Fermentative Hydrogen Production by a Newly Isolated Mesophilic Bacterium HN001

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Summary of this presentation

- Obtained a very effective mesophilic bacterium named HN001.

  at pH 6.0, batch cultivation:

  Maximum H_2 production rate:

  3.6 NL-H_2/L·h (160mmol/L·h)

  at 47°C from synthetic culture

  H2 yield : 2.6 mol-H_2/mol-glucose

  By-product yields (mol/mol-glucose):

  Ethanol 0.92 and Acetate 0.88 at 50°C

  Ethanol 0.10 and Acetate 0.51 at 37°C

Composition of the synthetic culture

YNU anaerobic culture:

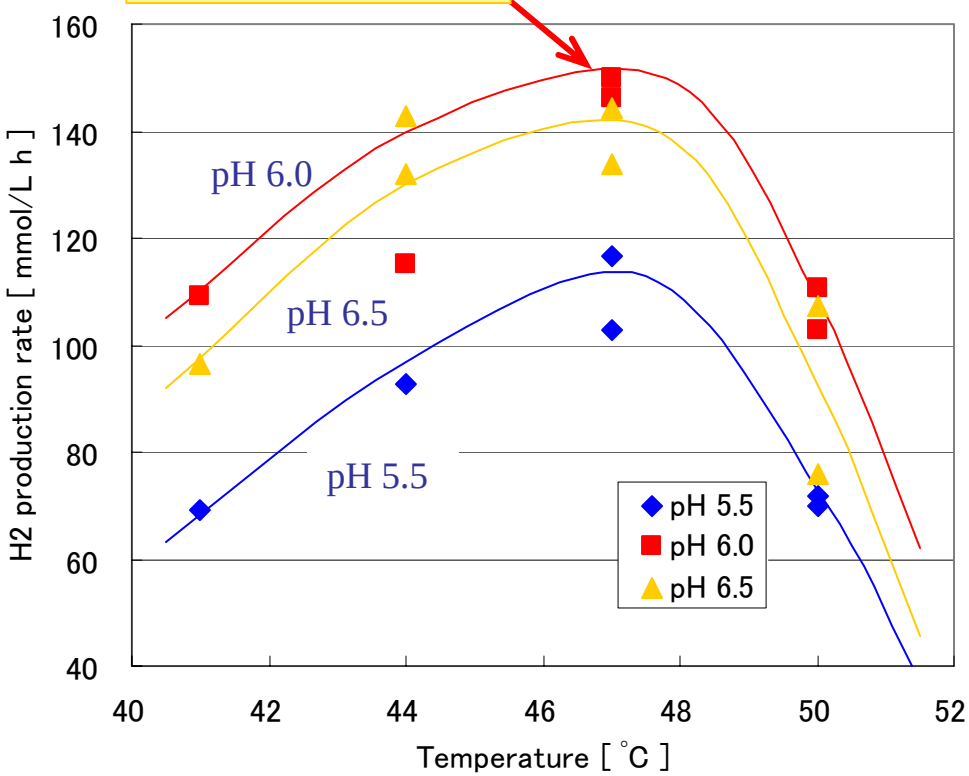
Casein peptone	:	25g/L
Dried Yeast Extract-S	:	22g/L
L-Cystein hydrochloride monohydrate	:	0.3g/L
Mercaptoacetic acid	:	0.3g/L

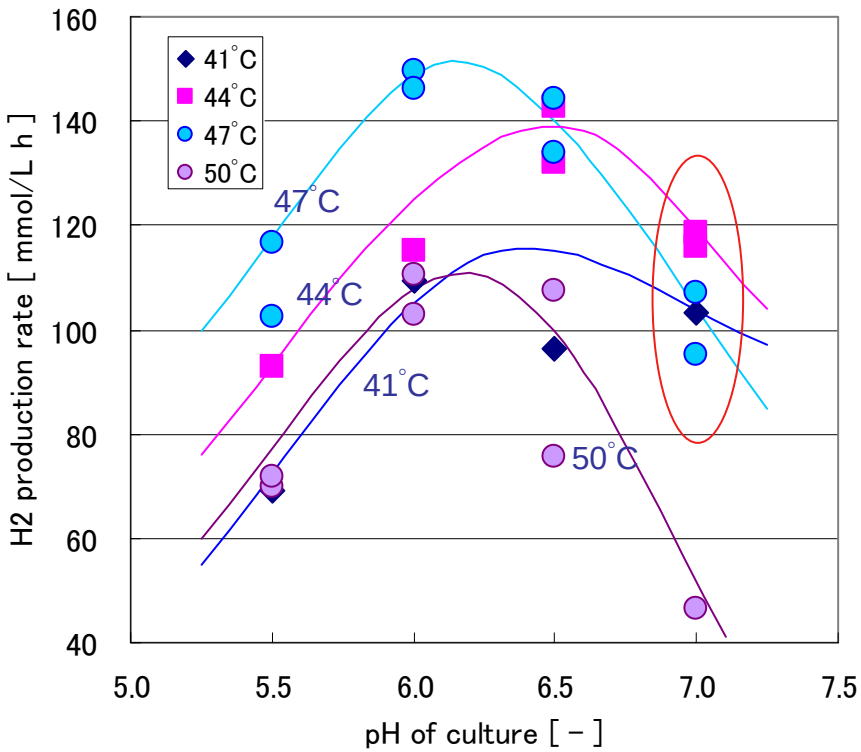
Glucose 15g/L

Effect of temperature and pH on the H2 evolution rate

Glucose concentration : 1.5 % (83mM)

