

Experimental Study of Salt Bead Dissolutions in Aqueous Solvents

Michael Shaltry^a and Supathorn Phongikaroon^{b,*}

*Department of Chemical and Materials Engineering and Nuclear Engineering Program
Center for Advanced Energy Studies, University of Idaho, 995 University Boulevard, Idaho
Falls, Idaho 83401, United States*

^aCurrent address: Separations Department, Idaho National Laboratory, P.O. Box 1625, Idaho Falls, Idaho 83415, United States

^bCurrent address: Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University, 401 West Main Street, Richmond, Virginia 23284, United States

*Corresponding Author: Tel: (804)827-2278. E-mail: sphongikaroon@vcu.edu

Table S1. Density, average radius, and average mass of the chloride beads utilized for the dissolution tests.

<i>Solute</i> % Purity	Eutectic	LiCl	SrCl ₂	CeCl ₃	LaCl ₃	PrCl ₃	YCl ₃
	99.99	99.9	99.5	99.9	99.9	99.99	99.9
$\rho_s \times 10^3$ (g/cm ³)	2.02	2.07 ^a	3.05 ^a	3.97 ^a	3.84 ^a	4.00 ^a	2.61 ^a
$\langle r_0 \rangle$ (mm)	0.81	0.82	0.86	0.70	0.79	0.64	0.65
$\langle m_0 \rangle$ (mg)	3.99	3.97	7.91	5.06	7.36	3.92	3.03

^aDensity values are obtained from ref. 11.

Table S2. Composition of the GSEEP and ERDA-6 brines given as the molarity of the components.

Brine	NaCl	MgCl ₂	CaSO ₄	KCl	MgSO ₄	KBr	Na ₂ SO ₄
GSEEP ^a	1.83 M	1.42 M	0.02 M	0.76 M	0.02 M	0.01 M	-
ERDA-6 ^b	4.71 M	-	0.012 M	0.086 M	0.019 M	0.011 M	0.139 M

^aRepresentative brine found in a particular room at the Waste Isolation Pilot Plan (WIPP) as indicated in refs. 8 and 9. ^bRepresentative brine found in an exploratory drill hole at a candidate WIPP site as indicated in ref. 10.

Table S3. List of available solubility data for solutes in the given solvent.

<i>Solvent</i>	ERDA-6	GSEEP			H ₂ O				
<i>Solute</i>	Eutectic	Eutectic	Eutectic	LiCl	SrCl ₂	CeCl ₃	LaCl ₃	PrCl ₃	YCl ₃
$C_e \times 10^3$ (g mm ⁻³)	0.0395 ^b	0.0685 ^b	0.297 ^b	0.820 ^a	0.524 ^a	0.980 ^c	0.944 ^a	0.944 ^a	0.749 ^a

^aValues are obtained from ref. 11. ^bValues are obtained from ref. 13. ^cValues are obtained from ref. 14.

Table S4. Average values of k , t_d , and R^2 from eq 4.

<i>Solvent</i>	ERDA-6	GSEEP	H ₂ O						
<i>Solute</i>	Eutectic	Eutectic	Eutectic	LiCl	SrCl ₂	CeCl ₃	LaCl ₃	PrCl ₃	YCl ₃
$\langle k \rangle \times 10^2$ (mm s ⁻¹)	2.67	1.42	2.55	1.50	2.08	1.37	1.00	1.12	1.45
$\langle t_d \rangle$ (s)	1665	1645	201	138	240	212	328	252	159
$\langle R^2 \rangle$	0.948	0.953	0.987	0.989	0.993	0.949	0.978	0.942	0.949

Table S5. List of values for R , R^2 , N , and P_c for each of the solute-solvent pairs.

Solute	Solvent	R	R^2	N	P_c
Eutectic	ERDA-6	0.986	0.972	113	1.17E-87
Eutectic	GSEEP	0.983	0.966	79	2.89E-58
Eutectic	H ₂ O	0.994	0.988	69	1.79E-60
LiCl	H ₂ O	0.995	0.990	46	6.16E-46
SrCl ₂	H ₂ O	0.997	0.994	80	2.01E-88
CeCl ₃	H ₂ O	0.982	0.964	61	8.76E-45
LaCl ₃	H ₂ O	0.991	0.982	71	4.85E-63
PrCl ₃	H ₂ O	0.977	0.954	49	1.09E-33
YCl ₃	H ₂ O	0.981	0.962	49	1.07E-35

Table S6. Values of t_c , τ_c , and w_c . The values for t_d are taken from Table S4.

Solvent	ERDA-6	GSEEP			H ₂ O				
Solute	Eutectic	Eutectic	Eutectic	LiCl	SrCl ₂	CeCl ₃	LaCl ₃	PrCl ₃	YCl ₃
t_c (s)	614	632	74.8	52.3	88.3	76.9	116.3	87.4	59.8
τ_c	0.369	0.384	0.373	0.380	0.367	0.363	0.355	0.347	0.377
w_c	0.245	0.228	0.246	0.235	0.252	0.250	0.263	0.265	0.246

Table S7. List of values for A , b , c , ε , and the range of D for the four correlations regressed to the current set of data based on Eq. (12): $Sh = 2 + AGr^b Sc^c$.

Correlation Number	1	2	3	4
A	0.6	0.558	0.569	0.0254
b	0.25	0.25	0.25	0.333
c	0.333	0.25	0.25	0.577
ε	18665	2983	3163	127
D (mm ² s ⁻¹)	10 ⁻⁵ - 10 ⁻³	10 ⁻⁴ - 10 ⁻³	10 ⁻⁴ - 10 ⁻³	10 ⁻⁵ - 10 ⁻³
Reference	15	5	7	18

Table S8. Calculated average D values with the average initial values of the Sherwood ($\langle Sh_0 \rangle$) and Grashof ($\langle Gr_0 \rangle$) along with calculated ranges of Sh and Gr for each of the solute-solvent pairs associating with $\langle Sc \rangle$.

Solute	Solvent	$\langle D \rangle \times 10^3$ (mm ² s ⁻¹)	Sh Range	$\langle Sh_0 \rangle$	$Gr \times 10^{-2}$ Range	$\langle Gr_0 \rangle$ $\times 10^{-2}$	$\langle Sc \rangle$ $\times 10^{-2}$
Eutectic	ERDA-6	5.31	2.2 – 11	8.76	0.08 – 26	21.3	1.8
Eutectic	GSEEP	1.26	10 – 24	18.3	6 – 36	29.9	7.21
Eutectic	H ₂ O	1.49	6.9 – 31	25.9	2 – 125	97.5	6.86
LiCl	H ₂ O	0.232	22 – 134	109	4 – 518	361	45.7
SrCl ₂	H ₂ O	0.666	16 – 62	53.8	8 – 356	259	15.3
CeCl ₃	H ₂ O	0.167	37 – 169	123	13 – 349	266	68.8
LaCl ₃	H ₂ O	0.0833	92 – 276	201	42 – 428	375	131
PrCl ₃	H ₂ O	0.110	68 – 257	146	39 – 236	197	114
YCl ₃	H ₂ O	0.229	23 – 119	86.1	5 – 205	164	47.1

