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# Syngas Fermentation

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### Abstract

Syngas fermentation is a bioconversion technology of syngas/waste gas components to produce low-carbon biofuels. This technology is currently undergoing an intensive research and development phase. The fermentation process depends on the use of a microorganism called acetogen that generates acetate as a product of anaerobic respiration. Acetogens are found in a variety of habitats, generally those that are anaerobic. Acetogens can use a variety of compounds as sources of energy and carbon; the best-studied form of acetogenic metabolism involves the use of carbon dioxide as a carbon source, and hydrogen as an energy source.

A number of laboratory- and demonstration-scale studies have been done on the subject of using acetogens that have the ability to convert various synthesis gas (syngas) components (CO, CO<sub>2</sub>, and H<sub>2</sub>) to multicarbon compounds such as ethanol, 2,3-butanediol, acetate, butyrate, butanol, and lactate. At present, ethanol is the most noteworthy final product, followed by 2,3-butanediol. This bioconversion process occurs under mild conditions of temperature and pressure. Unlike conventional thermochemical processes, it does not require a specific H<sub>2</sub>:CO ratio for converting the gas into fuels and chemicals.

Syngas fermentation technology is still in the commercializing stage. Several aspects affecting product output and yield are under constant review for improvements and refinements. Some of the noteworthy parameters that are a focus of research for ethanol and 2,3-butanediol production include yield, biological catalysts, process kinetics, mass transfer, catalytic separation, materials recycling/reusing, etc.

The objective of this report is to examine the abovementioned fermentation technologies, to evaluate their economics, and to offer a financial impact assessment on the economics resulting from variations in those process parameters.

In this report, we present a critical review of CO-rich gas fermentation processes to produce ethanol and 2,3-butanediol. We also present a comprehensive description of the fermentation product impurities, microorganisms, chemical reactions, separation techniques, bioreactor types, fermentation conditions, gas-liquid mass transfer, current industry status, process scale-up, and future directions for the technology. Further, we offer an analysis of LanzaTech technology; LanzaTech, a revolutionary carbon recycling company, is a major player in the developing syngas fermentation market, and has made big announcements recently about the commercialization of its technology.

The following cases are covered in this report:

1. Case I—LanzaTech syngas fermentation using biomass syngas, producing anhydrous ethanol.
2. Case II—LanzaTech syngas fermentation using biomass syngas, producing anhydrous ethanol as well as 2,3-butanediol.
3. Case III—LanzaTech syngas fermentation using steel mill waste gases, producing anhydrous ethanol.

We have used Aspen Plus™ and IHS internal tools to work out a process design and its economics. While the challenges associated with the scale-up and operation of this novel process remain with the selection of

proper feedstock and variable product prices, syngas fermentation offers numerous advantages compared with the established fermentation or conventional thermochemical approaches for biofuel production. This process is capable of producing multiple products from the same gas stream and same hardware. The technology is feedstock-flexible, and microbial catalyst can utilize a range of gases with different H<sub>2</sub>:CO composition while retaining product specificity.

