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Continuous Separation of Racemic 3,5-Dinitrobenzoyl-Amino Acids in a Centrifugal Contact Separator with the Aid of Cinchona-Based Chiral Host Compounds

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Supporting Information

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Cichona alkaloids as chiral hosts for the enantioselective separation of *N*-derivatised amino acids using liquid-liquid centrifugal separators

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Supplementary Information

Two-phase extraction experiments of <i>N</i> -3,5-dinitrobenzoylleucine	2
Two-phase extraction experiments with <i>N</i> -3,5-dinitrobenzoylphenylalanine.....	3
Two-phase extraction experiments with <i>N</i> -3,5-dinitrobenzoylvaline.....	4
Two-phase extraction experiments with <i>N</i> -3,5-dinitrobenzoylalanine.....	5
Two-phase extraction experiments with <i>N</i> -3,5-dinitrobenzoylphenylglycine.....	6
Conditions of CCS extraction experiments.....	7
CCS extraction experiment 3.....	8
CCS extraction experiment 4.....	9
CCS extraction experiment 5.....	10
CCS extraction experiment 6.....	11
CCS extraction experiment 7.....	12
CCS extraction experiment 8.....	13
CCS extraction experiment 9.....	14
CCS extraction experiment 10.....	15
CCS extraction experiment 11.....	16
CCS extraction experiment 12.....	17
CCS extraction experiment 13.....	18
CCS extraction experiment 14.....	19
CCS extraction experiment 15.....	20
CCS extraction experiment 16.....	21
CCS extraction experiment 17.....	22
CCS extraction experiment 18.....	23
CCS extraction experiment 19.....	24
Graphs of CCS extraction experiments.....	25

Two-phase extraction experiments of *N*-3,5-dinitrobenzoylleucine

Exp. No.	Host	Organic solvent	pH (aq)	Yield ^a (%)	e.e. (%)
1	CA D	Heptane	6	38	99
2	CA D	Dichloromethane	6	27	54
3	CA D	^t Butylmethylether	6	71	14
4	CA D	Dichloroethane	6	26	57
5	CA D	Toluene	6	20	1
6	CA D	Heptane	7	21	96
7	CA D	Dichloromethane	7	14	3
8	CA D	^t Butylmethylether	7	27	7
9	CA D	Dichloroethane	7	18	5
10	CA D	Toluene	7	7	40
11	CA D	Heptane	9	3	29
12	CA D	Dichloromethane	9	7	15
13	CA D	^t Butylmethylether	9	8	20
14	CA D	Dichloroethane	9	7	12
15	CA D	Toluene	9	4	6
16	CA E	Dichloromethane	6	7	64
17	CA F	Heptane	6	8	2
18	CA F	Dichloromethane	6	25	67
19	CA F	^t Butylmethylether	6	83	6
20	CA G	Heptane	6	24	20
21	CA G	Dichloromethane	6	36	59
22	CA G	^t Butylmethylether	6	86	6
23	CA H	Heptane	6	17	23
24	CA H	Dichloromethane	6	16	42
25	CA H	^t Butylmethylether	6	83	6
26	CA A	Dichloromethane	6	49	13
27	CA B	Dichloromethane	6	32	55

^a theoretical maximum 50%

Two-phase extraction experiments with *N*-3,5-dinitrobenzoylphenylalanine

Exp. No.	Host	Organic solvent	pH (aq)	Yield ^a (%)	e.e. (%)
28	CA A	Dichloroethane	6	58	5
29	CA B	Dichloroethane	6	46	19
30	CA D	Dichloroethane	6	46	19
31	CA F	Dichloroethane	6	37	30
32	CA G	Dichloroethane	6	52	19
33	CA H	Dichloroethane	6	22	19
34	CA D	Dichloroethane	7	13	38
35	CA F	Dichloroethane	7	10	55
36	CA G	Dichloroethane	7	20	30
37	CA H	Dichloroethane	7	6	2
38	CA D	Dichloroethane	9	0	0
39	CA D	Heptane	6	50	43
40	CA D	Chloroform	6	33	15
41	CA D	Toluene	6	14	6