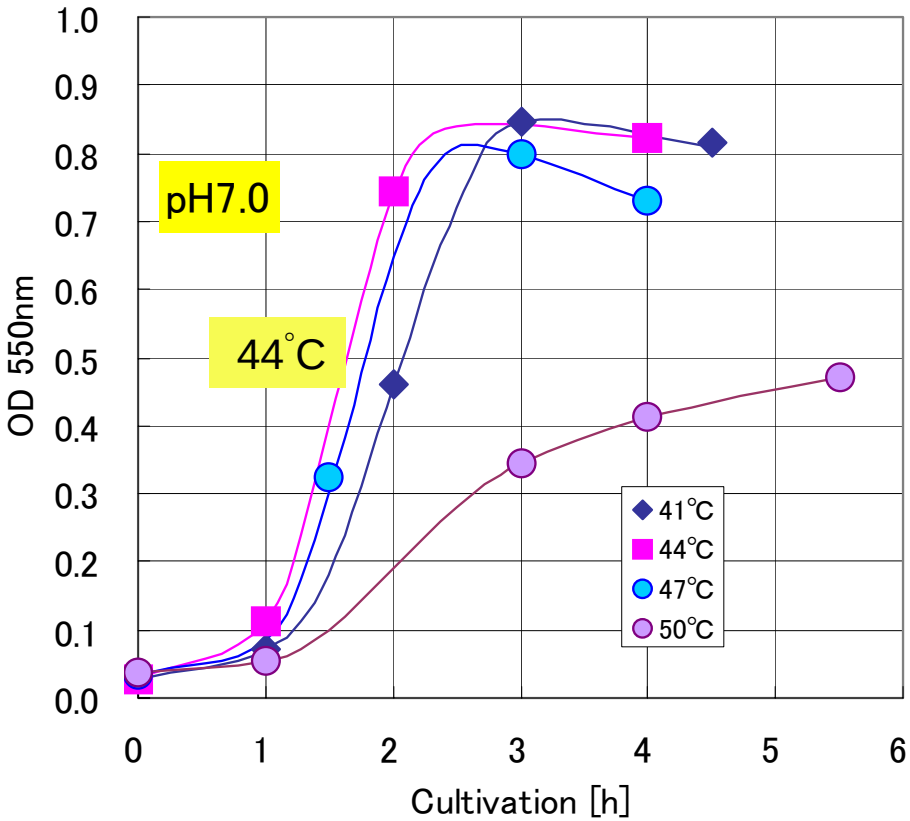
147 mmol/(L·h)

