25/09/2015   Benay and Wipff

Liquid-Liquid Extraction of Alkali Cations by 18-Crown-6: Complexation and Interface Crossing Studied by MD and PMF Simulations

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Electronic Supplementary Information

Table S1: Force field parameters: alkali ion parameters and atomic polarizabilities of Pic⁻, Cl⁻ ions, 18C6 and solvents used for the "POL" model. Sets of 18C6 charges.

Alkali ion parameters

Ion	R* (Å)	ε (kcal / mol)	α (Å³)	Ref.
Na⁺	1.4502	0.1		L. X. Dang, *J. Am. Chem. Soc.*, **117** (1995) 6954
Na⁺ POL	1.3350	0.1	0.240	L. X. Dang, *J. Phys. Chem. A*, **108** (2004) 9014
K⁺	1.8700	0.1		L. X. Dang, *J. Am. Chem. Soc.*, **117** (1995) 6954
K⁺ POL	1.7701	0.1	0.830	T.-M. Chang, L. X. Dang, *J. Phys. Chem. B*, **101** (1997) 10518
Cs⁺	2.1798	0.1		L. X. Dang, *J. Am. Chem. Soc.*, **117** (1995) 6954
Cs⁺ POL	2.1501	0.1	2.440	T.-M. Chang, L. X. Dang, *J. Phys. Chem. B*, **101** (1997) 10518

Atomic polarizabilities of Pic⁻, Cl⁻ ions, 18C6 and solvents used for the "POL" model.

Atom type	α (Å³)	q (e)
C (18C6; CHCl₃)	0.878 [a]	
H$_C$ (18C6; CHCl₃)	0.135 [a]	
N (Pic⁻)	0.530 [a]	
O (18C6; Pic⁻)	0.465 [a]	
C$_{Pic}$ (Pic⁻)	0.360 [b]	
H$_{Pic}$ (Pic⁻)	0.167 [b]	
Cl (CHCl₃ ; Cl⁻)	1.910 [c]	
O (H₂O POL3)	0.528 [a]	-0.730
H (H₂O POL3)	0.170 [a]	0.365

a: Caldwell J.W. and Kollman P.A., *J. Phys. Chem.*, **1995,** *99*, 6208

b: Wang, J.; Cieplak, P.; Kollman, P. A., *J. Comput. Chem.*, **2000,** *21*, 1049

c: Chang, T.-M.; Dang, L. X.; Peterson, K. A., *J. Phys. Chem. B*, **1997,** *101*, 3413

d: Dang, L. X., Chang, T.-M., *J. Chem. Phys.* **119** (2003) 9851-9857

Atomic charges of 18C6 and corresponding dipole moment of dimethyl ether (in D).

Model	q$_C$	q$_H$	q$_O$	q$_M$	μ_{MeOMe} [a]
18C6(-0.4)	0.244	-0.021	-0.406	+1.000	1.45
18C6(-0.5)	0.300	-0.025	-0.500	+1.000	1.79
18C6(-0.6)	0.360	-0.030	-0.600	+1.000	2.15
18C6(-0.34) [b]	0.086	0.042	-0.340	+1.000	1.43
18C6(-0.30) [c]	0.089	0.032	-0.305	+1.000	1.26
18C6(+0.4)/M(+0.6) [d]	-0.055	0.093	-0.198	+0.618	

a: Experimental value: 1.31 D ; QM value (HF/6-31G(d,p) : 1.52 D;

b: ESP HF/6-31G(d,p) charges on 18C6.

c: ESP DFT/6-31G(d,p) charges on 18C6.

d: ESP DFT/6-31G(d,p) charges on the whole complex.

Table S2: Complexation of M^+ by 18C6 ("D_{3d}" [a]) in the gas phase: complexation energy E_c, enthalpy ΔH, and free energy ΔG (kcal/mol). Average M-O distances. QM (Gaussian 09 software) and AMBER results.

