Supporting Information for

Extraction Chromatographic Materials for Clean Hydrometallurgical Separation of Rare Earth Elements Using Diglycolamide Extractants

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Table S1: Concentrations of rare earth elements (REE) for stoichiometric loading with the DGA resins. Each batch extraction experiment was conducted by contacting 200 mg of TODGA and 132 mg of DMDODGA resins with 6 mL of REE solution in appropriate acid concentration.

Element	[Element], ppm	[Element], M
Sc	20	4.45E-04
Y	40	4.50E-04
La	62	4.46E-04
Ce	62	4.42E-04
Pr	63	4.47E-04
Nd	64	4.44E-04
Sm	67	4.46E-04
Eu	68	4.47E-04
Gd	70	4.45E-04
Tb	72	4.53E-04
Dy	72	4.43E-04
Ho	73	4.43E-04
Er	74	4.42E-04
Tm	75	4.44E-04
Yb	77	4.45E-04
Lu	78	4.46E-04
Total REE	1037	7.13E-03

Table S2: Concentrations of rare earth elements (REE) for excess loading with the DGA resins. Each batch extraction experiment was conducted by contacting 100 mg of TODGA and 70 mg of DMDODGA resins with 6 mL of REE solution in appropriate acid concentration.

Element	[Element], ppm	[Element], M
Sc	30	6.67E-04
Y	60	6.75E-04
La	90	6.48E-04
Ce	90	6.42E-04
Pr	90	6.39E-04
Nd	90	6.24E-04
Sm	100	6.65E-04
Eu	100	6.58E-04
Gd	100	6.36E-04
Tb	100	6.29E-04
Dy	100	6.15E-04
Ho	100	6.06E-04
Er	110	6.58E-04
Tm	110	6.51E-04
Yb	110	6.36E-04
Lu	110	6.29E-04
Total REE	1490	1.03E-02

Table S3: D_w values for TODGA and DMDODGA resins contacted with REE (0.007M) in HCl at stoichiometric concentration, that is, the full theoretical capacity of the resin dia. The bold and italic values are the number generated by putting analytical lower limit of detection of the ICP-OES instrument for the after extraction aqueous concentration the into the *Dw* formula.

TODGA resin

[HCl], M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.01	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
1	0.0	37.3	0.0	0.0	0.0	0.0	5.2	19.1	26.9	53.4	86.7	117.0	136.0	125.0	119.0	111.0
3	***60900.0***	2040.0	4.0	50.8	74.1	183.0	745.0	1810.0	1860.0	6950.0	5900.0	5600.0	5560.0	3810.0	4280.0	2850.0
5	***61100.0***	186.0	0.0	15.9	16.2	24.6	101.0	255.0	315.0	575.0	640.0	511.0	386.0	266.0	229.0	187.0
8	1320.0	15.9	0.0	0.4	0.8	1.1	3.5	11.0	13.6	23.1	32.3	37.9	39.8	38.1	37.1	34.4

DMDODGA resin

[HCl], M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.01	63.4	139.0	0.0	0.0	0.0	0.0	0.0	65.0	84.0	158.0	250.0	342.0	425.0	438.0	481.0	528.0
0.1	2020.0	7920.0	0.0	0.0	0.0	0.0	529.0	1560.0	1890.0	10300.0	16300.0	20200.0	***74000.0***	***44500.0***	***254000.0***	***201000.0***
1	***95100.0***	***116000.0***	0.0	0.0	0.0	7800.0	***13200.0***	20700.0	***14600.0***	***16100.0***	***51300.0***	***37800.0***	***74000.0***	***43900.0***	***242000.0***	***188000.0***
3	***93100.0***	***112000.0***	447.0	5890.0	***7200.0***	***13700.0***	***12700.0***	***213000.0***	***14300.0***	***15700.0***	***49700.0***	***36700.0***	***71700.0***	***42800.0***	***239000.0***	***182000.0***
5	***94000.0***	***113000.0***	670.0	***7910.0***	***7250.0***	***13800.0***	***12800.0***	***216000.0***	***14400.0***	***15900.0***	***50000.0***	***37000.0***	***72400.0***	***43300.0***	***241000.0***	***185000.0***
8	***91400.0***	***109000.0***	328.0	***7650.0***	***7000.0***	***13300.0***	***12500.0***	***210000.0***	***14000.0***	***15200.0***	***48200.0***	***35800.0***	***69700.0***	***41700.0***	***231000.0***	***178000.0***

Table S4: D_w values for TODGA and DMDODGA resins contacted with REE (0.007M) in H_2SO_4 at stoichiometric concentration, that is, the full theoretical capacity of the resin. The bold and italic values are the number generated by putting analytical lower limit of detection of the ICP-OES instrument for the after extraction aqueous concentration the into the D_w formula.