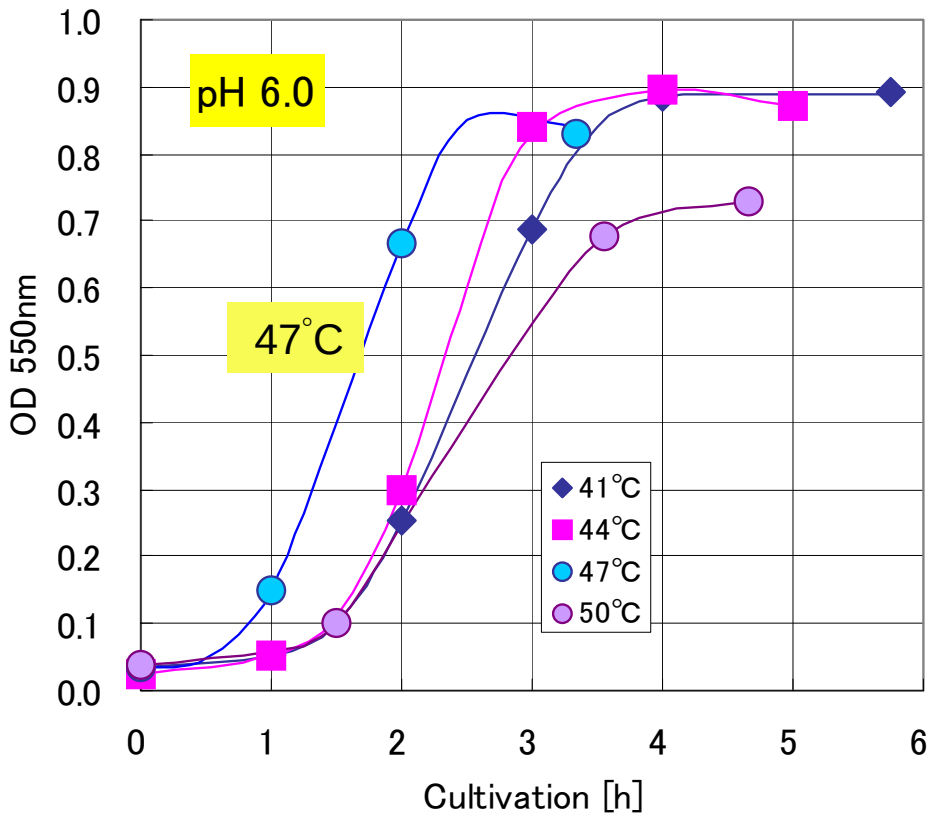




Maximum rate of H_2 production : 147 mmol/(L·h) at pH 6.0, 47° C

Effect of temperature and pH on the cell production



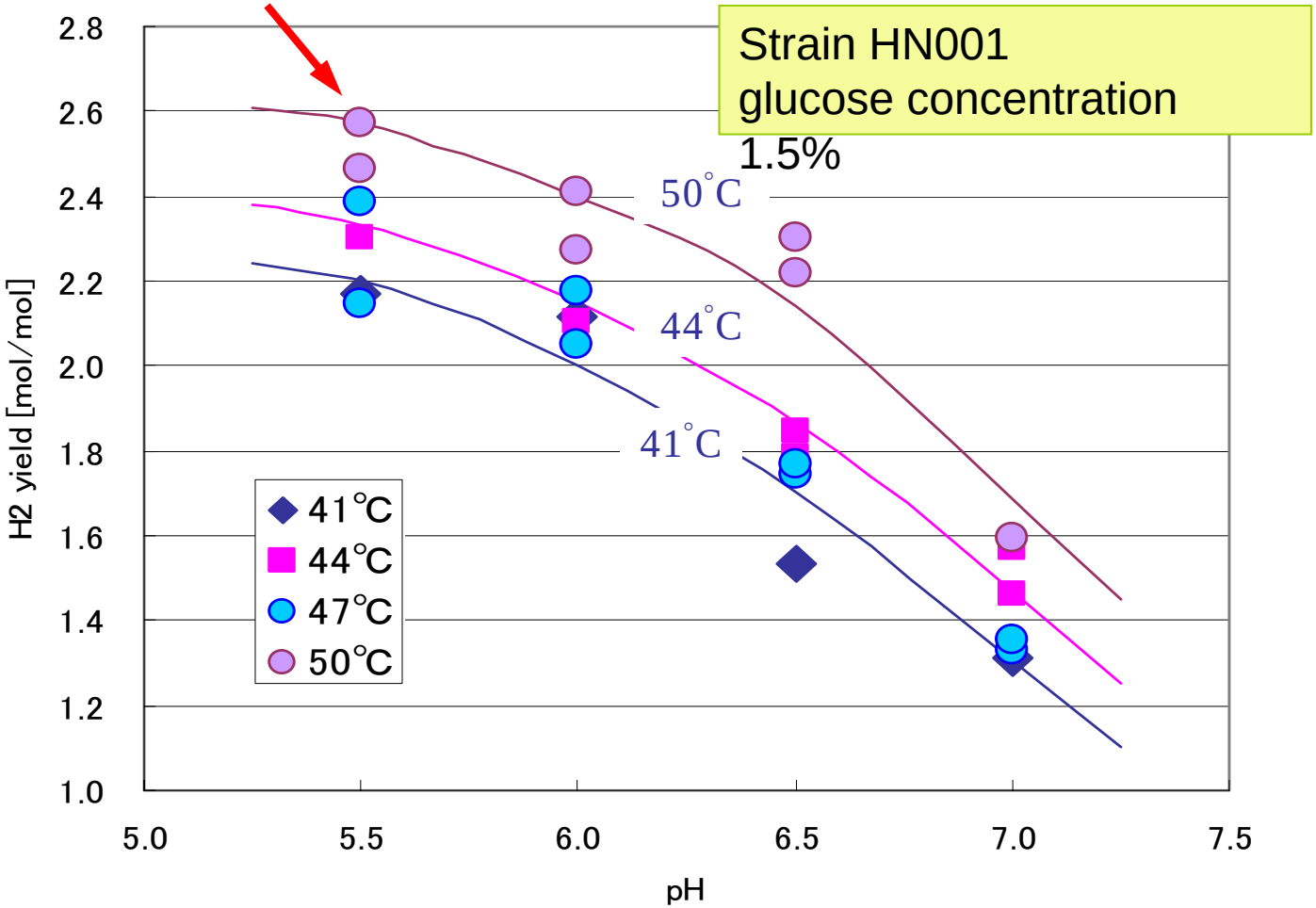


At pH 7.0; 44°C→ 47°C → 41°C

At pH 6.0; 47°C→ 44°C → 41°C

Suitable temperature for cell production changes with the culture pH.

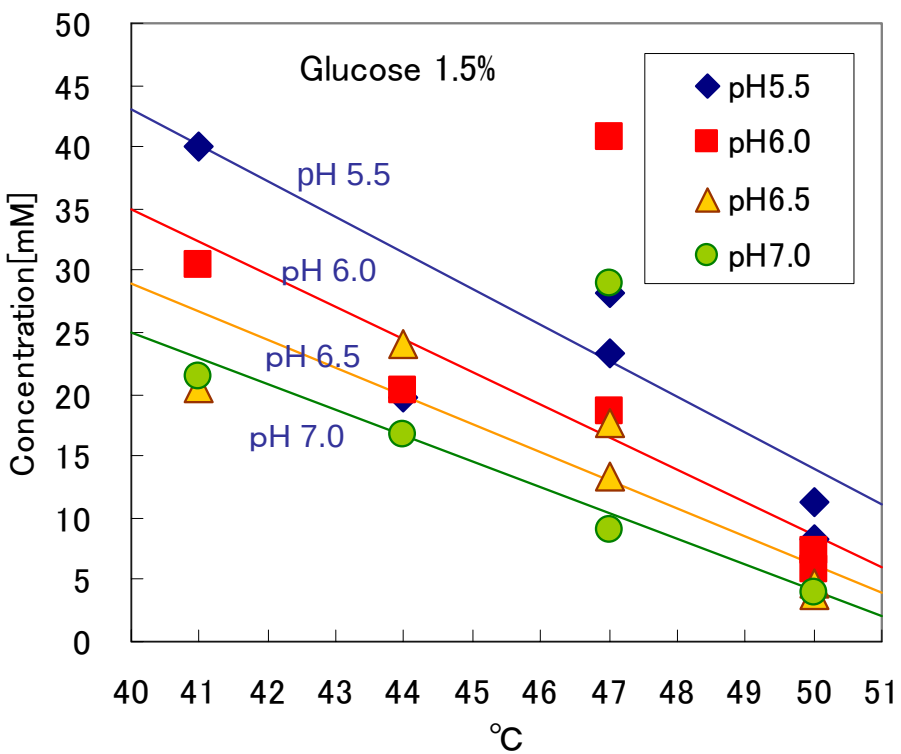
Effect of temperature and pH on the H2 yield