# Contents

<b>1</b>	<b>Introduction</b>	<b>13</b>
	First-generation biofuels	13
	Debate on first-generation biofuels	14
	Second-generation biofuels	15
	Second-generation biofuel feedstocks and technologies	15
	Syngas fermentation	17
	Advantages of syngas fermentation and comparison with Fischer-Tropsch (FT) process	19
	Advantages of syngas fermentation and comparison with other second-generation technologies	19
<b>2</b>	<b>Summary</b>	<b>23</b>
	Industry aspects	23
	Technical aspects	24
	LanzaTech syngas fermentation technology	24
	LanzaTech technology advances	25
	Economic aspects	26
	Capital cost economics comparison	27
	Product cost economics comparison	28
	Conclusions	30
<b>3</b>	<b>Industry status</b>	<b>31</b>
	Bioethanol and 2,3-butanediol production from syngas fermentation	31
	Major syngas fermentation companies and associated research	33
	University of Arkansas/Bioengineering Resources, Inc.	34
	Mississippi Ethanol LLC	34
	Mississippi State University	34
	Oklahoma State University	34
	Michigan Biotechnology Institute (MBI)	34
	Michigan State University	34
	Iowa State University	35
	Technical University of Denmark (Research project—SYNFERON)	35
	SYNPOL project	35
	Syngas Biofuels Energy, Inc.	36
	Evonik Industries (2-HIBA production via syngas fermentation)	37
	OPX Biotechnologies/Cargill, Inc.	37
	INEOS Bio	38
	Corskata, Inc./Synata Bio	38
	LanzaTech	39
	Global opportunities	42
	LanzaTech – SK innovation – INVISTA	42
	LanzaTech – DBT-IOC	44
	LanzaTech – Swedish Biofuels – Virgin Atlantic – HSBC	44
	LanzaTech – PETRONAS	46
	LanzaTech – Evonik Industries	46
	LanzaTech – NREL – University of Washington	46
	LanzaTech – Global Bioenergies	47
	LanzaTech – Siemens (Primetals Technologies)	47
	LanzaTech – Aemetis, Inc.	48



Methyl ethyl ketone (MEK)	54
Butadiene	56
<b>4 Syngas fermentation technical review</b>	<b>60</b>
Acetogens	60
Process chemistry	61
Organisms and products	65
Acetate producers (CO <sub>2</sub> fermentation)	66
Ethanol production	67
Butanol	68
2,3-Butanediol	69
Other products	70
Factors affecting syngas fermentation	71
Gas composition and inhibiting compounds	71
Mass transfer	73
Reactor type	75
pH	75
Temperature	77
Growth media nutrients	77
Substrate pressure	79
Reducing agents (Redox potential)	80
Effect of trace metals	81
Fermentation operating mode	82
Effect of cell-recycle on syngas fermentation	84
Bioreactors for syngas fermentation	85
Continuous stirred-tank reactor (CSTR)	85
Bubble column reactor (BCR)	86
Moving bed biofilm reactor (MBBR)	86
Membrane bioreactor (MBR)	86
Trickling bed reactor (TBR)	87
Microbubble dispersion stirred-tank reactor (MDSR)	87
Inoculator	90
Bioreactor versus chemical reactor	92
Product yields of syngas fermentation	92
Cell separation and product recovery	93
Liquid-liquid extraction	93
Perstraction/use of membranes	94
Pervaporation	94
Gas stripping	95
Strain improvement and metabolic engineering	95
Process scale-up and commercialization	99
Challenges and future R&D directions for commercialization	99
Feedstock and quality of syngas	99
Microbial catalysts	100
Mass transfer limitations	100
Product recovery	100
Production cost	101
Redirection of metabolic pathway	101
Living system	101
Availability and reliability	101
<b>5 Case I—Ethanol production via syngas fermentation using biomass gasification syngas</b>	<b>102</b>
Syngas as renewable source of energy	102
Biomass gasification	102
Licensor (LanzaTech) technology review	104
Feed gas handling system/gas pretreatment	105
Inoculator	105

