Supplementary information

The following is included as additional **Supplementary information** for this paper

Figure Legends

Fig. S1. Variation of CO-water $k_L a$ in a 1x composition medium. The experimental setup is the same as the biotic test condition and only gas flowrate was controlled. All data point was obtained in triplicate.

Fig. S2. Change in the ethanol productivity against mean dilution rate and gas circulation rate. The experimental conditions to obtain the maximized ethanol productivity were determined by the linear fitting line.

Fig. S3. Extrapolation of the volumetric ethanol productivity versus the experimental internal gas circulation rate. Eqn. 9 was used to fit the data. a and b were estimated to be 3.78 and 0.49, respectively.

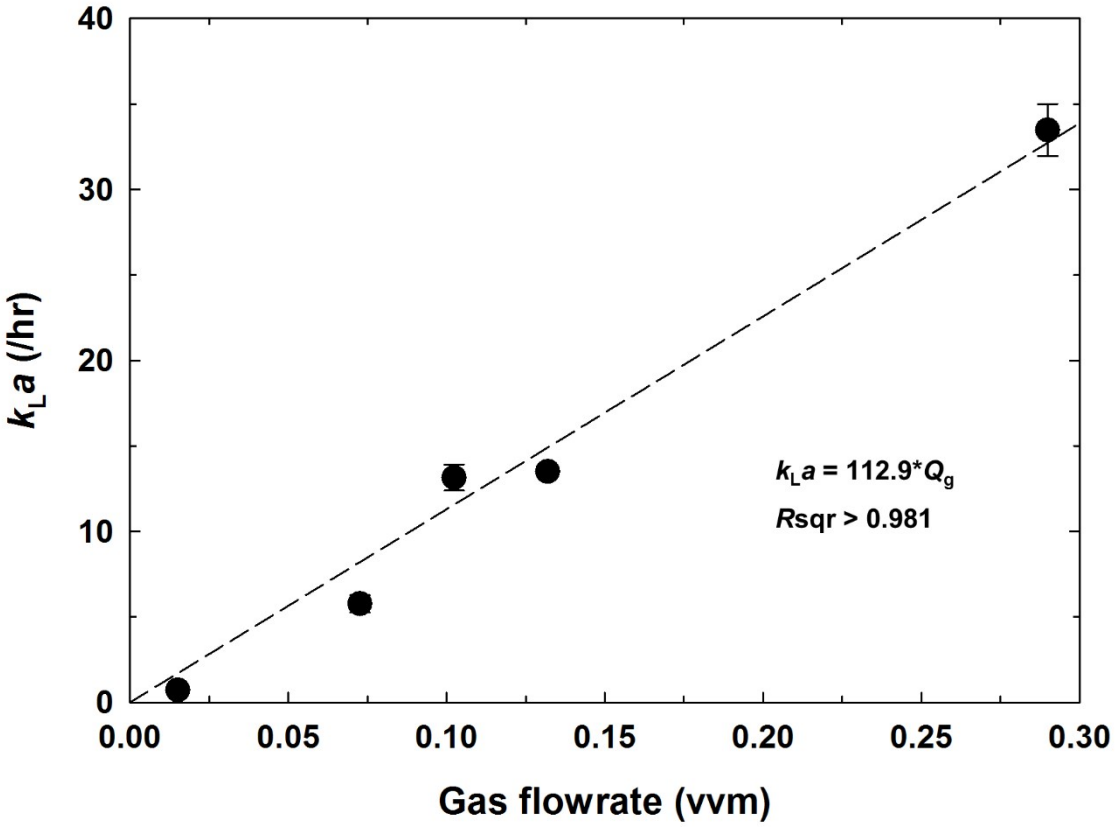

Figure S1. Variation of CO-water k_La in a 1x composition medium. The experimental setup is the same as the biotic test condition and only gas flowrate was controlled. All data point was obtained in triplicate.

