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Extraction in cholinium-based magnetic ionic liquid aqueous two-phase system for the determination of berberine hydrochloride in *Rhizoma Coptidis*

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Table S1 Binodal curve data for the mass fraction (w) in the five MILs (1) + K_3PO_4 (2) + H_2O (3) systems at 298.15 K

$100w_2$	$100w_1$	$100w_2$	$100w_1$	$100w_2$	$100w_1$
$[N_{1\,1\,H\,2OH}]$ [TEMPO-OSO_3]+K_3PO_4+H_2O					
14.816	39.479	22.897	13.129	27.361	4.8330
15.078	36.604	23.182	12.424	27.711	4.3960
15.515	33.619	23.574	11.677	28.198	3.9500
15.821	30.957	23.889	10.995	28.357	3.6840
16.371	28.39	24.241	10.346	28.595	3.3830
17.243	25.773	24.575	9.7710	28.986	3.0710
17.969	23.659	24.780	9.3210	29.482	2.6670
18.757	21.759	25.046	8.7600	29.762	2.4420
19.554	20.131	25.377	8.2020	30.208	2.2200
20.033	18.928	25.696	7.6260	30.798	1.9250
20.592	17.651	25.921	7.1250	31.371	1.6530
21.375	16.352	26.254	6.6400	31.974	1.4240
21.899	15.386	26.447	6.2340	33.083	1.1330
22.236	14.593	26.722	5.8090	34.587	0.8600
22.506	3.8650	27.005	5.3670		
$[N_{1\,1\,2\,2OH}]$ [TEMPO-OSO_3]+K_3PO_4+H_2O					
10.929	59.602	21.502	11.035	26.227	4.6110
12.181	37.159	21.871	10.403	26.547	4.3620
12.481	33.869	22.411	9.6610	26.790	4.1940
13.205	30.766	22.863	8.8800	26.939	4.0320
14.139	27.304	23.096	8.4720	27.222	3.8360

14.935	24.913	23.543	7.8650	27.481	3.6260
15.915	22.501	23.984	7.4490	27.969	3.3100
16.503	21.311	24.068	7.2350	28.525	3.0420
17.151	19.971	24.268	6.9850	28.779	2.8170
17.965	18.450	24.411	6.6720	29.116	2.6190
18.396	17.303	24.632	6.3990	29.499	2.4400
19.141	15.983	24.851	6.1300	29.910	2.2530
19.428	15.101	25.037	5.8610	30.390	2.0220
19.844	14.089	25.409	5.5020	31.130	1.7980
20.292	13.32	25.710	5.1740	31.868	1.5770
20.481	12.881	25.911	4.9820	33.337	1.2310
20.933	12.025	26.129	4.7750		
		$[N_{1\,1\,3\,2OH}]$ $[TEMPO\text{-}OSO_3]+K_3PO_4+H_2O$			
8.5642	66.634	18.863	13.199	23.195	5.7421
10.175	36.274	19.189	12.480	23.484	5.3893
11.561	31.109	19.242	12.042	23.933	5.0603
11.911	28.723	19.371	11.623	24.184	4.7200
13.032	27.182	19.554	11.231	24.446	4.4409
13.454	25.635	19.736	10.874	24.812	4.1842
14.294	23.926	19.999	10.427	25.228	3.9150
14.559	22.720	20.186	10.002	25.601	3.6446
14.840	21.634	20.506	9.5700	25.808	3.4184
15.453	20.581	20.640	9.2138	26.087	3.1522
15.980	19.546	20.876	8.8538	26.596	2.8958
16.191	18.870	21.102	8.4935	27.025	2.6310
16.713	18.086	21.431	8.1469	27.500	2.4075
16.952	16.882	21.538	7.7897	28.255	2.1487
17.472	15.990	21.706	7.4473	29.668	1.6549
17.552	15.478	22.077	6.9802	35.168	0.8947
17.867	14.922	22.313	6.6376	35.894	0.5984
18.144	14.377	22.636	6.3187		
18.467	13.854	22.857	6.0393		
		$[N_{1\,1\,4\,2OH}]$ $[TEMPO\text{-}OSO_3]+K_3PO_4+H_2O$			
4.9295	68.094	15.416	16.252	19.789	7.9110