M^+	Na^+	Na^+ Pic⁻	K^+	K^+ Pic⁻	Cs^+ [b]	Cs^+ Pic⁻ [b]
QM HF/6-31G(d,p)						
E_c	-87.3		-69.0		-43.6	
ΔG	-77.7		-56.5		-32.7	
ΔH	-85.7		-68.8		-42.9	
q_M (Mulliken)	0.71		0.80		0.89	
q_O (Mulliken)	-0.67		-0.68		-0.70	
$<d_{M-O}>$ (Å)	2.700		2.814		3.131	
QM HF/6-311++G(d,p)						
E_c	-84.5		-70.2		-48.3	
ΔG	-74.8		-57.7		-37.2	
ΔH	-82.8		-69.9		-47.5	
QM DFT/6-31G(d,p)						
E_c	-83.3	-33.2	-70.5	-31.5	-34.6	-13.6
ΔG	-74.4		-59.6		-23.7	
ΔH	-81.4		-69.0		-33.4	
q_M (ESP)	0.66	0.41	0.62	0.43	0.78	0.53
q_O (ESP)	-0.25	-0.20	-0.20	-0.18	-0.20	-0.20
$<d_{M-O}>$ (Å)	2.769		2.807		3.149	
QM DFT/6-311++G(d,p)						
E_c	-82.4		-70.3		-47.9	
ΔG	-73.5		-59.4		-37.4	
ΔH	-80.6		-68.7		-50.3	
AMBER q_O -0.4 E_c	-56.5 31.4% [c]		-49.5 29.6% [c]		-39.8 16.9% [c]	
AMBER q_O -0.4 + POL E_c	-66.5 19.3% [c]		-59.2 15.8% [c]		-48.3 0.8% [c]	
AMBER q_O -0.5 E_c	-68.2 17.2% [c]		-61.1 13.1% [c]		-49.7 3.7% [c]	
AMBER q_O -0.6 E_c	-79.3 3.8% [c]		-72.4 3.0% [c] -75.8 [d] 7.8% [c]		-59.8 24.8% [c]	
AMBER q_O -0.34 [e] E_c	-63.7 22.7% [c]		-56.7 19.3% [c]		-46.1 3.7% [c]	
AMBER q_O -0.34 +POL [e] E_c	-73.3 11.0% [c]		-66.1 6.0% [c]		-54.5 13.8% [c]	
AMBER q_O -0.30 [f] E_c	-56.1 31.9% [c]		-49.2 30.0% [c]		-39.8 16.9% [c]	

a: Conformation of 18C6 complexed and uncomplexed.

b: Cs^+ sits in "perched" position over the ring and is described by a SDD basis set with the Stuttgart/Dresden ECPs.

c: % difference relative to E_c at the QM DFT/6-311++G(d,p) level.

d: Cheatham's M^+ parameters: Joung, I. S., Cheatham III, T. E., *J. Phys. Chem. B*, **2008**, *112*, 9020.

e: ESP HF/6-31G(d,p) charges on 18C6.

f: ESP DFT/6-31G(d,p) charges on 18C6.

Table S3: Dissociation $PMF_{0.01+t}$ of 18C6/M^+ X^- complexes (sampling time t in ns). Free energy difference ΔA_{CD} (in kcal / mol) between complexed and decomplexed states in water and at interface. Corresponding "selectivities" $\Delta\Delta A_{CD}$

M^+ / q_O		t	Na^+	K^+	Cs^+	Selectivity $\Delta\Delta A_{CD}$			Order
						K/Na	Cs/K	Na/Cs	
In water	**M^+**	**Cl^-**							
(SPC/E)	-0.4	0.16	6.2	6.0	5.1	+0.2	+0.9	-1.1	Na > K > Cs
		0.5	4.6	4.0	2.8	+0.6	+1.2	-1.8	
	-0.5	0.16	5.0	8.1	3.5	-3.1	+4.6	-1.5	K > Na > Cs
		0.5	6.0	8.8	4.3	-2.8	+4.5	-1.7	
	-0.6	0.16	8.4	9.1	5.0	-0.7	+4.1	-3.4	K > Na > Cs
		0.5	6.6	8.3	4.4	-1.7	+3.9	-2.2	
	-0.34 [a]	0.5	6.4	7.9	3.3	-1.5	+4.6	-3.1	K > Na > Cs
		3.0	6.0	7.4	3.4	-1.4	+4.0	-2.6	K > Na > Cs
	-0.4+POL	0.5	3.3	8.5	4.2	-2.8	+1.4	+1.4	K > Cs > Na
(TIP3P)	-0.6	0.5	7.0	11.0	5.2	-4.0	+5.8	-1.8	K > Na > Cs
	-0.6 Ch. [b]	0.5	5.2	10.7	8.3	-5.5	+2.4	+3.1	K > Cs > Na
	Exp. [c]		*1.1*	*2.8*	*1.3*	*-1.7*	*+1.5*	*+0.2*	
At the interface	**M^+**	**Pic^-**							
CHCl₃ / SPC/E	-0.34 [c]	0.5	5.1	7.3	6.2	-2.2	+1.1	+1.1	K > Cs > Na