TODGA resin

$[H_2SO_4]$, M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.1	0.0	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	39.3	0.0	0.0	0.0	0.0
3	0.0	10.8	0.0	0.0	0.0	0.0	3.9	9.7	10.2	16.2	22.1	25.5	26.0	21.4	21.3	14.4
5	0.0	5.5	0.0	0.6	3.4	0.6	1.5	7.0	4.9	7.9	10.3	11.9	12.2	10.6	11.9	7.7
8	2.0	13.1	0.0	0.7	7.5	1.3	4.1	16.5	9.4	14.5	19.3	22.6	25.6	27.5	34.3	29.2

DMDODGA resin

$[H_2SO_4]$, M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.01	36.8	76.6	0.0	0.0	0.0	0.0	0.0	29.6	40.3	75.8	126.0	182.0	238.0	257.0	307.0	341.0
0.1	92.0	897.0	0.0	0.0	0.0	0.0	135.0	276.0	378.0	820.0	1440.0	2010.0	3670.0	3750.0	4870.0	5720.0
1	***48300.0***	***58000.0***	0.0	0.0	0.0	3370.0	***6370.0***	***111000.0***	***7490.0***	***8130.0***	***25500.0***	***20700.0***	***37100.0***	***21700.0***	***127000.0***	***93300.0***
3	***43800.0***	***53600.0***	268.0	4360.0	16600.0	***6700.0***	***5890.0***	***103000.0***	***6930.0***	***7540.0***	***23600.0***	***19200.0***	***34300.0***	***20000.0***	***117000.0***	***84900.0***
5	***40800.0***	***49900.0***	152.0	2890.0	14700.0	***6250.0***	***5490.0***	***95600.0***	***6430.0***	***7030.0***	***22000.0***	***17900.0***	***31900.0***	***18500.0***	***108000.0***	***79000.0***
8	***34000.0***	***40700.0***	13.6	140.0	235.0	776.0	*4410.0*	*77400.0*	*5140.0*	*5660.0*	*17800.0*	*14500.0*	*26100.0*	*15200.0*	*89400.0*	*65300.0*

Table S5: D_w values for TODGA and DMDODGA resins for REE (0.01M) in HNO_3 in excess of the stoichiometric capacity of the resin.

TODGA resin

$[HNO_3]$, M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.01	50.2	48.6	0.0	1.8	1.4	3.9	20.0	34.4	43.5	70.3	97.0	115.0	125.0	117.0	118.0	114.0
0.1	59.5	51.5	1.8	8.4	9.0	14.9	30.0	41.2	49.0	72.8	96.3	114.0	125.0	117.0	119.0	113.0
0.5	61.9	53.7	5.7	8.0	8.1	10.2	17.7	29.4	36.6	61.6	91.5	120.0	143.0	145.0	155.0	161.0
1	57.2	55.7	9.1	10.1	10.0	11.4	17.2	27.9	35.3	61.0	93.2	125.0	152.0	158.0	167.0	175.0
2	51.4	73.8	5.3	6.8	6.7	7.6	13.3	26.0	34.9	70.5	123.0	184.0	240.0	258.0	279.0	295.0
3	57.6	106.0	2.6	5.6	5.7	7.3	14.6	29.2	42.5	91.8	172.0	271.0	371.0	422.0	475.0	494.0
5	70.7	183.0	0.0	0.8	0.1	1.8	13.6	33.9	58.4	142.0	285.0	457.0	664.0	801.0	930.0	912.0
8	60.2	179.0	0.1	1.5	0.8	2.7	16.5	39.0	62.2	132.0	240.0	372.0	562.0	779.0	1010.0	980.0

DMDODGA resin

$[HNO_3]$, M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.01	134.0	111.0	0.0	3.2	2.6	6.7	31.7	62.0	82.2	144.0	220.0	293.0	354.0	367.0	408.0	435.0
0.1	211.0	123.0	0.8	3.1	2.5	5.4	25.5	53.7	76.8	149.0	245.0	338.0	423.0	447.0	511.0	549.0
0.5	332.0	172.0	1.1	4.8	4.3	7.3	30.9	68.6	97.3	198.0	342.0	485.0	624.0	674.0	766.0	833.0
1	327.0	173.0	2.7	6.3	5.7	9.1	29.7	62.7	89.9	184.0	320.0	469.0	611.0	670.0	761.0	829.0
2	312.0	218.0	2.4	4.8	4.1	6.1	22.6	55.1	85.8	202.0	392.0	617.0	865.0	993.0	1160.0	1290.0
3	277.0	234.0	2.7	4.3	3.8	5.0	18.3	47.0	77.4	192.0	387.0	636.0	927.0	1110.0	1350.0	1490.0
5	194.0	263.0	3.1	5.0	3.5	5.2	16.6	42.5	71.5	175.0	372.0	657.0	1040.0	1390.0	1820.0	2050.0
8	172.0	399.0	0.0	1.8	0.7	3.1	17.0	47.8	89.1	234.0	534.0	1020.0	1850.0	2970.0	5050.0	6020.0

Table S6: D_w values for TODGA and DMDODGA resins for REE (0.01M) in HCl in excess of the stoichiometric capacity of the resin.