6.7129	48.491	15.605	15.553	20.151	7.4700
7.7829	40.443	15.918	14.881	20.341	7.0180
8.8517	35.629	16.208	14.385	20.692	6.6410
9.8614	30.957	16.609	13.575	20.997	6.2620
10.363	29.243	17.070	12.877	21.246	5.9180
11.063	27.372	17.346	12.308	21.512	5.5570
11.704	25.611	17.502	11.741	21.917	5.2190
12.267	24.118	17.770	11.276	22.272	4.9160
12.821	22.639	18.044	10.842	22.625	4.6430
13.409	21.319	18.372	10.385	22.906	4.3460
13.829	20.203	18.584	9.8390	23.430	3.8900
14.226	19.163	19.025	9.2810	24.176	3.4130
14.622	18.162	19.272	8.8460	25.074	3.0130
15.004	17.269	19.442	8.4610	27.925	1.6580
		$[N_{1152OH}]$ $[TEMPO\text{-}OSO_3]$+K_3PO_4+H_2O			
1.0692	76.377	13.427	17.891	17.726	8.0460
1.7720	63.009	13.612	17.328	18.221	7.5530
3.1849	52.682	13.943	16.695	18.357	7.0500
5.8886	40.307	14.259	15.943	18.637	6.6780
7.0010	36.971	14.356	15.392	19.049	6.2100
7.6231	34.633	14.688	14.725	19.472	5.7320
8.1639	32.698	14.933	14.172	19.677	5.3720
8.9991	31.002	15.095	13.597	20.040	5.0470
9.3518	29.307	15.286	13.031	20.299	4.7090
10.065	27.686	15.486	12.438	20.663	4.3560
10.578	26.022	15.842	11.784	21.090	4.0670
11.213	24.662	15.898	11.324	21.349	3.7880
11.681	23.238	16.162	10.865	21.732	3.5170
11.860	22.263	16.547	10.276	22.187	3.2710
12.164	21.161	16.843	9.7430	23.201	2.6570
12.599	20.227	17.019	9.2840	23.724	2.2660
12.923	19.320	17.249	8.8480	25.430	1.6170
13.166	18.540	17.535	8.4790		

Table S2 Values of parameters of Eq. (1) for the MILs + salts + water at different temperature

MILs+salts (T)	*a*	*b*	*c*	100SD[a]
$[N_{1\,1\,H\,2OH}]$ [TEMPO-OSO_3]+ K_3PO_4 (298.15k)	3.14989	-4.99127	71.6165	0.8789
$[N_{1\,1\,2\,2OH}]$ [TEMPO-OSO_3] +K_3PO_4 (298.15k)	22.7191	-11.4177	13.4885	1.8696
$[N_{1\,1\,3\,2OH}]$ [TEMPO-OSO_3] +K_3PO_4 (298.15k)	13.0105	-10.5055	21.6850	1.9313
$[N_{1\,1\,4\,2OH}]$ [TEMPO-OSO_3] +K_3PO_4 (298.15k)	3.24427	-7.15220	64.0562	0.8019
$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3] + K_3PO_4 (298.15k)	1.10129	-3.90652	164.739	0.7061
$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3] + K_2HPO_4 (298.15k)	1.09084	-3.38581	130.960	0.3526
$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3] + K_2CO_3 (298.15k)	1.41234	-3.70054	141.232	0.5397
$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3] + $K_3C_6H_5O_7$ (298.15k)	1.14377	-2.61512	58.4064	0.6944
$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3] + $Na_3C_6H_5O_7$ (298.15k)	1.12097	-3.32560	88.8466	0.3906
$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3] + K_3PO_4 (308.15)	1.08030	-4.04766	161.813	0.9053
$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3] + K_3PO_4 (318.15)	0.95882	-3.64297	176.941	0.7061

[a]SD = $\{\sum_{i=1}^{n}(w_1^{cal} - w_1^{exp})^2/n\}^{0.5}$, where w_1^{exp} is the experimental mass fraction of MIL, w_1^{cal} is the corresponding data calculated using Eq. (1). *n* is the number of bimodal data points.