a: ESP HF 6-31G(d,p) charges on 18C6.
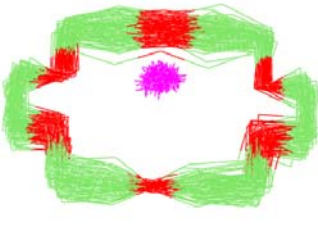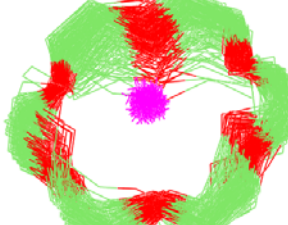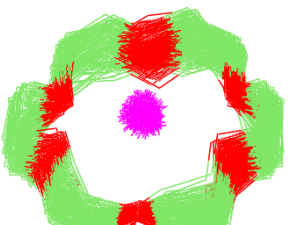
b: Cheatham's parameters.
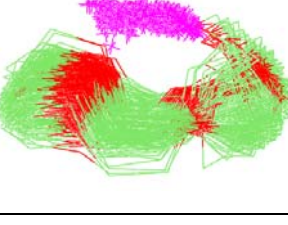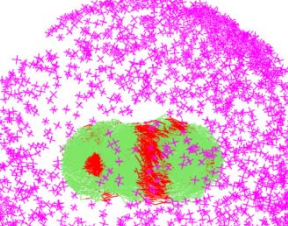
c: Experimental $-\Delta G_c$ decomplexation energy.

Table S4: Analysis of 18C6/ M^+ complexes in water and at interface: $M^+ \ldots O(18C6)$ and $M^+ \ldots X^-$ distances (in Å), hydration number of M^+, $n_{+/-}$ number of $g^+ \leftrightarrow g^-$ interconversions of OC-CO dihedrals, and interaction energies (in kcal/mol) between 18C6, M^+ and Water. Averages during 2 ns except when otherwise noted. [a] See also Figures S7 to S9.