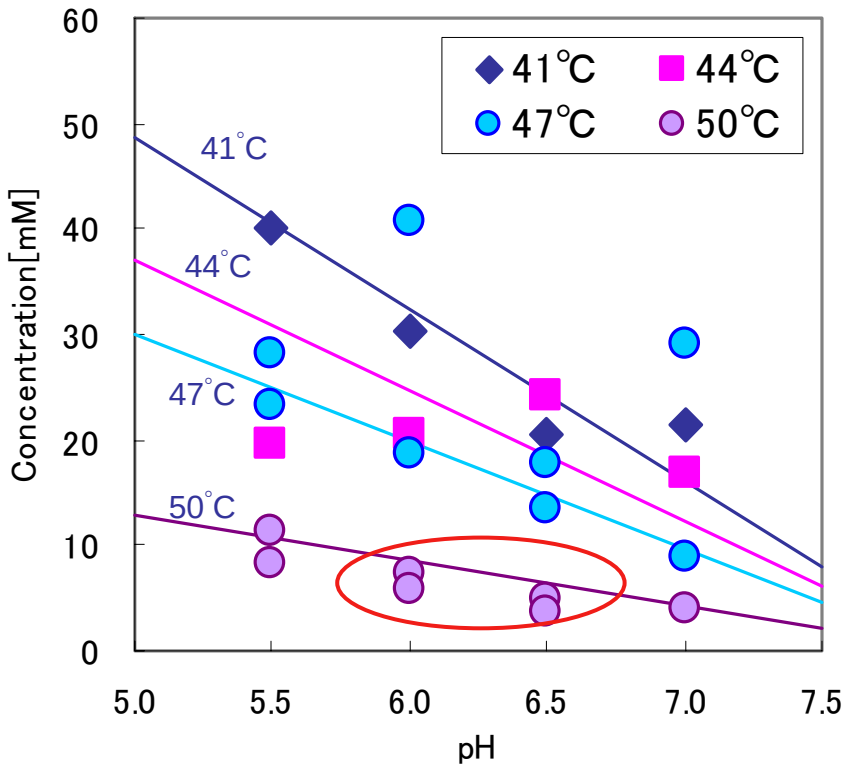


Maximum yield : 2.57 mol/mol at pH 5.5, 50° C

Effect of temperature and pH on lactate production

Strain HN001, glucose concentration 1.5%



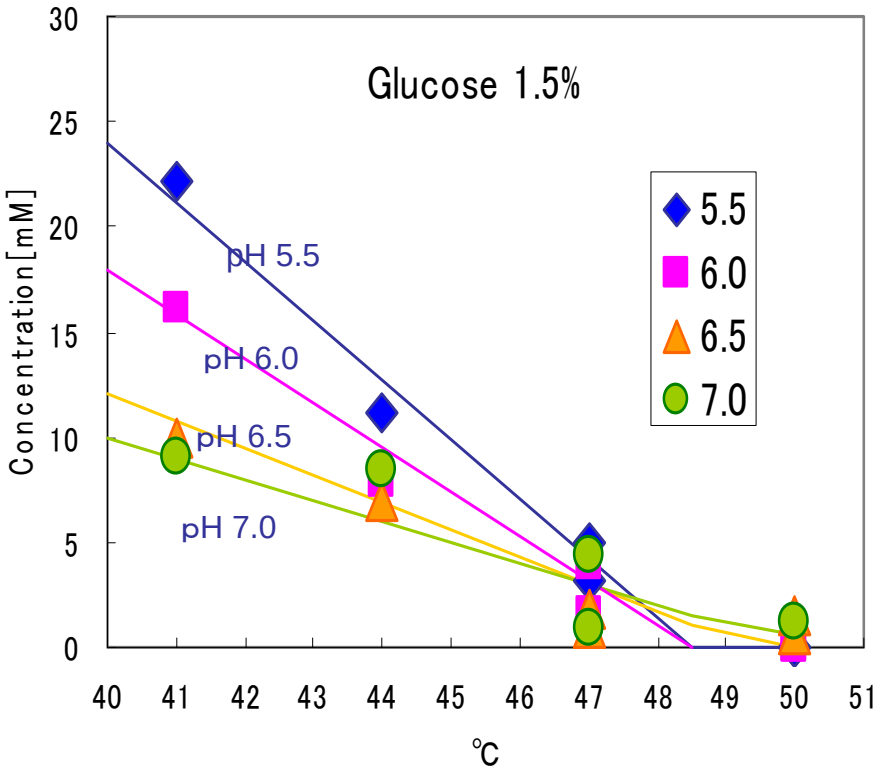


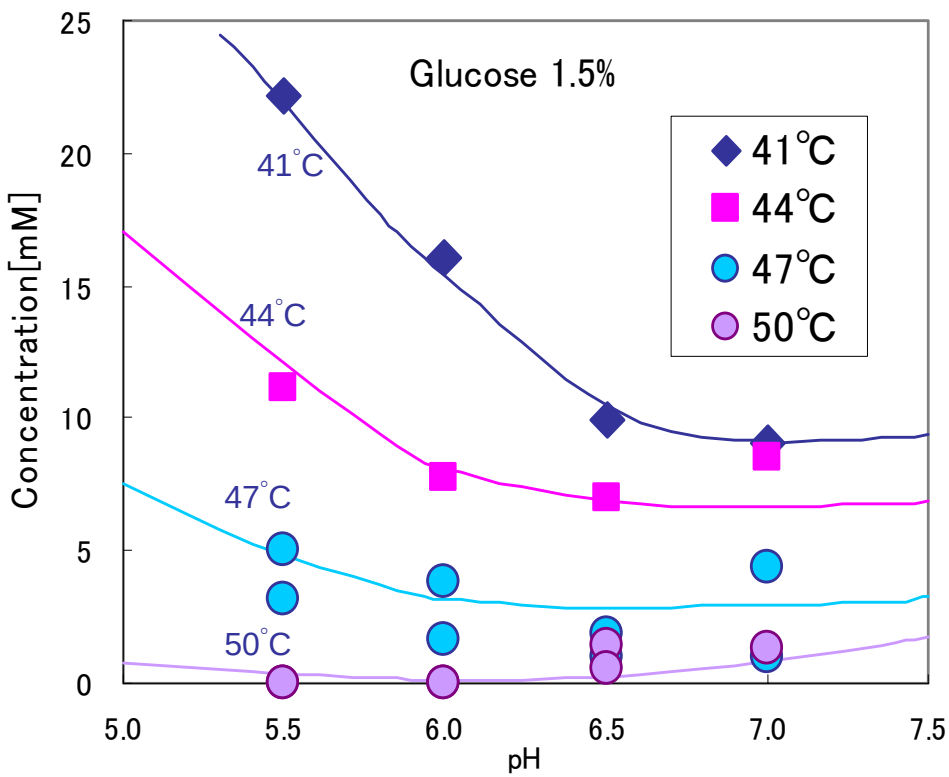
Lactate productivity decreased in accordance with the temperature increase and also with the culture pH increase.

At 50˚C, the concentration was less than 10 mM.