Bioreactors	106
Media preparations	108
Fermentation additives	110
Vent gas handling system	110
Broth storage tanks	111
CIP (clean-in-place system)	111
Distillation system	112
Wastewater treatment and recycle	112
Bioreactor process control and operation for ethanol production	113
Dilution rate	113
Maintaining H <sub>2</sub> S concentration in tail gas	114
Optimizing ethanol production/CO oversupply and undersupply	114
Maintaining pH/rate of pH change	114
Maintaining CO <sub>2</sub> partial pressure	115
Bioreactor pressure	115
Handling operation during limited gas supply	115
Controlling ethanol-to-butanediol ratio inside the bioreactor	116
Ratio of CO <sub>2</sub> produced to CO consumed	116
Case assumptions	117
Process description	119
Gas storage and pretreatment (Section 100)	119
Fermentation (Section 200)	120
Distillation and dehydration (Section 300)	121
Process discussion	121
Cost estimates	126
Fixed capital costs	126
Production costs	128
Cost discussion and sensitivity analysis	130
Feedstock prices (syngas, media, and microbes cost basis)	130
Pretreatment cost impact	132
Battery limit and off-sites	133
By-products credit	134
Other sensitivity analysis with respect to plant capacity	134
Process yield	135
Depreciation and taxes	136
<b>6 Case II—Ethanol+2,3-butanediol production via syngas fermentation using biomass gasification syngas</b>	<b>137</b>
Introduction	137
Licensor SMB technology review	137
SMB separation unit	137
Bioreactor process control and operation for 2,3-butanediol production	138
Providing a hydrogen depleted gaseous stream (substrate)	138
Age of microbial cells	139
Specific rate of CO uptake	139
Increasing vitamin B <sub>1</sub> , B <sub>5</sub> , and B <sub>7</sub> concentration	139
Other nutrient addition	139
Case assumptions	139
Process description	142
Gas storage and pretreatment (Section 100)	142
Fermentation (Section 200)	143
SMB process with distillation and ethanol dehydration (Section 300)	145
Process discussion	146
Cost estimate	152
Fixed capital costs	152
Production costs	154

Cost discussion and sensitivity analysis	156
Feedstock prices (syngas, media, and microbes)	156
Pretreatment cost impact	159
Battery limit and off-sites	160
By-products credit (2,3-BDO and tail gas)	161
Other sensitivity analysis with respect to plant capacity	162
Process yield	163
Depreciation and taxes	164
<b>7 Case III—Ethanol production via syngas fermentation using steel mill gases</b>	<b>165</b>
Introduction	165
Licensor (LanzaTech) technology review	165
Deoxygenation vessel	166
Gas clean-up/BTEX removal	166
Bioreactor process control and operation for ethanol production	169
Case assumptions	169
Process description	171
Gas storage and pretreatment (Section 100)	171
Fermentation (Section 200)	172
Distillation and dehydration (Section 300)	173
Process discussions	173
Cost estimate	178
Fixed capital costs	178
Production costs	180
Cost discussion and sensitivity analysis	182
Feedstock prices	182
Pretreatment cost impact	184
Battery limit and off-sites	185
By-products credit	185
Other sensitivity analysis with respect to plant capacity	186
Process yield	187
Depreciation and taxes	187
<b>Appendix A—Patent summaries by assignee</b>	<b>188</b>
<b>Appendix B—Public domain literature (articles, books, and web presentations)</b>	<b>205</b>
<b>Appendix C—IHS internal reference</b>	<b>230</b>
<b>Appendix D—Process flow diagrams</b>	<b>232</b>

## Tables

Table 1.1	Comparison of first-generation versus second-generation biofuels	14
Table 1.2	Comparison between first-generation and second-generation biochemical, thermochemical, and gas fermentation biomass-to-biofuel technologies	21
Table 2.1	Overall comparison of three cases considered for LanzaTech syngas fermentation process	25
Table 2.2	Overall comparison of capital investment and production cost	26
Table 3.1	E2's advanced biofuel capacity projections, 2013–16	32
Table 3.2	List of LanzaTech syngas fermentation plants	41
Table 3.3	World supply and demand for ethanol <sup>1</sup>	50
Table 3.4	Ethylene glycol, oxide, and derivatives report	52
Table 3.5	World supply and demand for methyl ethyl ketone—2014	56
Table 3.6	World supply and demand for butadiene—2015	58
Table 3.7	Butadiene price summary	59
Table 4.1	Mesophilic and thermophilic microorganisms fermenting syngas into fuels and chemicals	63