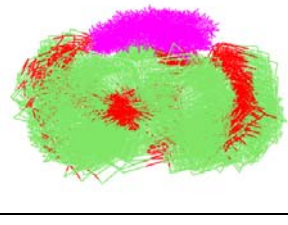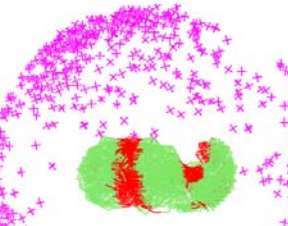|		Na^+	K^+	Cs^+
In Water				
18C6(-0.6)	$d_{M-O(18C6)}$	2.6 (x4), 3.2 (x2)	3.0 (x6)	3.2 (x6)
	d_{M-Cl}	14.5 ±3.9	14.6 ±3.5	13.0 ±4.5
	$N_{Water}(M^+)$	2.1 ± 0.3	2.6 ±0.7	3.5 ±1.1
	$n_{+/-}$	70	28	9
	$E_{18C6/M}$	-86 ± 6	-70 ± 5	-62 ± 6
	$E_{18C6/Wat}$	-30 ± 7	-33 ± 7	-41 ± 9
	$E_{M/Wat}$	-62 ± 10	-48 ± 10	-36 ± 18
18C6(-0.4) POL	$d_{M-O(18C6)}$	2.9 (x6)	2.9 (x6)	3.3 (x6) [a]
	d_{M-Cl}	14.7 ±3.4	13.8 ±4.2	14.0 ±3.3 [a]
	$N_{Water}(M^+)$	2.0 ±0.1	2.1 ±0.5	3.5 ±0.9 [a]
	$n_{+/-}$	18	4	6 [a]
18C6(-0.34)	$d_{M-O(18C6)}$	2.8 (x6)	3.0 (x6)	3.2 (x6)
	d_{M-Cl}	16 ±3	15 ±3	15 ±3
	$N_{Water}(M^+)$	2.0 ± 0.1	2.7 ±0.5	3.5 ±0.7
	$n_{+/-}$ conversions	61	9	0
	$E_{18C6/M}$	-67 ± 3	-53 ± 3	-47 ± 3
	$E_{18C6/Wat}$	-16 ± 5	-21 ± 5	-27 ± 6
	$E_{M/Wat}$	-74 ± 10	-63 ± 9	-53 ± 9
At the interface				
18C6(-0.34)	$d_{M-O(18C6)}$	2.8 (x6)	3.0 (x6)	3.2 (x6)
	d_{M-Pic}	6.9 ±1.0	20 ±11	13.3 ±4.7
	$N_{Water}(M^+)$	2.1 ±0.3	2.1 ±0.7	3.0 ±0.8
	$n_{+/-}$	26	0	0
	$E_{18C6/M}$	-67 ± 4	-57 ± 3	-47 ± 3
	$E_{18C6/Wat}$	0 ± 5	-2 ± 4	-2 ± 3
	$E_{M/Pic}$	-44 ± 4	-23 ± 17	-30 ± 11
	$E_{M/Wat}$	-60 ± 10	-61 ± 20	-54 ± 14

[a]: Average over 1 ns since M^+ decomplexes afterwards.

Figure S1: Complexation of K^+ Cl^- by 18C6(-0.6) in SPC/E water: cumulated view of the complex (C in green, O in red, K in purple; recentered on the mean plane of O_1, O_7 and O_{13} oxygens) at different steps of $PMF_{0.01+0.16}$, $PMF_{0.01+0.5}$ and $PMF_{0.01+3.0}$.

$d_{K-CM(18C6)}$	$PMF_{0.01+0.16}$	$PMF_{0.01+0.5}$	$PMF_{0.01+3.0}$
0.9 Å			
2.5 Å			
8.3 Å			

☞ Note that along a "rapid" PMF (for instance $PMF_{0.01+0.08}$ or $PMF_{0.01+0.16}$) M^+ always sits on top of a single face of the crown. Along a "long" PMF ($PMF_{0.01+3}$) it explores the two faces of the crown at long distances ($d > 8$ Å), while being restrained at a single face at shorter distances, thereby causing some entropy penalty.

Figure S2: Complexation PMF of K^+ Cl^- by 18C6(-0.4) in SPC/E water: association (in blue) and dissociation (in red) pathways. Free energy curves (ΔA in kcal / mol, as a function of the d distance in Å) for different sampling times.

$PMF_{0.01+0.08}$	$PMF_{0.01+0.16}$	$PMF_{0.01+0.5}$
Dissociation $PMF_{0.01+0.08}$ (red): $\Delta A_{CD} = 6.5$, $\Delta G_{diss} = 1.9$ Association $PMF_{0.01+0.08}$ (blue): $\Delta A_{CD} = 1.9$, $\Delta G_{ass} = 0.1$	Dissociation $PMF_{0.01+0.16}$: $\Delta A_{CD} = 6.0$, $\Delta G_{diss} = 1.2$ Association $PMF_{0.01+0.16}$: $\Delta A_{CD} = 5.9$, $\Delta G_{ass} = -1.2$	Dissociation $PMF_{0.01+0.5}$: $\Delta A_{CD} = 4.0$, $\Delta G_{diss} = 0.03$ Association $PMF_{0.01+0.5}$: $\Delta A_{CD} = 4.3$, $\Delta G_{ass} = -0.2$