Effect of temperature and pH on butyrate production

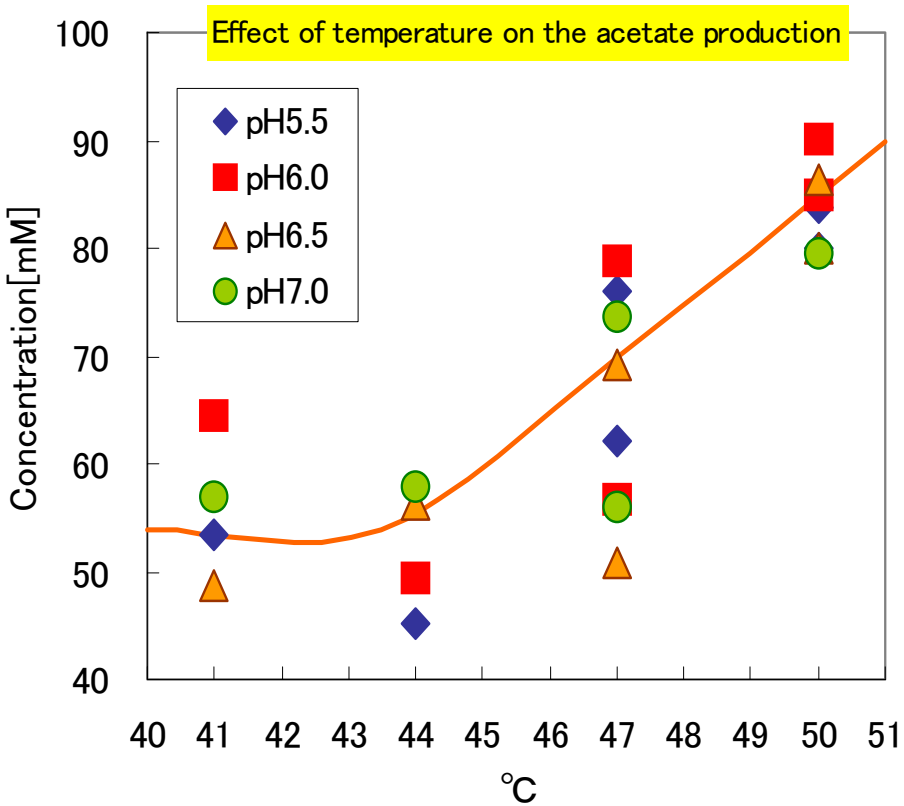
Strain HN001, glucose concentration 1.5%

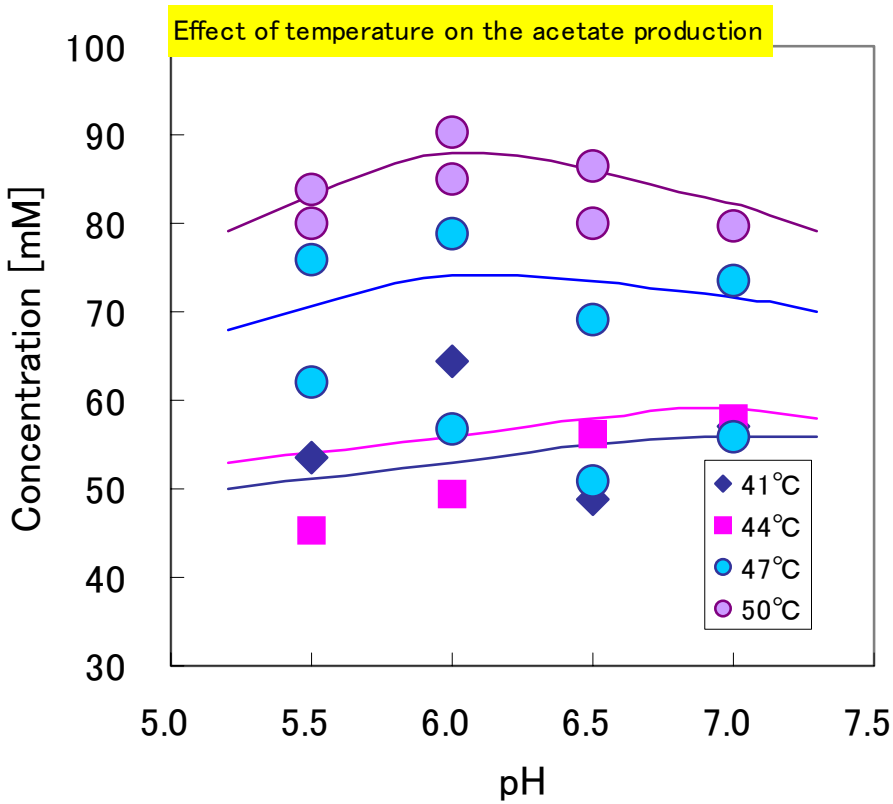




Effect of temperature and pH on acetate and ethanol production

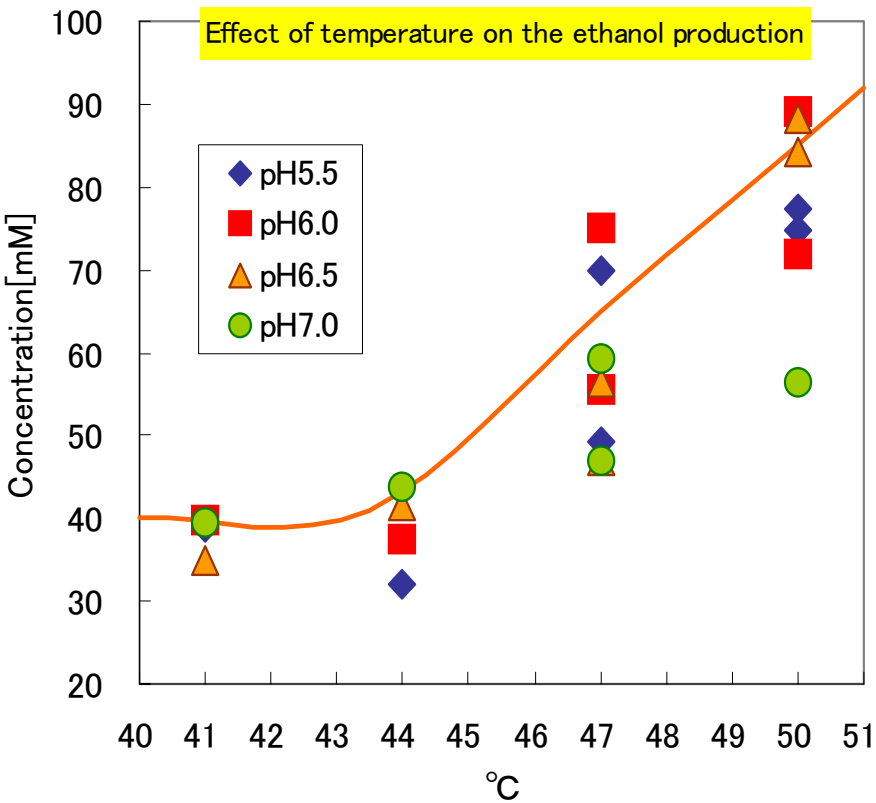
Strain HN001, glucose concentration 1.5%