Table 4.2	Main reactions with syngas components during anaerobic syngas fermentation	65
Table 4.3	Characteristics of different syngas/CO-rich waste gas fermenting bacteria for ethanol production	68
Table 4.4	Syngas impurities and its effect	71
Table 4.5	Major impact parameters on bioethanol yield during syngas fermentation	73
Table 4.6	Volumetric mass transfer coefficients in various reactor configurations and hydrodynamic conditions	74
Table 4.7	Performance parameters of various bioreactors used in syngas fermentation	75
Table 4.8	Frequently used mesophilic and thermophilic microorganisms, and their optimum growth conditions	76
Table 4.9	Effect of minerals and trace metals on acetyl-CoA pathway	82
Table 4.10	Syngas fermentation operation modes	83
Table 4.11	Different type of syngas fermentation reactor	88
Table 4.12	Ethanol production using various components of syngas in bioreactors	89
Table 4.13	Maximum product and cell yields from different studies	93
Table 4.14	Genetically modified acetogens and their target product	98
Table 5.1	Gas composition of different gasification processes	103
Table 5.2	Potential impurities and their safe level for LanzaTech syngas fermentation process	105
Table 5.3	Media components for <i>C. autoethanogenum</i>	109
Table 5.4	<i>C. autoethanogenum</i> composite mineral and vitamin solutions	109
Table 5.5	Composite trace metal solution	110
Table 5.6	Basis of design	118
Table 5.7	Ethanol production via syngas fermentation using biomass syngas (Case I)—Material streams flow	123
Table 5.8	Ethanol production via syngas fermentation using biomass syngas (Case I)—Major equipment	124
Table 5.9	Ethanol production via syngas fermentation using biomass syngas (Case I)—Utility summary	126
Table 5.10	Ethanol production via syngas fermentation using biomass syngas (Case I)—Total capital investment	127
Table 5.11	Ethanol production via syngas fermentation using biomass syngas (Case I)—Capital investment by section	128
Table 5.12	Ethanol production via syngas fermentation using biomass syngas (Case I)—Production cost	129
Table 5.13	Combined effect of feedstock prices on net production cost and product value—Ethanol production via syngas fermentation using biomass syngas (Case I)	132
Table 5.14	Combined effect of feedstock prices on net production cost and product value (deleting gas holders and C <sub>2</sub> –C <sub>3</sub> separation system)—Ethanol production via syngas fermentation using biomass syngas (Case I)	133
Table 6.1	Basis of design	141
Table 6.2	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Material streams flow	147
Table 6.3	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Major equipment	149
Table 6.4	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Utilities summary	151
Table 6.5	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Total capital investment	153
Table 6.6	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Capital investment by section	154
Table 6.7	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Production costs	155
Table 6.8	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Combined effect of feedstock prices on net production cost and product value	159
Table 6.9	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Combined effect of feedstock prices on net production cost and product value (deleting gas holders and C <sub>2</sub> –C <sub>3</sub> separation system)	160



Table 6.10	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Effect of 2,3-BDO price change on net production cost and product value	161
Table 7.1	Liquid impact levels of BTEX components in the fermentation broth (US 20150152441)	168
Table 7.2	Basis of design	170
Table 7.3	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Material streams flow	174
Table 7.4	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Major equipment	176
Table 7.5	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Utility summary	178
Table 7.6	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Total capital investments	179
Table 7.7	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Capital investment by section	180
Table 7.8	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Production cost	181
Table 7.9	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Combined effect of feedstock prices on net production cost and product value	184
Table 7.10	Ethanol production via syngas fermentation using steel mill waste gases (Case III)—Combined effect of feedstock prices on net production cost and product value (omitting gas holders and BTEX removal system)	185