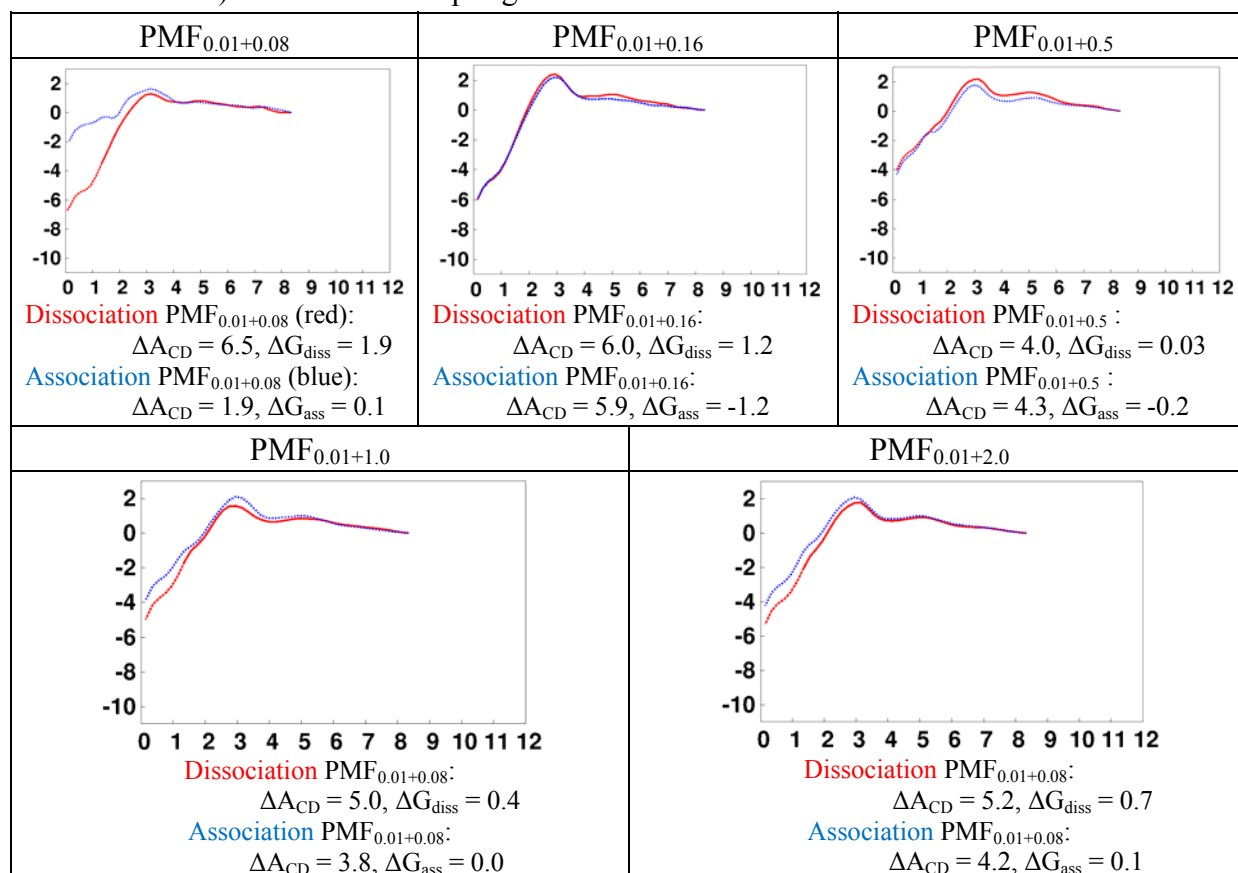| $PMF_{0.01+1.0}$	$PMF_{0.01+2.0}$
Dissociation $PMF_{0.01+0.08}$: $\Delta A_{CD} = 5.0$, $\Delta G_{diss} = 0.4$ Association $PMF_{0.01+0.08}$: $\Delta A_{CD} = 3.8$, $\Delta G_{ass} = 0.0$	Dissociation $PMF_{0.01+0.08}$: $\Delta A_{CD} = 5.2$, $\Delta G_{diss} = 0.7$ Association $PMF_{0.01+0.08}$: $\Delta A_{CD} = 4.2$, $\Delta G_{ass} = 0.1$

Figure S3: Complexation of K^+ Cl^- by 18C6 in SPC/E water: association or dissociation $PMF_{0.01+0.5}$ with different charges. From top to bottom: (i) Free energy curves (ΔA in kcal / mol, as a function of the d distance in Å) and binding energies ΔG_{ass} and ΔG_{diss}. (ii) Average energy components as a function of the d distance. Energies for the C (complexed) and D (decomplexed) states from the "diss" and "ass" pathways. (iii) Typical structures along the Association and Dissociation PMFs (at K-CM(18C6) distances of 0.7, 1.3 and 1.7 Å, respectively). PMFs results with the three cations and $PMF_{0.01+0.016}$ sampling are shown in Figure S4.