Table S3 Tie-line data of MILs (1) + salts (2) + water (3) systems at different temperature

MILs+salts	total system		MIL-rich phase		salt-rich phase		*TLL*	*S*
(T)	$100w_2$	$100w_1$	$100\ w_2^t$	$100\ w_1^t$	$100w_2^b$	$100w_1^b$		
MIL 1+K_3PO_4 (298.15K)	20.00	30.00	12.109	48.838	31.770	1.9017	50.887	-2.3873
	18.26	32.63	12.443	47.176	29.302	3.487	46.829	-2.5915
	16.86	35.73	12.345	47.660	29.912	3.022	47.970	-2.5410
MIL 2+K_3PO_4 (298.15K)	20.00	30.00	10.075	62.771	28.805	3.5899	59.221	-2.9995
	18.91	33.90	9.6233	62.002	27.798	4.1321	63.526	-3.349
	15.73	35.57	10.385	56.478	22.658	8.4708	49.551	-3.912
MIL 3+K_3PO_4 (298.15K)	20.00	30.00	7.8780	67.474	28.814	2.7538	68.022	-3.0913
	17.86	30.98	8.1740	63.787	25.717	4.3693	61.953	-3.3870
	17.19	34.76	8.1504	64.071	26.754	3.7503	63.124	-3.2425
MIL 4+K_3PO_4 (298.15K)	20.00	30.00	4.4210	71.714	30.857	0.9297	75.560	-2.6776
	19.00	33.67	4.3279	72.891	31.283	0.8359	76.932	-2.6731
	15.92	35.60	4.9167	65.927	28.211	1.7248	68.297	-2.7561
MIL 5+K_3PO_4 (298.15K)	20.00	30.00	0.3786	76.255	32.764	0.0227	78.672	-.2.2214
	18.93	32.09	1.0995	75.099	32.368	0.0338	79.673	-2.2999
	16.70	35.50	1.1017	73.069	31.408	0.0749	79.036	-2.4085
MIL 5+K_2HPO_4 (298.15K)	20.00	30.00	1.4614	72.414	33.052	0.1376	78.879	-2.2879
	18.27	33.32	1.5616	71.415	32.817	0.1532	78.457	-2.3160
	16.42	35.29	1.9428	67.981	31.949	0.2249	74.103	-2.2581
MIL5+K_2CO_3 (298.15K)	20.00	30.00	2.7423	76.302	31.086	0.2579	81.154	-2.6830
	17.98	33.78	2.8440	75.422	30.116	0.3914	79.834	-2.7512
	15.56	35.27	3.6166	69.407	27.527	1.0650	72.404	-2.8582
MIL 5+ $K_3C_6H_5O_7$ (298.15K)	20.00	30.00	4.4673	65.468	31.144	4.5525	66.501	-2.2834
	17.67	32.67	5.3675	61.843	28.202	7.6958	58.765	-2.3713
	15.90	36.92	5.1799	62.565	28.019	7.9282	59.218	-2.4165
MIL 5+ $Na_3C_6H_5O_7$ (298.15K)	20.00	30.00	1.6799	72.814	32.495	0.7985	78.332	-2.3370
	18.19	33.05	1.9407	70.487	32.150	0.8881	75.872	-2.3039
	15.91	36.04	2.5969	65.490	31.749	1.0020	70.771	-2.2121
MIL 5+K_3PO_4 (308.15K)	20.00	30.00	0.8366	74.595	32.877	0.0338	81.154	-2.3271
	18.98	31.14	1.0188	73.786	32.724	0.0367	78.442	-2.2630
	16.67	35.61	0.9386	69.976	31.634	0.0661	79.108	-2.3752
MIL 5+K_3PO_4	20.00	30.00	0.3953	76.252	32.706	0.0245	82.793	-2.3593

