not been independently verified or otherwise examined to determine its accuracy, completeness or financial feasibility. Neither NexantECA, Client nor any person acting on behalf of either assumes any liabilities with respect to the use of or for damages resulting from the use of any information contained in this Report. NexantECA does not represent or warrant that any assumed conditions will come to pass.