	-0.4	-0.5	-0.6
(i)	Diss (red): ΔA_{CD} = 4.0, ΔG_{diss} = 0.03 Ass (blue): ΔA_{CD} = 4.3, ΔG_{ass} = -0.2	Diss (red): ΔA_{CD} = 8.8, ΔG_{diss} = 3.4 Ass (blue): ΔA_{CD} = 5.9, ΔG_{ass} = -1.0	Diss (red): ΔA_{CD} = 8.2, ΔG_{diss} = 3.0 Ass (blue): ΔA_{CD} = 8.8, ΔG_{ass} = -3.3
(ii)	$E_{18C6\ diss}$ = 119 (C), 119 (D) (black) $E_{18C6\ ass}$ = 118 (C), 123 (D) (purple) $E_{K/18C6\ diss}$ = -48 (C), 0 (D) (red) $E_{K/18C6\ ass}$ = -48 (C), -1 (D) (pink) $E_{18C6/Wat\ diss}$ = -20 (C), -59 (D) (green) $E_{18C6/Wat\ ass}$ = -20 (C), -57 (D) (orange) $E_{K/Wat\ diss}$ = -63 (C), -113 (D) (blue) $E_{K/Wat\ ass}$ = -51 (C), -115 (D) (cyan)	$E_{18C6\ diss}$ = 158 (C), 161 (D) $E_{18C6\ ass}$ = 158 (C), 162 (D) $E_{K/18C6\ diss}$ = -61 (C), 1 (D) $E_{K/18C6\ ass}$ = -61 (C), 0 (D) $E_{18C6/Wat\ diss}$ = -21 (C), -72 (D) $E_{18C6/Wat\ ass}$ = -20 (C), -71 (D) $E_{K/Wat\ diss}$ = -53 (C), -118 (D) $E_{K/Wat\ ass}$ = -51 (C), -118 (D)	$E_{18C6\ diss}$ = 208 (C), 210 (D) $E_{18C6\ ass}$ = 208 (C), 210 (D) $E_{K/18C6\ diss}$ = -74 (C), -2 (D) $E_{K/18C6\ ass}$ = -75 (C), -1 (D) $E_{18C6/Wat\ diss}$ = -27 (C), -86 (D) $E_{18C6/Wa\ ass}$ = -27 (C), -87 (D) $E_{K/Wat\ diss}$ = -51 (C), -99 (D) $E_{K/Wat\ ass}$ = -46 (C), -112 (D)
(iii)	Ass.	Diss.	Ass.	Diss.	Ass.	Diss.