(318.15K)	18.43	32.21	0.3510	75.068	31.332	0.0540	83.198	-2.4923
	16.54	34.16	0.5125	73.869	30.290	0.0945	79.557	-2.4775

Note: MIL 1= [$N_{1\,1\,H\,2OH}$] [TEMPO-OSO_3]; MIL 2= [$N_{1\,1\,2\,2OH}$] [TEMPO-OSO_3]; MIL 3= [$N_{1\,1\,3\,2OH}$] [TEMPO-OSO_3]; MIL 4= [$N_{1\,1\,4\,2OH}$] [TEMPO-OSO_3]; MIL 5= [$N_{1\,1\,5\,2OH}$] [TEMPO-OSO_3].

Table S4 Values of parameters of Eq. (10) and Eq. (11) for the five MILs (1) + salts (2) + water (3) systems at different temperature

MILs+salts (T)	k_1	n	k_2	r	R_1^2	R_2^2

MIL 1+ K_3PO_4 (298.15K)	0.6798	0.5651	2.8576	1.4002	0.9981	0.9972
MIL 2+ K_3PO_4 (298.15K)	0.2813	0.8202	4.7885	0.8540	0.9992	0.9996
MIL 3+ K_3PO_4 (298.15K)	0.1794	1.1034	4.5290	0.6424	0.9255	0.9285
MIL 4+ K_3PO_4 (298.15K)	0.0665	2.1969	3.4261	0.3952	0.9981	0.9981
MIL 5+ K_3PO_4 (298.15K)	0.0013	7.2925	2.5003	0.1366	0.9989	0.9955
MIL 5+ K_2HPO_4 (298.15K)	0.0199	4.1886	2.5858	0.2400	0.9995	0.9995
MIL 5+ K_2CO_3 (298.15K)	0.0566	2.1122	3.9300	0.4378	0.9826	0.9810
MIL 5+ $K_3C_6H_5O_7$ (298.15K)	0.2468	0.9588	3.6551	0.7302	0.9436	0.9457
MIL 5+ $Na_3C_6H_5O_7$ (298.15K)	0.0002	10.137	2.2652	0.0923	0.9789	0.9788
MIL 5+ K_3PO_4 (308.15K)	0.0466	2.6500	3.3869	0.4226	0.9915	0.9966
MIL 5+ K_3PO_4 (318.15K)	0.0204	3.9560	2.6779	0.2456	0.9963	0.9989

Note: MIL 1= [$N_{1\,1\,H\,2OH}$] [TEMPO-OSO_3]; MIL 2= [$N_{1\,1\,2\,2OH}$] [TEMPO-OSO_3]; MIL 3= [$N_{1\,1\,3\,2OH}$] [TEMPO-OSO_3]; MIL 4= [$N_{1\,1\,4\,2OH}$] [TEMPO-OSO_3]; MIL 5= [$N_{1\,1\,5\,2OH}$] [TEMPO-OSO_3].

Table S5 Binodal curve data for the mass fraction (w) in MILs (1) + salts (2) + H_2O (3) systems at 298.15 K

$100w_2$	$100w_1$	$100w_2$	$100w_1$	$100w_2$	$100w_1$
[$N_{1\,1\,5\,2OH}$] [TEMPO-OSO_3]+K_2HPO_4+H_2O					
5.6593	47.856	16.314	15.807	20.005	8.2465
7.3401	40.950	16.472	15.153	20.160	7.8909