^a theoretical maximum 50%

Two-phase extraction experiments with *N*-3,5-dinitrobenzoylvaline

Exp. No.	Host	Organic solvent	pH (aq)	Yield ^a (%)	e.e. (%)
42	CA A	Dichloroethane	6	40	20
43	CA B	Dichloroethane	6	21	41
44	CA D	Dichloroethane	6	14	34
45	CA F	Dichloroethane	6	15	17
46	CA G	Dichloroethane	6	11	80
47	CA H	Dichloroethane	6	28	13
48	CA D	Dichloroethane	7	11	29
49	CA F	Dichloroethane	7	6	72
50	CA G	Dichloroethane	7	8	93
51	CA H	Dichloroethane	7	11	76
52	CA D	Dichloroethane	9	5	59
53	CA D	Heptane	6	29	89
54	CA D	Chloroform	6	10	29
55	CA D	Toluene	6	2	89

^a theoretical maximum 50%

Two-phase extraction experiments with *N*-3,5-dinitrobenzoylalanine

Exp. No.	Host	Organic solvent	pH (aq)	Yield ^a (%)	e.e. (%)
56	CA A	Dichloroethane	6	15	48
57	CA B	Dichloroethane	6	5	99
58	CA D	Dichloroethane	6	10	68
59	CA F	Dichloroethane	6	6	43
60	CA G	Dichloroethane	6	7	94
61	CA H	Dichloroethane	6	10	61
62	CA D	Dichloroethane	7	7	85
63	CA F	Dichloroethane	7	9	96
64	CA G	Dichloroethane	7	8	93
65	CA H	Dichloroethane	7	7	94
66	CA D	Dichloroethane	9	6	86
67	CA D	Heptane	6	12	16
68	CA D	Chloroform	6	9	68
69	CA D	Toluene	6	5	85

^a theoretical maximum 50%

Two-phase extraction experiments with *N*-3,5-dinitrobenzoylphenylglycine

Exp. No.	Host	Organic solvent	pH (aq)	Yield ^a (%)	e.e. (%)
70	CA A	Dichloroethane	6	57	6
71	CA B	Dichloroethane	6	40	10
72	CA D	Dichloroethane	6	35	22
73	CA F	Dichloroethane	6	28	25
74	CA G	Dichloroethane	6	14	32
75	CA H	Dichloroethane	6	45	18
76	CA D	Dichloroethane	7	11	1
77	CA F	Dichloroethane	7	4	10
78	CA G	Dichloroethane	7	9	34
79	CA H	Dichloroethane	7	19	9
80	CA D	Dichloroethane	9	2	49
81	CA D	Heptane	6	35	49
82	CA D	Chloroform	6	15	3
83	CA D	Toluene	6	0	0

^a theoretical maximum 50%

Conditions of CCS extraction experiments

Exp. No.	Composition of feeding phase and flow rate	Composition of receiving phase and flow rate	Transport phase: Host compound, concentration, solvent and flow rate	Stirring rate
1	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml heptane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
2	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml heptane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
3	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
4	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA G , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
5	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA F , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
6	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 2.5 mM , 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
7	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), No KBr , 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
8	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 4800 rpm Stripping CCS 4800 rpm
9	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 450 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 450 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
10	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA B , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm

11	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.66 mM , 500 ml 1,2-dichloroethane, 490 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
12	0.1 M phosphate buffer (pH 6.0), 5 mM 3,5-DNB-leu, 5 mM KOH , 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
13	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 500 ml H₂O , 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
14	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 2800 rpm Stripping CCS 2800 rpm
15	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-leu, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 2800 rpm Stripping CCS 4800 rpm
16	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-PheOH, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
17	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-PheOH, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA F , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
18	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-PheOH, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA B , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm
19	0.1 M phosphate buffer (pH 6.5), 5 mM 3,5-DNB-val, 500 ml H ₂ O, 625 ml/min	0.1 M phosphate buffer (pH 9), 0.1 M KBr, 1000 ml H ₂ O, 625 ml/min	CA D , 0.5 mM, 500 ml 1,2-dichloroethane, 625 ml/min	Feed CCS 3500 rpm Stripping CCS 3500 rpm

CCS extraction experiment 3

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l-leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	3	0	0
1	97	1	98	1	1	1	0	1	2	1	100
2	95	2	96	2	3	2	0	2	2	2	100
3	91	3	96	3	5	3	1	3	0	3	84
4	92	4	97	4	8	4	3	4	0	4	49
5	90	5	96	5	12	5	4	5	0	5	51
6	84	6	89	6	14	6	5	6	0	6	48
7	83	7	89	7	17	7	6	7	-1	7	50
8	81	8	88	8	19	8	6	8	-1	8	52
9	78	9	85	9	23	9	8	9	-1	9	50
10	76	10	86	10	24	10	7	10	-3	10	56
12	69	12	84	12	30	12	12	12	-7	12	44
14	68	14	85	14	34	14	13	14	-9	14	46
16	62	16	83	16	38	16	16	16	-12	16	43
18	59	18	77	18	44	18	18	18	-10	18	43
20	55	20	76	20	47	20	21	20	-13	20	40
25	43	25	70	25	56	25	28	25	-22	25	36
30	36	30	65	30	65	30	33	30	-26	30	35
45	18	45	52	45	78	45	45	45	-47	45	29
60	9	60	37	60	96	60	63	60	-59	60	23
90	2	90	18	90	100	90	79	90	-83	90	14
120	1	120	9	120	99	120	89	120	-84	120	8
180	1	180	2	180	99	180	90	180	-46	180	7

CCS extraction experiment 4

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l- leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	3	0	0
2	85	2	92	2	10	2	3	2	-1	2	59
4	75	4	87	4	20	4	6	4	-5	4	53
6	67	6	84	6	28	6	9	6	-9	6	52
8	59	8	80	8	37	8	13	8	-12	8	49
10	52	10	75	10	45	10	17	10	-15	10	48
12	45	12	71	12	53	12	22	12	-20	12	44
14	39	14	68	14	58	14	25	14	-24	14	42
20	25	20	56	20	75	20	36	20	-36	20	38
30	11	30	39	30	88	30	53	30	-53	30	28
45	5	45	24	45	97	45	66	45	-64	45	22
60	3	60	17	60	98	60	75	60	-66	60	16
90	2	90	7	90	98	90	85	90	-45	90	10
120	3	120	3	120	96	120	86	120	1	120	8
180	3	180	1	180	97	180	91	180	40	180	6

CCS extraction experiment 5

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l-leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	3	0	0
1	97	1	96	1	3	1	0	1	3	1	100
2	92	2	95	2	4	2	0	2	2	2	100
3	92	3	94	3	6	3	0	3	2	3	100
4	91	4	94	4	9	4	0	4	1	4	100
5	88	5	92	5	10	5	2	5	0	5	74
6	86	6	94	6	12	6	2	6	-2	6	69
7	83	7	91	7	15	7	3	7	-1	7	68
8	83	8	92	8	17	8	5	8	-2	8	56
9	79	9	91	9	19	9	4	9	-4	9	66
10	77	10	89	10	21	10	5	10	-4	10	65
12	76	12	89	12	24	12	6	12	-5	12	60
14	71	14	85	14	27	14	7	14	-7	14	59
16	68	16	85	16	32	16	11	16	-8	16	50
18	67	18	84	18	34	18	11	18	-8	18	53
20	62	20	82	20	35	20	11	20	-11	20	56
25	55	25	77	25	44	25	15	25	-14	25	52
30	48	30	76	30	51	30	18	30	-19	30	50
45	32	45	65	45	70	45	27	45	-31	45	46
60	20	60	58	60	80	60	38	60	-45	60	37
90	8	90	40	90	99	90	57	90	-66	90	30
120	4	120	27	120	98	120	69	120	-76	120	20
180	2	180	10	180	100	180	89	180	-67	180	9