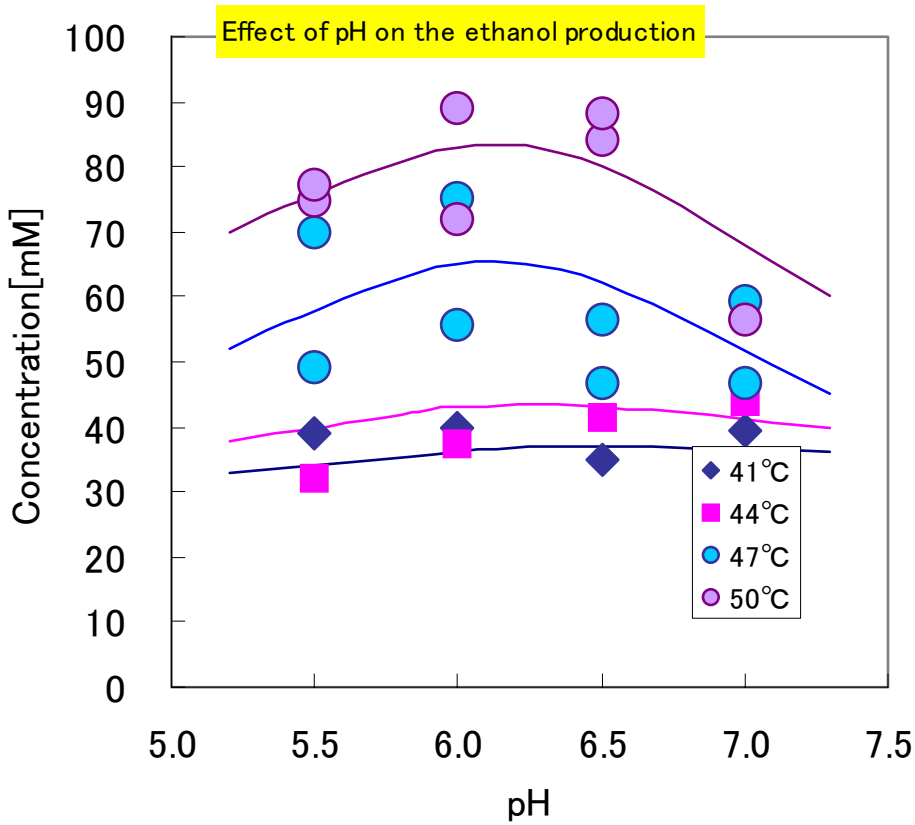




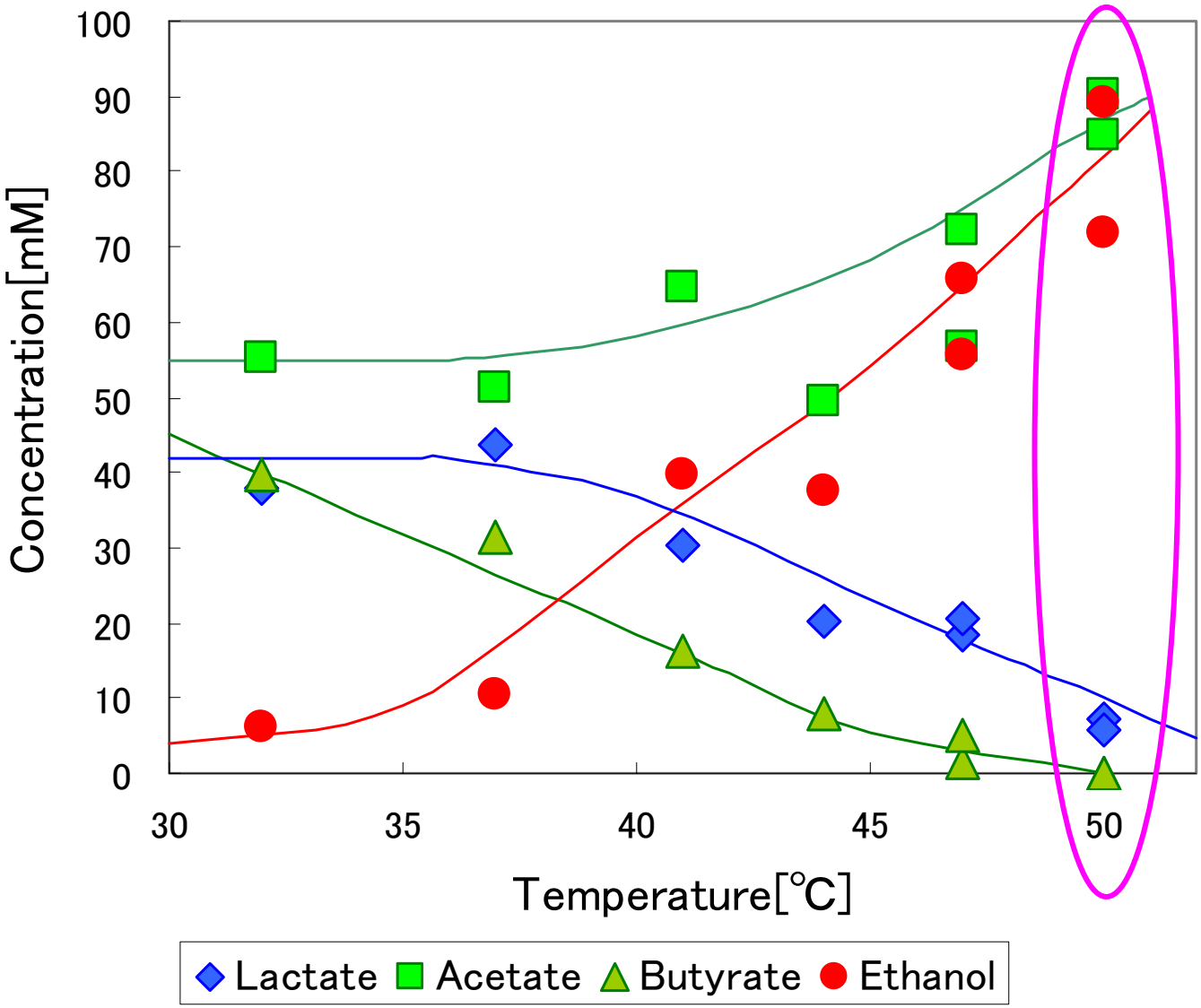
Effect of temperature and pH on ethanol production