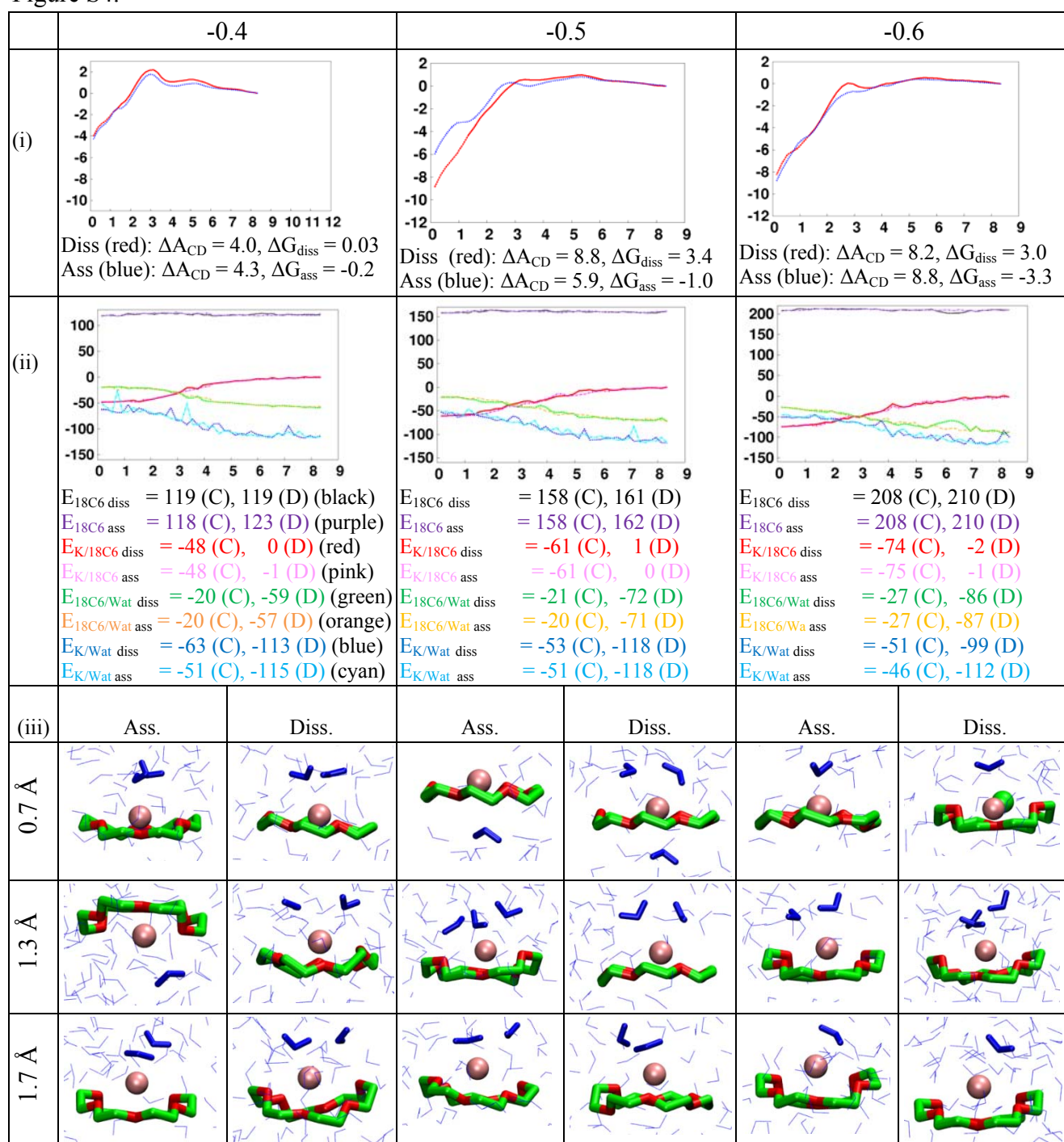|	Ass.	Diss.	Ass.	Diss.	Ass.	Diss.
0.7 Å						
1.3 Å						
1.7 Å						

Figure S4: Complexation of M^+ Cl^- by 18C6 in SPC/E water: dissociation $PMF_{0.01+0.16}$ with different charges. Free energy curves (ΔA in kcal / mol, as a function of the *d* distance in Å) for Na^+ to Cs^+ cations.