CCS extraction experiment 6

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l-leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	2	0	0
1	87	1	91	1	6	1	2	1	0	1	50
2	81	2	90	2	10	2	4	2	-3	2	49
3	71	3	81	3	13	3	5	3	-4	3	47
4	66	4	78	4	16	4	5	4	-6	4	53
5	63	5	78	5	18	5	6	5	-8	5	52
6	61	6	77	6	22	6	9	6	-10	6	46
7	57	7	73	7	24	7	11	7	-10	7	39
8	53	8	70	8	27	8	11	8	-11	8	44
9	56	9	78	9	32	9	14	9	-14	9	42
10	51	10	71	10	33	10	14	10	-14	10	42
12	47	12	69	12	38	12	19	12	-17	12	37
14	42	14	65	14	44	14	21	14	-20	14	39
16	38	16	62	16	50	16	25	16	-21	16	35
18	33	18	55	18	53	18	28	18	-23	18	34
20	30	20	55	20	58	20	32	20	-26	20	32
25	24	25	49	25	74	25	42	25	-31	25	30
30	19	30	46	30	75	30	47	30	-38	30	26
45	9	45	30	45	88	45	60	45	-53	45	21
60	5	60	22	60	93	60	71	60	-61	60	16
90	2	90	9	90	97	90	89	90	-57	90	7
120	2	120	5	120	100	120	96	120	-43	120	4
180	2	180	2	180	96	180	92	180	9	180	5

CCS extraction experiment 7

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l-leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	2	0	0
1		1		1		1		1		1	
2		2		2		2		2		2	
3		3		3		3		3		3	
4		4		4		4		4		4	
5	89	5	86	5	11	5	3	5	4	5	58
6		6		6		6		6		6	
7		7		7		7		7		7	
8		8		8		8		8		8	
9		9		9		9		9		9	
10	77	10	78	10	21	10	9	10	1	10	43
12		12		12		12		12		12	
14		14		14		14		14		14	
16	66	16	75	16	33	16	15	16	-5	16	40
18		18		18		18		18		18	
20	58	20	69	20	41	20	19	20	-6	20	38
25	50	25	63	25	48	25	24	25	-9	25	35
30	43	30	59	30	57	30	30	30	-14	30	32
45	26	45	47	45	71	45	40	45	-26	45	29
60	16	60	35	60	83	60	52	60	-35	60	25
90		90		90		90		90		90	
120	2	120	6	120	97	120	82	120	-40	120	10
180	2	180	1	180	93	180	88	180	24	180	5

CCS extraction experiment 8

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l-leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	6	0	0
1		1		1		1		1		1	
2		2		2		2		2		2	
3		3		3		3		3		3	
4		4		4		4		4		4	
5	83	5	91	5	11	5	4	5	1	5	50
6		6		6		6		6		6	
7		7		7		7		7		7	
8		8		8		8		8		8	
9		9		9		9		9		9	
10	70	10	86	10	23	10	11	10	-4	10	41
12		12		12		12		12		12	
14		14		14		14		14		14	
16	56	16	76	16	38	16	20	16	-9	16	36
18		18		18		18		18		18	
20		20		20		20		20		20	
25	38	25	63	25	54	25	30	25	-19	25	34
30	31	30	54	30	67	30	46	30	-21	30	25
45	13	45	35	45	85	45	63	45	-40	45	21
60	6	60	17	60	84	60	68	60	-44	60	17
90	2	90	5	90	94	90	93	90	-46	90	7
120	1	120	2	120	96	120	96	120	-56	120	6
180	1	180	0	180	88	180	88	180	100	180	6