9.0890	34.847	16.724	14.546	20.486	7.5416
10.070	32.585	16.955	14.003	20.638	7.2446
11.135	30.081	17.154	13.507	20.929	6.9199
11.891	27.504	17.309	12.975	21.232	6.5571
12.759	25.711	17.656	12.433	21.520	6.2366
13.268	23.745	18.034	11.942	21.726	5.9799
13.867	22.193	18.258	11.446	22.058	5.6761
14.237	20.755	18.521	10.971	22.389	5.3955
14.566	19.660	18.857	10.476	22.802	5.0815
15.067	18.756	19.008	10.031	23.302	4.4175
15.422	17.981	19.120	9.6301	24.440	3.8157
15.738	17.227	19.417	9.0331	24.836	3.3914
16.040	16.525	19.855	8.6119		
		$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3]+K_2CO_3+H_2O			
6.8950	51.075	16.374	16.921	20.224	8.0819
7.9507	46.341	16.643	16.285	20.493	7.6304
8.6324	42.550	16.725	15.692	20.854	7.2150
9.6142	38.837	16.968	15.161	21.108	6.8304
11.020	35.177	17.015	14.749	21.460	6.3817
11.535	32.748	17.403	14.021	21.956	5.9258
12.429	30.598	17.537	13.422	22.153	5.5233
12.735	28.698	17.644	12.921	22.544	5.1698
13.098	26.980	18.020	12.350	22.915	4.8545
13.656	25.479	18.203	11.884	23.303	4.5064
14.057	24.178	18.332	11.488	23.551	4.2571
14.637	22.460	18.562	11.049	24.051	3.9711
15.004	21.213	18.814	10.620	24.310	3.7489
15.195	20.233	19.054	10.156	24.925	3.5022
15.702	19.039	19.363	9.6207	25.759	2.9371
15.930	18.280	19.680	9.0806	26.184	2.5977
16.085	17.603	19.988	8.5444	27.044	2.2350
		$[N_{1\,1\,5\,2OH}]$ [TEMPO-OSO_3]+ $K_3C_6H_5O_7$+H_2O			
2.7841	73.938	20.878	20.363	27.037	9.0599
4.9500	63.390	21.259	19.176	27.639	8.2374
7.2287	55.661	21.776	18.086	28.299	7.6204
8.1665	51.496	22.180	17.108	29.005	6.9474
10.419	46.082	22.646	16.194	29.797	6.2815
11.640	42.248	23.032	15.382	30.527	5.7607
13.708	37.924	23.497	14.644	31.889	5.0167
15.181	34.605	23.847	13.817	32.786	4.4857
16.237	31.735	24.135	13.169	33.662	3.9693
17.585	28.611	24.596	12.480	34.953	3.4423
18.475	26.437	25.022	11.832	38.203	2.4174
19.056	24.679	25.460	11.137	42.224	1.5380

19.839	23.030	25.837	10.550		
20.276	21.689	26.279	9.8836		
		[$N_{1\,1\,5\,2OH}$] [TEMPO-OSO_3]+ $Na_3C_6H_5O_7$+H_2O			
1.0631	79.789	15.108	23.061	20.669	11.005
3.5969	59.387	15.691	21.611	21.360	9.7888
5.3176	50.772	16.164	20.354	22.103	8.7865
7.3480	43.498	16.499	19.378	22.745	7.9068
8.8480	38.829	16.987	18.227	23.541	7.0670
10.772	34.010	17.452	17.103	24.440	6.1804
12.158	30.692	18.110	15.715	25.672	5.1369
12.909	28.555	18.695	14.540	27.525	3.9767
13.640	26.545	19.326	13.275		
14.354	24.736	19.934	12.167		

Table S6 Binodal curve data for the mass fraction (w) in [$N_{1\,1\,5\,2OH}$] [TEMPO-OSO_3] (1) + K_3PO_4 (2) + H_2O (3) systems at different temperature