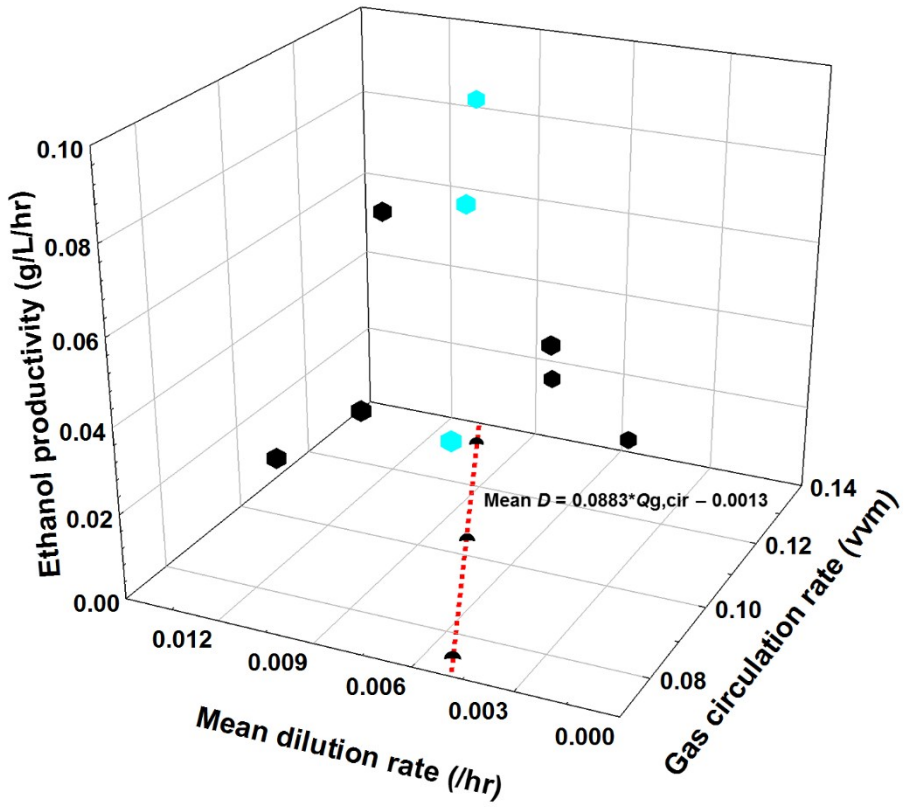

Figure S2. Change in the ethanol productivity against mean dilution rate and gas circulation rate. The experimental conditions to obtain the maximized ethanol productivity were determined by the linear fitting line.