TODGA resin

[HCl], M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
1	18.9	10.7	0.0	0.0	0.0	0.0	1.4	5.0	8.0	14.4	20.6	25.1	27.5	25.6	24.5	23.4
2	78.4	20.7	0.0	0.0	0.0	0.0	4.8	11.7	15.7	28.6	41.3	50.1	54.3	49.7	46.5	45.0
3	196.0	33.2	0.0	0.1	0.1	1.2	7.8	19.2	25.1	44.7	65.9	85.8	97.6	90.1	86.5	88.0
5	265.0	20.6	0.0	0.0	0.0	0.0	5.0	13.1	17.4	29.6	41.3	48.4	50.8	45.8	44.0	42.9
8	492.0	6.6	0.0	0.0	0.0	0.0	0.0	2.5	4.6	8.6	11.6	14.4	15.2	15.4	13.6	14.3

DMDODGA resin

[HCl], M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
1	541.0	131.0	0.0	0.0	0.0	1.3	25.4	55.9	77.0	141.0	223.0	301.0	373.0	382.0	432.0	473.0
2	884.0	142.0	0.0	0.4	0.2	2.9	29.8	62.2	82.7	153.0	242.0	325.0	404.0	411.0	459.0	516.0
3	1390.0	176.0	0.0	2.4	1.8	6.5	37.6	76.5	101.0	187.0	294.0	401.0	502.0	515.0	577.0	644.0
5	1810.0	165.0	0.0	4.0	2.4	8.3	32.0	65.8	89.1	163.0	260.0	361.0	459.0	475.0	551.0	604.0
8	2930.0	189.0	0.8	9.7	9.8	16.4	36.6	66.5	88.2	160.0	259.0	374.0	490.0	530.0	637.0	696.0

Table S7: D_w values for TODGA and DMDODGA resins for REE (0.01M) in H_2SO_4 in excess of the stoichiometric capacity of the resin.

TODGA resin

$[H_2SO_4]$, M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
0.5	0.0	6.6	0.0	0.0	0.0	0.0	0.1	3.4	4.8	9.6	13.1	16.2	16.6	14.6	12.7	10.0
1	4.8	15.9	4.8	5.6	5.6	6.2	9.4	14.0	15.4	19.7	23.5	26.1	26.4	24.1	22.2	18.8
2	0.0	7.5	0.0	0.5	0.4	0.6	2.5	5.5	6.6	9.1	12.3	13.9	14.4	12.7	11.8	9.7
3	0.0	8.1	0.0	0.3	0.1	0.3	2.6	6.2	7.4	10.9	13.8	15.5	15.3	13.4	12.1	9.5
5	0.4	6.5	0.6	0.9	0.7	0.7	2.7	4.8	5.4	7.2	9.6	10.4	11.2	10.3	10.4	8.8
8	3.2	10.3	0.0	1.0	0.7	1.4	4.2	7.0	7.8	10.2	13.1	14.6	16.9	18.5	21.8	21.8

DMDODGA resin

$[H_2SO_4]$, M	$D_{w,Sc}$	$D_{w,Y}$	$D_{w,La}$	$D_{w,Ce}$	$D_{w,Pr}$	$D_{w,Nd}$	$D_{w,Sm}$	$D_{w,Eu}$	$D_{w,Gd}$	$D_{w,Tb}$	$D_{w,Dy}$	$D_{w,Ho}$	$D_{w,Er}$	$D_{w,Tm}$	$D_{w,Yb}$	$D_{w,Lu}$
0.01	29.1	40.9	0.0	0.0	0.0	0.0	0.0	13.1	13.3	27.4	44.5	65.8	86.2	94.1	109.0	126.0
0.1	11.0	91.2	0.0	0.0	0.0	0.0	8.0	33.2	31.8	59.7	92.7	135.0	174.0	192.0	219.0	249.0
0.5	19.7	135.0	0.0	0.0	0.0	1.1	15.0	48.2	46.4	87.5	140.0	204.0	269.0	293.0	337.0	384.0
1	47.4	178.0	4.2	9.3	8.1	13.2	32.4	71.9	94.9	167.0	264.0	381.0	496.0	550.0	620.0	709.0
2	60.0	150.0	2.5	8.8	8.8	13.1	26.6	58.8	77.1	139.0	230.0	338.0	449.0	498.0	575.0	660.0
3	65.1	116.0	7.0	13.2	11.9	15.7	25.3	51.4	64.3	106.0	167.0	246.0	326.0	366.0	426.0	493.0
5	68.3	87.1	11.1	18.4	18.3	22.6	31.6	51.1	58.1	81.3	112.0	151.0	192.0	219.0	256.0	287.0
8	68.2	107.0	3.7	17.9	19.3	25.9	34.2	51.8	58.2	82.0	116.0	169.0	239.0	321.0	432.0	558.0