$100w_2$	$100w_1$	$100w_2$	$100w_1$	$100w_2$	$100w_1$
		[$N_{1\,1\,5\,2OH}$] [TEMPO-OSO_3]+K_3PO_4+H_2O at 298.15 K			
1.0692	73.517	13.427	17.661	17.726	8.4942
1.7720	65.413	13.612	17.200	18.221	7.6723
3.1849	54.553	13.943	16.384	18.357	7.4550
5.8886	41.266	14.259	15.626	18.637	7.0204
7.0010	37.021	14.356	15.397	19.049	6.4109

7.6231	34.816	14.688	14.621	19.472	5.8218
8.1639	32.977	14.933	14.061	19.677	5.5497
8.9991	30.256	15.095	13.697	20.040	5.0885
9.3518	29.145	15.286	13.275	20.299	4.7765
10.065	26.958	15.486	12.840	20.663	4.3603
10.578	25.435	15.842	12.084	21.090	3.9053
11.213	23.601	15.898	11.966	21.349	3.6464
11.681	22.286	16.162	11.424	21.732	3.2862
11.860	21.792	16.547	10.657	22.187	2.8931
12.164	20.962	16.843	10.087	23.201	2.1436
12.599	19.798	17.019	9.7562	23.724	1.8209
12.923	18.951	17.249	9.3354	25.430	1.0226
13.166	18.324	17.535	8.8251	17.726	8.4942
[N $_{1\,1\,5\,2OH}$] [TEMPO-OSO_3]+K_3PO_4+H_2O at 308.15 K					
1.0500	71.758	12.126	19.928	16.185	10.563
2.9630	53.439	12.245	19.620	16.381	10.183
3.7978	48.379	12.413	19.187	16.697	9.5856
4.4848	44.835	12.642	18.603	16.898	9.2148
5.3348	40.986	12.815	18.166	17.092	8.8666
6.6831	35.829	13.071	17.525	17.180	8.7099
7.3357	33.701	13.334	16.879	17.413	8.3053
7.8013	32.233	13.582	16.276	17.501	8.1559
8.2531	30.842	13.806	15.742	17.649	7.9063
8.4433	30.265	13.917	15.480	17.816	7.6307
8.7370	29.384	14.123	14.996	18.190	7.2527
8.9084	28.875	14.248	14.708	18.446	6.8808
9.3758	27.504	14.451	14.241	18.762	6.4388
9.8786	26.058	14.661	13.768	19.012	6.1009
10.168	25.239	14.769	13.528	19.371	5.6372
10.446	24.459	14.889	13.264	19.652	5.2917
10.760	23.587	15.122	12.755	20.118	4.7499
11.197	22.395	15.348	12.273	20.577	4.2535
11.439	21.741	15.531	11.886	21.099	3.7352
11.665	21.141	15.886	11.158	21.724	3.1755
11.882	20.566	16.014	10.903	22.688	2.4360
[N $_{1\,1\,5\,2OH}$] [TEMPO-OSO_3]+K_3PO_4+H_2O at 318.15 K					
0.5065	73.682	12.433	18.711	16.784	9.5164
1.9086	57.971	12.662	18.153	17.006	9.1350
4.2493	44.936	12.950	17.459	17.278	8.6786
5.1274	41.367	13.223	16.815	17.574	8.1987
5.9705	38.270	13.505	16.160	17.811	7.8260
6.0589	38.048	13.587	15.972	19.038	5.7978
7.0574	34.372	13.836	15.409	19.218	5.5548
7.5249	32.768	14.151	14.708	19.498	5.1895

8.2631	30.357	14.437	14.088	19.583	5.0822
8.9480	28.234	14.707	13.515	19.952	4.6325
9.6371	26.192	14.963	12.980	20.249	4.2914
10.159	24.701	15.193	12.512	20.858	3.6463
10.751	23.067	15.325	12.246	21.599	2.9583
10.931	22.581	15.482	11.933	21.920	2.6927
11.364	21.429	15.647	11.612	22.542	2.2279
11.817	20.258	16.100	10.748	22.875	2.0050
12.019	19.745	16.374	10.245		
12.344	18.932	16.548	9.9315		