## Figures

Figure 1.1	Simplified depiction of process steps for production of second-generation fuel ethanol	15
Figure 1.2	Overview of potential feedstock for production of second-generation biofuels	16
Figure 1.3	Novel approaches to biofuels and chemicals	17
Figure 1.4	Overview of gas fermentation process	18
Figure 1.5	Waste carbon streams as a resource for product synthesis	18
Figure 2.1	Capital cost comparison (battery limits and off-sites)	27
Figure 2.2	Capital cost versus plant capacity	28
Figure 2.3	Production cost comparison (variable, total direct, plant cash, plant gate and product value)	28
Figure 2.4	Net production cost versus operating level as a fraction of design capacity of plant	29
Figure 2.5	Product value versus operating level as a fraction of design capacity of plant	29
Figure 3.1	Syngas fermentation technology status to date	31
Figure 3.2	SYNPOL project	35
Figure 3.3	SYNPOL project platform	36
Figure 3.4	Syngas Biofuels Energy technology concept	36
Figure 3.5	INEOS gasification process for producing ethanol	38
Figure 3.6	Coskata process overview	39
Figure 3.7	LanzaTech gas-to-liquid platform	40
Figure 3.8	Potential to produce ethanol from waste sources	42
Figure 3.9	Two-step syngas-to-butadiene process	43
Figure 3.10	Conversion of acetate to lipids	44
Figure 3.11	Syngas fermentation process to produce jet fuels	45
Figure 3.12	Syngas-to-refined fuel via fermentation	46
Figure 3.13	Synergies and integration between steel mill process and LanzaTech syngas fermentation	47
Figure 3.14	World consumption of ethanol	49
Figure 3.15	Key chemical derived from ethanol	51
Figure 3.16	US ethanol and gasoline wholesale prices versus world ethanol prices	53
Figure 3.17	2,3- Butanediol derivatives and potential market	54

Figure 3.18	World consumption of methyl ethyl ketone	55
Figure 3.19	World consumption of butadiene	57
Figure 3.20	2,3- Butanediol derivatives and production estimates	57
Figure 4.1	Wood-Ljungdahl pathway of acetogens and their metabolic end products	61
Figure 4.2	Classification of genera capable of converting syngas to multicarbon compounds	66
Figure 4.3	General scheme of metabolite production from gas fermentation using native and genetically modified Clostridia	70
Figure 4.4	Schematic of bioreactor set-up with cell-recycle system	84
Figure 4.5	Schematic representation of various bioreactors for the conversion of syngas/CO-rich waste gas into ethanol	90
Figure 4.6	Steps of inoculation system	91
Figure 4.7	Growth curve of microbes for syngas fermentation	91
Figure 4.8	Continuous fermenter <i>in situ</i> with liquid-liquid extraction	94
Figure 4.9	Membrane separation	94
Figure 4.10	Schematic diagram of the pervaporation process	95
Figure 5.1	Schematic representation of the gasification process and further syngas bioconversion to biofuels and/or valuable chemicals	102
Figure 5.2	LanzaTech bioreactor configuration	106
Figure 5.3	LanzaTech bioreactor inside geometry	107
Figure 5.4	Two bioreactors in parallel	107
Figure 5.5	General syngas fermentation scheme with water recycle to fermenter	112
Figure 5.6	Syngas-to-ethanol simplified block flow diagram	117
Figure 5.7	Net production cost and product value of anhydrous ethanol as a function of biomass syngas price—Ethanol production via syngas fermentation using biomass syngas (Case I)	130
Figure 5.8	Net production cost and product value of anhydrous ethanol as a function of media price—Ethanol production via syngas fermentation using biomass syngas (Case I)	131
Figure 5.9	Net production cost and product value of anhydrous ethanol as a function of microbe price—Ethanol production via syngas fermentation using biomass syngas (Case I)	131
Figure 5.10	Effect of plant capacity on investment costs—Ethanol production via syngas fermentation using biomass syngas (Case I)	134
Figure 5.11	Net production cost of anhydrous ethanol as a function of operating level and plant capacity—Ethanol production via syngas fermentation using biomass syngas (Case I)	135
Figure 5.12	Product value of anhydrous ethanol as a function of operating level and plant capacity—Ethanol production via syngas fermentation using biomass syngas (Case I)	135
Figure 6.1	SMB unit schematic	138
Figure 6.2	Syngas to 2,3-butanediol and ethanol simplified block flow diagram	140
Figure 6.3	Wood-Ljungdhal pathway to acetyl-CoA, and then 2,3-BDO	144
Figure 6.4	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Net production cost and product value of anhydrous ethanol as a function of biomass syngas price	157
Figure 6.5	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Net production cost and product value of anhydrous ethanol as a function of media price	157
Figure 6.6	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)— Net production cost and product value of anhydrous ethanol as a function of microbe price	158
Figure 6.7	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Effect of plant capacity on investment costs	162
Figure 6.8	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Net production cost of anhydrous ethanol as a function of operating level and plant capacity	163
Figure 6.9	Ethanol+2,3-BDO production via syngas fermentation using biomass syngas (Case II)—Product value of anhydrous ethanol as a function of operating level and plant capacity	163
Figure 7.1	Understanding waste gases from a typical steel mill	165
Figure 7.2	Steel mill gas conditioning and clean-up	166