CCS extraction experiment 9

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l-leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	5	0	0
1		1		1		1		1		1	
2		2		2		2		2		2	
3		3		3		3		3		3	
4		4		4		4		4		4	
5	84	5	88	5	7	5	2	5	3	5	55
6		6		6		6		6		6	
7		7		7		7		7		7	
8		8		8		8		8		8	
9		9		9		9		9		9	
10	78	10	84	10	15	10	7	10	2	10	42
12		12		12		12		12		12	
14		14		14		14		14		14	
16	68	16	80	16	23	16	11	16	-3	16	40
18		18		18		18		18		18	
20		20		20		20		20		20	
25	57	25	72	25	36	25	20	25	-7	25	32
30	53	30	72	30	42	30	24	30	-10	30	32
45	38	45	55	45	58	45	37	45	-14	45	27
60	23	60	45	60	71	60	48	60	-27	60	25
90	10	90	26	90	87	90	70	90	-40	90	16
120	4	120	14	120	93	120	83	120	-52	120	11
180	1	180	2	180	96	180	91	180	-36	180	8

CCS extraction experiment 10

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l-leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	6	0	0
1		1		1		1		1		1	
2		2		2		2		2		2	
3		3		3		3		3		3	
4		4		4		4		4		4	
5	79	5	91	5	14	5	6	5	-1	5	47
6		6		6		6		6		6	
7		7		7		7		7		7	
8		8		8		8		8		8	
9		9		9		9		9		9	
10	64	10	78	10	29	10	13	10	-4	10	42
12		12		12		12		12		12	
14		14		14		14		14		14	
16	52	16	72	16	41	16	20	16	-10	16	40
18		18		18		18		18		18	
20		20		20		20		20		20	
25	35	25	60	25	59	25	30	25	-21	25	38
30	30	30	62	30	71	30	42	30	-30	30	31
45	15	45	41	45	84	45	57	45	-43	45	24
60	5	60	24	60	85	60	70	60	-60	60	15
90	3	90	11	90	96	90	87	90	-52	90	11
120	2	120	3	120	96	120	96	120	-10	120	6
180	1	180	0	180	96	180	96	180	26	180	6

CCS extraction experiment 11

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l- leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	5	0	0
2	85	2	89	2	8	2	2	2	2	2	67
4	77	4	85	4	12	4	4	4	-1	4	49
6	70	6	79	6	19	6	8	6	-1	6	47
8	65	8	77	8	25	8	10	8	-4	8	46
10	59	10	73	10	29	10	13	10	-6	10	44
12	53	12	67	12	37	12	15	12	-7	12	45
14	50	14	66	14	42	14	19	14	-10	14	42
20	36	20	55	20	55	20	27	20	-16	20	38
30	23	30	43	30	68	30	38	30	-26	30	33
45	12	45	29	45	84	45	55	45	-37	45	25
60	7	60	19	60	85	60	61	60	-43	60	21
90	3	90	7	90	93	90	81	90	-28	90	11
120	3	120	2	120	93	120	87	120	19	120	8
180	3	180	1	180	91	180	86	180	55	180	8

CCS extraction experiment 12

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l- leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	5	0	0
2	83	2	87	2	8	2	4	2	3	2	40
4	69	4	78	4	18	4	9	4	-1	4	38
6	63	6	75	6	24	6	12	6	-4	6	39
8	54	8	68	8	36	8	18	8	-7	8	38
10	47	10	63	10	42	10	22	10	-10	10	36
12	42	12	59	12	48	12	25	12	-12	12	35
14	35	14	54	14	55	14	30	14	-16	14	34
20	21	20	39	20	67	20	42	20	-26	20	27
30	8	30	23	30	84	30	61	30	-44	30	21
45	4	45	11	45	79	45	66	45	-48	45	14
60	3	60	5	60	83	60	75	60	-26	60	10
90	3	90	2	90	83	90	77	90	30	90	9
120	3	120	1	120	85	120	81	120	70	120	8
180	3	180	0	180	85	180	81	180	75	180	8