Strain HN001, glucose concentration 1.5%





Change of metabolite formation by culture temperature



Effect of temperature and pH on acetate and ethanol production

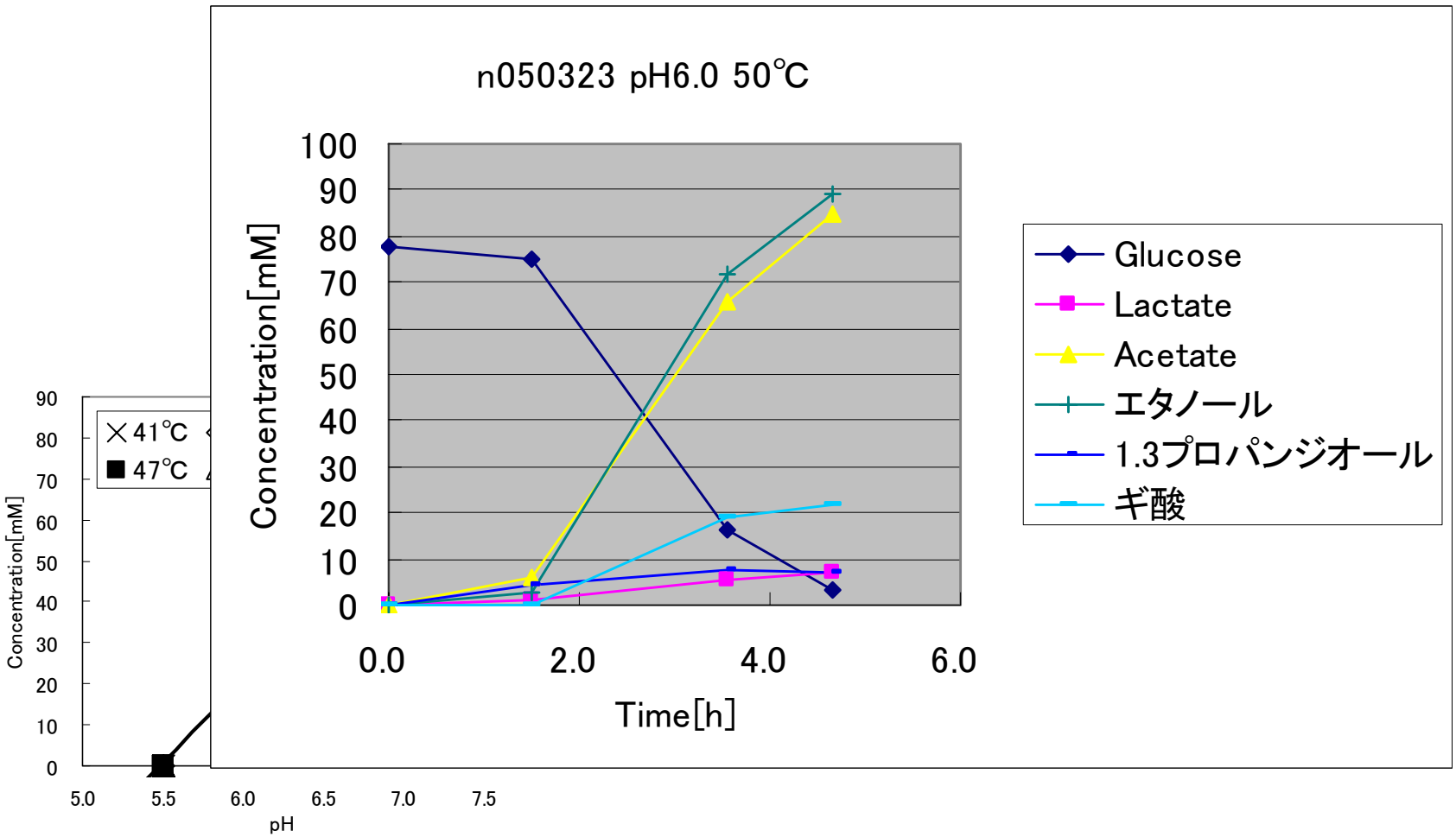
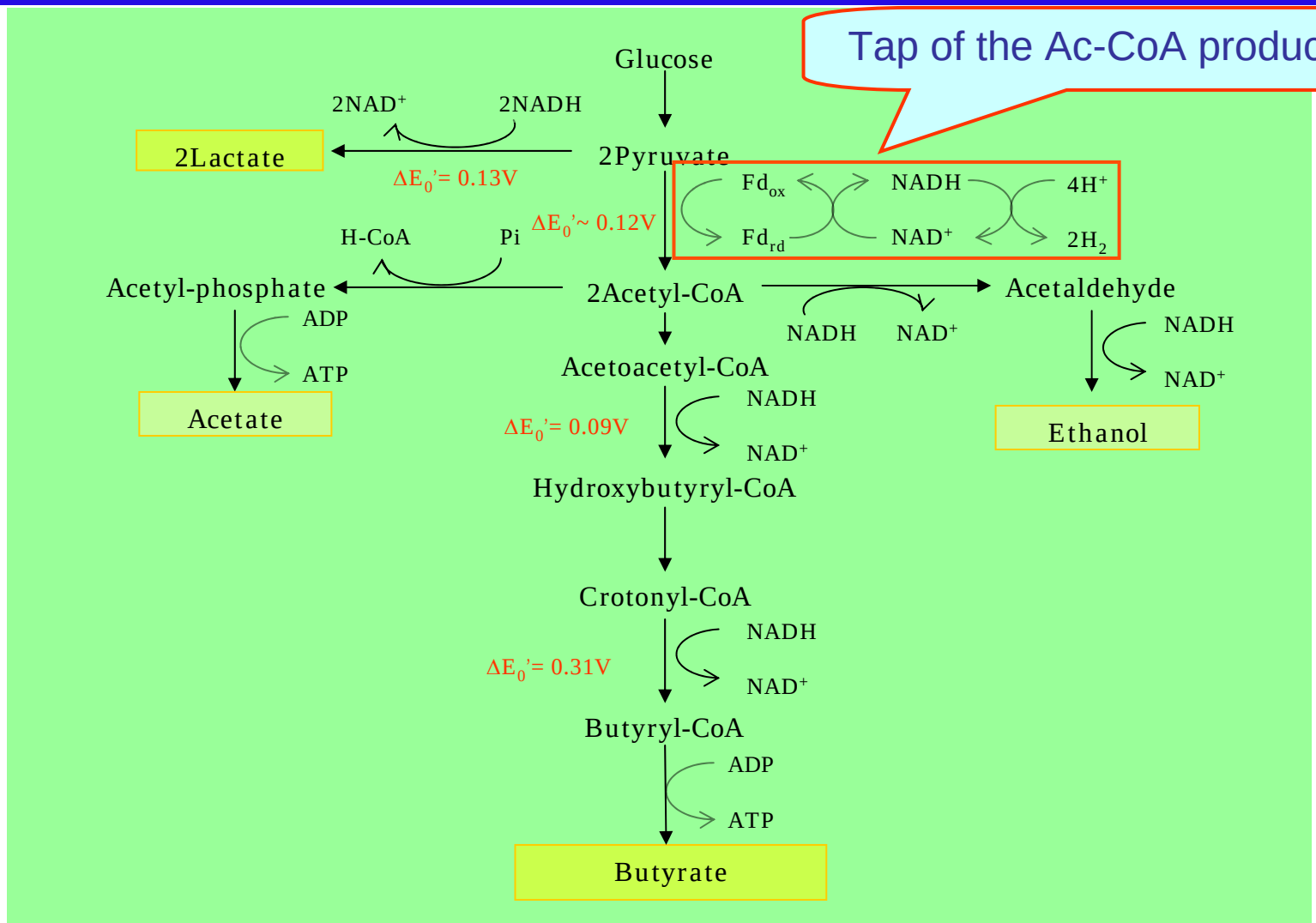