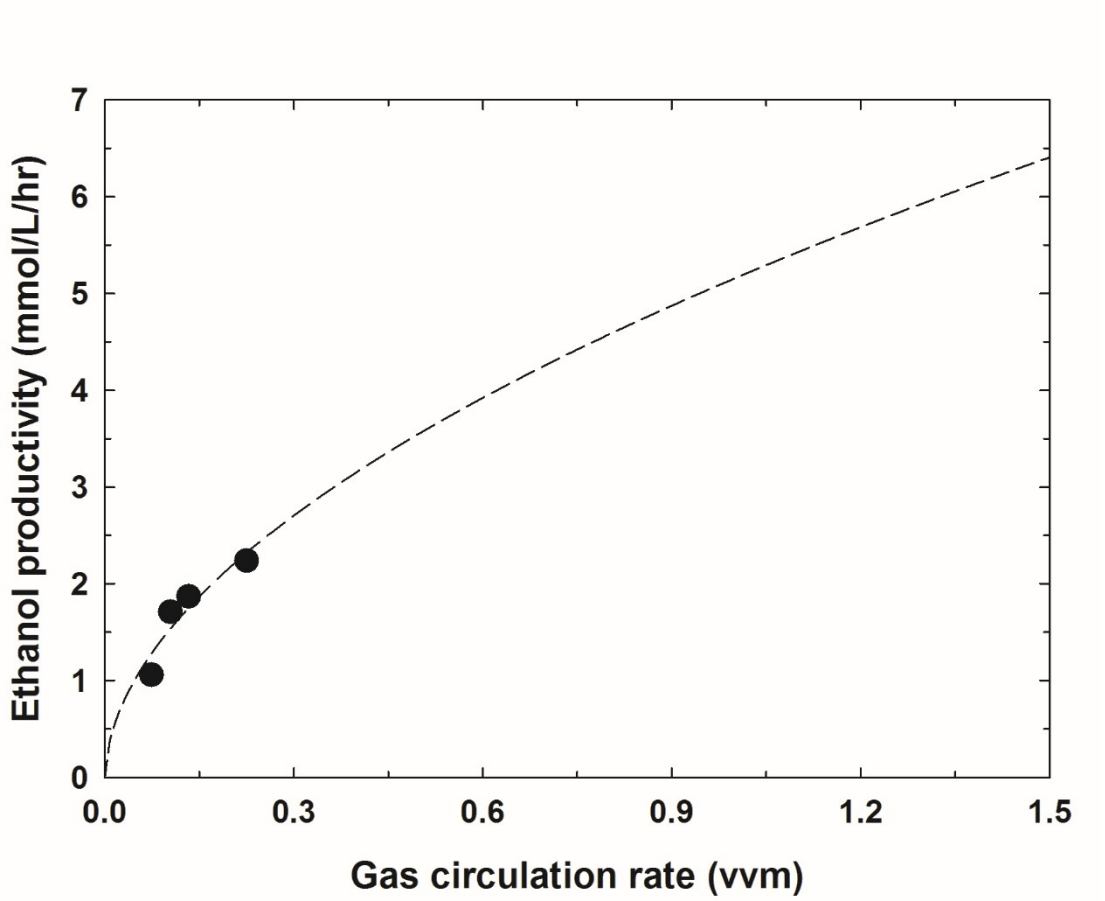

Figure S3. Extrapolation of the volumetric ethanol productivity versus the experimental internal gas circulation rate. Eqn. (4) was used to fit the data. a and b were estimated to be 3.78 and 0.49, respectively.

Table Legends

Table. S1. Price of chemical compounds according to medium composition. Prices of chemicals were mainly taken from the prices of the bulk products of Duksan chemicals (Korea), Samchun chemicals (Korea), Daejungchem (Korea), KANTO chemicals (Japan), Wako chemicals (Japan) and Sigma-Aldrich.

Table S1. Price of chemical compounds according to medium composition. Prices of chemicals were mainly taken from the prices of the bulk products of Duksan chemicals (Korea), Samchun chemicals (Korea), Daejungchem (Korea), KANTO chemicals (Japan), Wako chemicals (Japan) and Sigma-Aldrich.

	Price ($/L)		
Chemicals	**1x**	**10x**	**20x**
General			
Yeast extract	0.0120000	0.0120000	0.0120000
NaCl*	0.0015748	0.0157480	0.0314961
$MgSO_4$*	0.0004147	0.0041471	0.0082942
$CaCl_2$*	0.0010105	0.0101050	0.0202100
NH_4Cl*	0.0041032	0.0410324	0.0820647
K_2HPO_4	0.0091433	0.0091433	0.0091433
Resazurin	0.0000098	0.0000098	0.0000098
L-Cysteine-HCl	0.1058618	0.1058618	0.1058618
Trace minerals			
Nitrilotriacetic acid*	0.0018750	0.0187500	0.0375000
$FeSO_4.7H_2O$*	0.0000026	0.0000262	0.0000525
$MnCl_2.4H_2O$*	0.0000066	0.0000656	0.0001312
$CoCl_2.6H_2O$*	0.0001339	0.0013386	0.0026772
$ZnCl_2$*	0.0000066	0.0000656	0.0001312
$CaCl_2.6H_2O$*	0.0000355	0.0003552	0.0007104
$CuCl_2.2H_2O$*	0.0000057	0.0000570	0.0001141
H_3BO_3*	0.0000003	0.0000031	0.0000061
Na_2MoO_4*	0.0000606	0.0006060	0.0012120
Na_2SeO_4*	0.0000231	0.0002310	0.0004619
$NiSO_4.6H_2O$*	0.0000028	0.0000279	0.0000558
NaCl*	0.0000175	0.0001750	0.0003500
$MnSO_4.H_2O$*	0.0000962	0.0009624	0.0019248
$Fe(NH_4)_2(SO_4)_2.6H_2O$*	0.0001141	0.0011409	0.0022817
$ZnSO_4.7H_2O$*	0.0000086	0.0000857	0.0001715
$NiCl_2.6H_2O$*	0.0000057	0.0000570	0.0001141
Na_2WO_4*	0.0003180	0.0031800	0.0063600
Vitamin solution			
Biotin	0.0003264	0.0003264	0.0003264
Folic acid	0.0000173	0.0000173	0.0000173
Pyridoxine HCl	0.0000008	0.0000008	0.0000008
Thiamine HCl	0.0000768	0.0000768	0.0000768
Riboflavin	0.0000060	0.0000060	0.0000060
Nicotinic acid	0.0000013	0.0000013	0.0000013
Pantothenic acid	0.0005432	0.0005432	0.0005432
Cyanocobalamin	0.0004411	0.0004411	0.0004411
p-aminobenzoic acid	0.0000012	0.0000012	0.0000012
Lipoic acid	0.0002165	0.0002165	0.0002165
Total cost ($)	0.1384615	0.2268053	0.3249650

* Concentration reinforced