CCS experiment 13

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l- leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	4	0	0
2	91	2	98	2	4	2	0	2	1	2	82
4	87	4	95	4	8	4	1	4	0	4	73
6	83	6	92	6	13	6	4	6	-1	6	59
8	79	8	90	8	17	8	7	8	-2	8	47
10	74	10	89	10	21	10	9	10	-5	10	46
12	70	12	86	12	26	12	10	12	-6	12	48
14	66	14	84	14	30	14	13	14	-8	14	43
20	55	20	78	20	42	20	19	20	-13	20	42
30	40	30	67	30	58	30	30	30	-21	30	36
45	24	45	52	45	75	45	43	45	-33	45	31
60	13	60	39	60	87	60	57	60	-46	60	25
90	5	90	20	90	97	90	79	90	-56	90	14
120	4	120	9	120	97	120	91	120	-36	120	7
180	4	180	1	180	98	180	99	180	55	180	4

CCS experiment 14

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l- leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	3	0	0
2	92	2	94	2	6	2	1	2	2	2	77
4	86	4	91	4	10	4	3	4	0	4	55
6	82	6	89	6	16	6	5	6	-1	6	52
8	77	8	86	8	19	8	7	8	-3	8	51
10	74	10	85	10	23	10	8	10	-4	10	50
12	70	12	83	12	27	12	10	12	-5	12	48
14	65	14	80	14	32	14	10	14	-7	14	53
20	55	20	73	20	43	20	15	20	-12	20	50
30	40	30	63	30	56	30	22	30	-19	30	45
45	26	45	52	45	72	45	33	45	-30	45	39
60	17	60	41	60	83	60	44	60	-39	60	32
90	9	90	28	90	93	90	59	90	-50	90	25
120	6	120	18	120	95	120	70	120	-49	120	18
180	5	180	8	180	96	180	81	180	-22	180	11

CCS experiment 15

Time	% Feed DNB-d- leu	Time	% Feed DNB-l- leu	Time	% Receive DNB-d- leu	Time	% Receive DNB-l- leu	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	5	0	0
2	89	2	91	2	5	2	1	2	4	2	60
4	84	4	90	4	9	4	1	4	2	4	76
6	82	6	87	6	13	6	4	6	2	6	59
8	78	8	87	8	17	8	6	8	-1	8	54
10	73	10	84	10	22	10	7	10	-2	10	57
12	70	12	82	12	25	12	9	12	-3	12	51
14	66	14	83	14	30	14	11	14	-7	14	49
20	57	20	79	20	40	20	16	20	-11	20	47
30	43	30	68	30	55	30	25	30	-19	30	42
45	27	45	57	45	70	45	37	45	-31	45	36
60	17	60	46	60	80	60	48	60	-42	60	30
90	7	90	29	90	90	90	65	90	-58	90	21
120	4	120	20	120	94	120	76	120	-67	120	15
180	2	180	7	180	94	180	88	180	-49	180	8

CCS experiment 16

Time	% Feed DNB-d- PheOH	Time	% Feed DNB-l- PheOH	Time	% Receive DNB-d- PheOH	Time	% Receive DNB-l- PheOH	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	4	0	0
2	86	2	90	2	5	2	1	2	2	2	64
4	81	4	87	4	12	4	6	4	0	4	38
6	75	6	82	6	19	6	10	6	-1	6	35
8	69	8	79	8	25	8	14	8	-3	8	32
10	62	10	73	10	32	10	20	10	-5	10	26
12	55	12	68	12	39	12	23	12	-7	12	28
14	49	14	63	14	44	14	27	14	-9	14	26
20	35	20	52	20	58	20	40	20	-16	20	21
30	19	30	34	30	75	30	52	30	-26	30	21
45	6	45	16	45	88	45	74	45	-40	45	12
60	2	60	4	60	92	60	83	60	-31	60	9
90	1	90	0	90	92	90	89	90	97	90	5
120	2	120	1	120	92	120	89	120	52	120	5
180	2	180	0	180	91	180	90	180	72	180	4