Fig.9. The effect of pH on formate production.

Reaction pathways from pyruvate



List of the H2 yield and production rate by representative bacteria

Table. Hydrogen yields and production rates by microorganisms as reported in the literature.

	culture	pH	Temp.	substrate	yield[1)]	rate	Auther
Strict anaerobes		[–]	[°C]		[mol/mol]	[mmol/L·h]	
Clostridium sp. no 2	B	6.0	36	glucose	2.0	24	1992 Taguchi et al.
C. paraputrificum M-21	B	–	37	GlcNAc	2.5	31	2000 Evvyernie et al.
C. butyricum LMG1213tl	C	5.8	36	glucose	1.5	22	1986 Heindrichx et al.
Clostridium sp. no 2	C	6.0	36	glucose	2.4	21	1990 Taguchi et al.
Mesophilic bacterium HN001	B	6.0	47	glucose	2.3	147	2004 Nishiyama et al.
Thermophiles							
Thermotoga maritima	B	–	80	glucose	4.0	10	1994 Schroder et al.
Thermotoga elfii	B	7.4	65	glucose	3.3	3	2002 van Niel et al.
Caldicellulosiruptor saccharolyticus	B	7.0	70	sucrose	3.3	8	ibid.
Facultative anaerobes							
E. aerogene E.82005	B	6.0	38	glucose	1.0	21	1983 Tanisho et al.
E. cloacae IIT-BT 08 wt	B	–	36	glucose	3.0	35	2000 Kumar et al.
E. aerogenes E.2005	C	6.0	38	molasses	0.7	36	1993 Tanisho et al.
E. aerogenes HU-101 m AY-2	C	–	37	glucose	1.1	58	1998 Rachman et al.
Co-culture or Mixed cultures from:							
C. butyricum IFO13949 + E.. aerogenes HO-39	C	5.2	36	starch	2.6	53	1998 Yokoi et al.
-sludge compost	C	6.8	60	waste water	2.5	8	1996 Ueno et al.
-sewage sludge	C	5.7	35	glucose	1.7	30	1999 Lin et al.
-fermented soybean meal	C	6.0	35	glucose	1.4	8	2000 Mizuno et al.

* Vrije & Claassen, "Dark hydrogen Fermentation", in Bio-methane & Bio-hydrogen, ed. Reith et al. (2003), ISBN:90-9017165-7

1) [mol/mol-monosacch.]

List of the H2 yield and production rate by representative bacteria

147 mmol/L•h
= 3.3 L/L•h

47 ºC

65 ~ 80 ºC

4 mol/mol

Table. Hydrogen yields and production rates by micro ature.

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Strict anaerobes		[-]				mol/L·h]	
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1) [mol/mol-monosacch.]

Hydrogen production rates of representative microorganisms

Category	doubling [h]	H2 evolution rate [mmol/(L·h)]	H2 evolution rate [mmol/(g·h)]
A. Photochemical evolution			
1. Oxygenic photosynthetic organisms	7 ~ 25		
Oscillatoria sp. Miami BG7		0.4	0.4
Anabaena cylindrica	25	1.2	1.3
2. Anoxygenic photosynthetic organisms	2.2 ~ 9		
Rhodopseudomonas capsulata		5.3	5.3
Rhodosprillum rubrum		3.0	2.5
Rhodobacter sphaeroides 8703		–	10.4
B. Fermentative evolution	0.16 ~ 2		
1. Strict anaerobe			
Clostridium butyricum		–	15 ~ 20
Clostridium beijerinckii AM21B		17	25
Newly isolated bacterium HN001		160	44
2. Facultative anaerobe			
Citrobacter intermedius		11	9.5
Enterobacter aerogenes E.82005	0.25	36	17

Tanisho *et al.*, Int. J. Hydrogen Energy, **12**, pp.623-627(1987)

中温菌HN001の発酵水素生産特性

Condition of H_2 and metabolites production by newly isolated bacterium HN001