Figure 7.3	Deoxygenation vessel	166
Figure 7.4	Naphthalene and BTEX removal flow chart	167
Figure 7.5	Typical working of a PSA/TSA unit	167
Figure 7.6	Steel mill gas-to-ethanol simplified block flow diagram	169
Figure 7.7	Ethanol production via syngas fermentation using steel mill waste gases (Case III)— Net production cost and product value of anhydrous ethanol as a function of biomass syngas price	182
Figure 7.8	Ethanol production via syngas fermentation using steel mill waste gases (Case III)— Net production cost and product value of anhydrous ethanol as a function of media price	183
Figure 7.9	Ethanol production via syngas fermentation using steel mill waste gases (Case III)— Net production cost and product value of anhydrous ethanol as a function of microbe price	183
Figure 7.10	Ethanol production via syngas fermentation using steel mill waste gases (Case III)— Effect of plant capacity on investment costs	186
Figure 7.11	Ethanol production via syngas fermentation using steel mill waste gases (Case III)— Net production cost of anhydrous ethanol as a function of operating level and plant capacity	186
Figure 7.12	Ethanol production via syngas fermentation using steel mill waste gases (Case III)— Product value of anhydrous ethanol as a function of operating level and plant capacity	187
Figure 8.1	Case I—Ethanol production via syngas fermentation using biomass gasification syngas—Sections 100 and 200 (gas pretreatment and fermentation)	233
Figure 8.1	Case I—Ethanol production via syngas fermentation using biomass gasification syngas—Section 300 (distillation and dehydration)	234
Figure 8.1	Case I—Ethanol production via syngas fermentation using biomass gasification syngas—Section 200 (media and offsites)	235
Figure 8.2	Case II—Ethanol+2,3-butanediol production via syngas fermentation using biomass gasification syngas—Sections 100 and 200 (gas pretreatment and fermentation)	236
Figure 8.2	Case II—Ethanol+2,3-butanediol production via syngas fermentation using biomass gasification syngas—Section 300 (SMB technology and separation of ethanol and BDO)	237
Figure 8.2	Case II—Ethanol+2,3-butanediol production via syngas fermentation using biomass gasification syngas—Section 300 (SMB technology and separation of ethanol and BDO)	238
Figure 8.2	Case II—Ethanol+2,3-butanediol production via syngas fermentation using biomass gasification syngas—Section 200 (media and offsites)	239
Figure 8.3	Case III—Ethanol production via syngas fermentation using steel mill gases— Sections 100 and 200 (gas pretreatment and fermentation)	240
Figure 8.3	Case III—Ethanol production via syngas fermentation using steel mill gases—Section 300 (distillation and dehydration)	241
Figure 8.3	Case III—Ethanol production via syngas fermentation using steel mill gases—Section 200 (media and offsites)	242

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