CCS extraction experiment 17

Time	% Feed DNB-d- PheOH	Time	% Feed DNB-l- PheOH	Time	% Receive DNB-d- PheOH	Time	% Receive DNB-l- PheOH	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	4	0	0
2	92	2	93	2	5	2	2	2	4	2	48
4	88	4	93	4	10	4	5	4	1	4	41
6	82	6	89	6	15	6	8	6	0	6	36
8	76	8	85	8	21	8	11	8	-1	8	37
10	71	10	83	10	26	10	13	10	-4	10	35
12	67	12	80	12	31	12	17	12	-5	12	35
14	62	14	77	14	36	14	19	14	-6	14	34
20	50	20	69	20	47	20	27	20	-12	20	32
30	33	30	56	30	62	30	38	30	-22	30	28
45	16	45	39	45	80	45	55	45	-37	45	23
60	8	60	25	60	88	60	66	60	-49	60	19
90	2	90	12	90	94	90	80	90	-62	90	12
120	1	120	4	120	95	120	89	120	-44	120	8
180	2	180	1	180	95	180	92	180	44	180	6

CCS extraction experiment 18

Time	% Feed DNB-d- PheOH	Time	% Feed DNB-l- PheOH	Time	% Receive DNB-d- PheOH	Time	% Receive DNB-l- PheOH	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	4	0	0
2	96	2	97	2	5	2	2	2	3	2	48
4	85	4	89	4	10	4	6	4	2	4	33
6	78	6	83	6	16	6	9	6	1	6	31
8	74	8	81	8	22	8	13	8	0	8	27
10	69	10	78	10	27	10	17	10	-2	10	27
12	64	12	74	12	32	12	20	12	-3	12	26
14	60	14	71	14	38	14	24	14	-4	14	27
20	47	20	61	20	49	20	34	20	-9	20	22
30	30	30	45	30	67	30	49	30	-16	30	19
45	13	45	25	45	84	45	69	45	-28	45	14
60	5	60	13	60	93	60	82	60	-37	60	10
90	2	90	2	90	97	90	93	90	-14	90	6
120	2	120	1	120	97	120	95	120	25	120	5
180	2	180	1	180	96	180	95	180	47	180	5

CCS extraction experiment 19

Time	% Feed DNB-d- Val	Time	% Feed DNB-I- Val	Time	% Receive DNB-d- Val	Time	% Receive DNB-I- Val	Time	Feed e.e.	Time	Receive e.e.
0	100	0	100	0	0	0	0	0	3	0	0
2	94	2	96	2	2	2	1	2	2	2	41
4	90	4	93	4	5	4	1	4	1	4	59
6	87	6	92	6	9	6	3	6	0	6	45
8	83	8	91	8	12	8	5	8	-2	8	42
10	79	10	88	10	16	10	5	10	-2	10	56
12	76	12	87	12	20	12	5	12	-4	12	63
14	73	14	86	14	23	14	8	14	-5	14	50
20	64	20	81	20	31	20	15	20	-9	20	39
30	52	30	70	30	43	30	21	30	-12	30	37
45	35	45	60	45	62	45	34	45	-24	45	32
60	26	60	53	60	72	60	42	60	-31	60	29
90	12	90	38	90	84	90	57	90	-49	90	22
120	6	120	24	120	92	120	69	120	-60	120	17
180	2	180	7	180	96	180	87	180	-61	180	8

Graphs of CCS extraction experiments