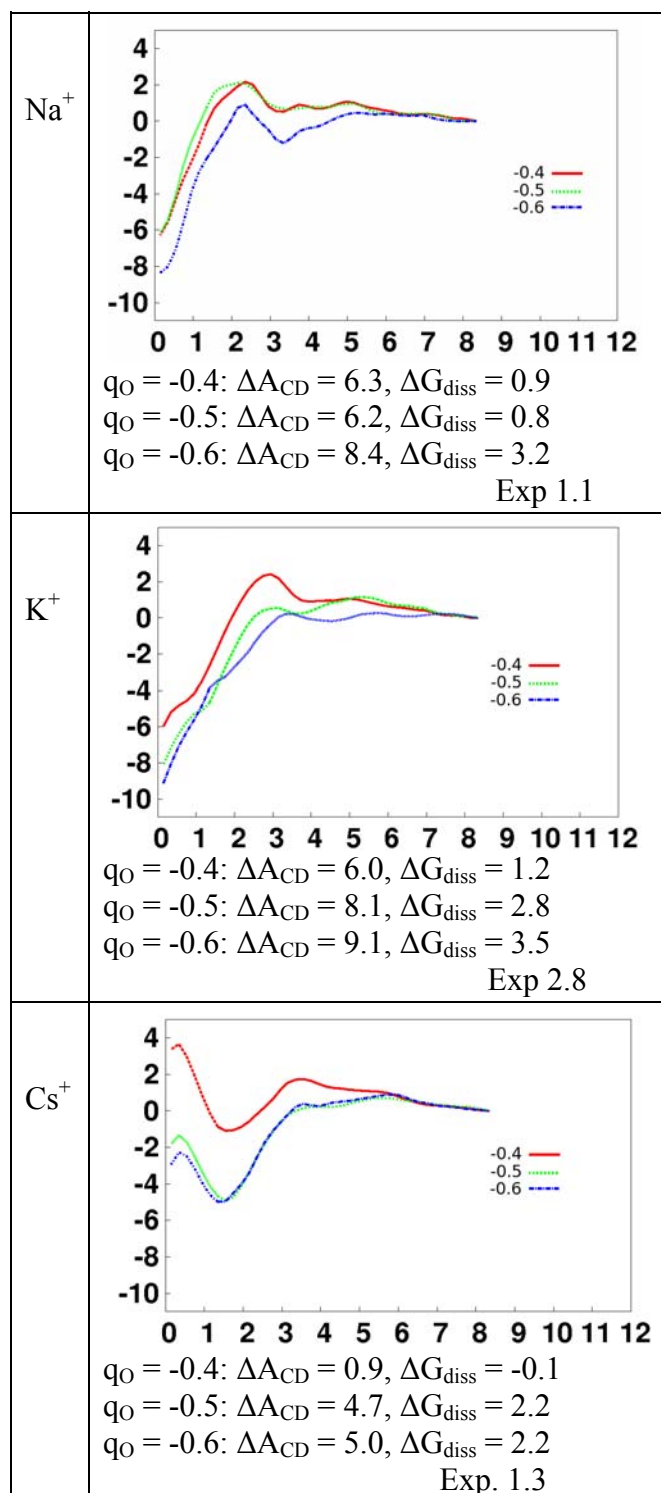|	
Na^+	
	$q_O = -0.4$: $\Delta A_{CD} = 6.3$, $\Delta G_{diss} = 0.9$ $q_O = -0.5$: $\Delta A_{CD} = 6.2$, $\Delta G_{diss} = 0.8$ $q_O = -0.6$: $\Delta A_{CD} = 8.4$, $\Delta G_{diss} = 3.2$ Exp 1.1
K^+	
	$q_O = -0.4$: $\Delta A_{CD} = 6.0$, $\Delta G_{diss} = 1.2$ $q_O = -0.5$: $\Delta A_{CD} = 8.1$, $\Delta G_{diss} = 2.8$ $q_O = -0.6$: $\Delta A_{CD} = 9.1$, $\Delta G_{diss} = 3.5$ Exp 2.8
Cs^+	
	$q_O = -0.4$: $\Delta A_{CD} = 0.9$, $\Delta G_{diss} = -0.1$ $q_O = -0.5$: $\Delta A_{CD} = 4.7$, $\Delta G_{diss} = 2.2$ $q_O = -0.6$: $\Delta A_{CD} = 5.0$, $\Delta G_{diss} = 2.2$ Exp. 1.3

Figure S5: Complexation $PMF_{0.01+0.5}$ of Na^+ to Cs^+ chlorides by 18C6(-0.6) in SPC/E water. From top to bottom: (i) Free energy curves (ΔA in kcal / mol, as a function of the d distance in Å). (ii) Snapshots of the complexed and decomplexed states.
(iii to v): Analysis as a function of the d distance: (iii) Curves of energy components, and average energies for Complexed and Decomplexed states. (iv) Number of H_2O molecules coordinated to M^+. (v) The six OC-CO dihedrals of 18C6 along the PMF. Results with other models are shown in Figure S6.
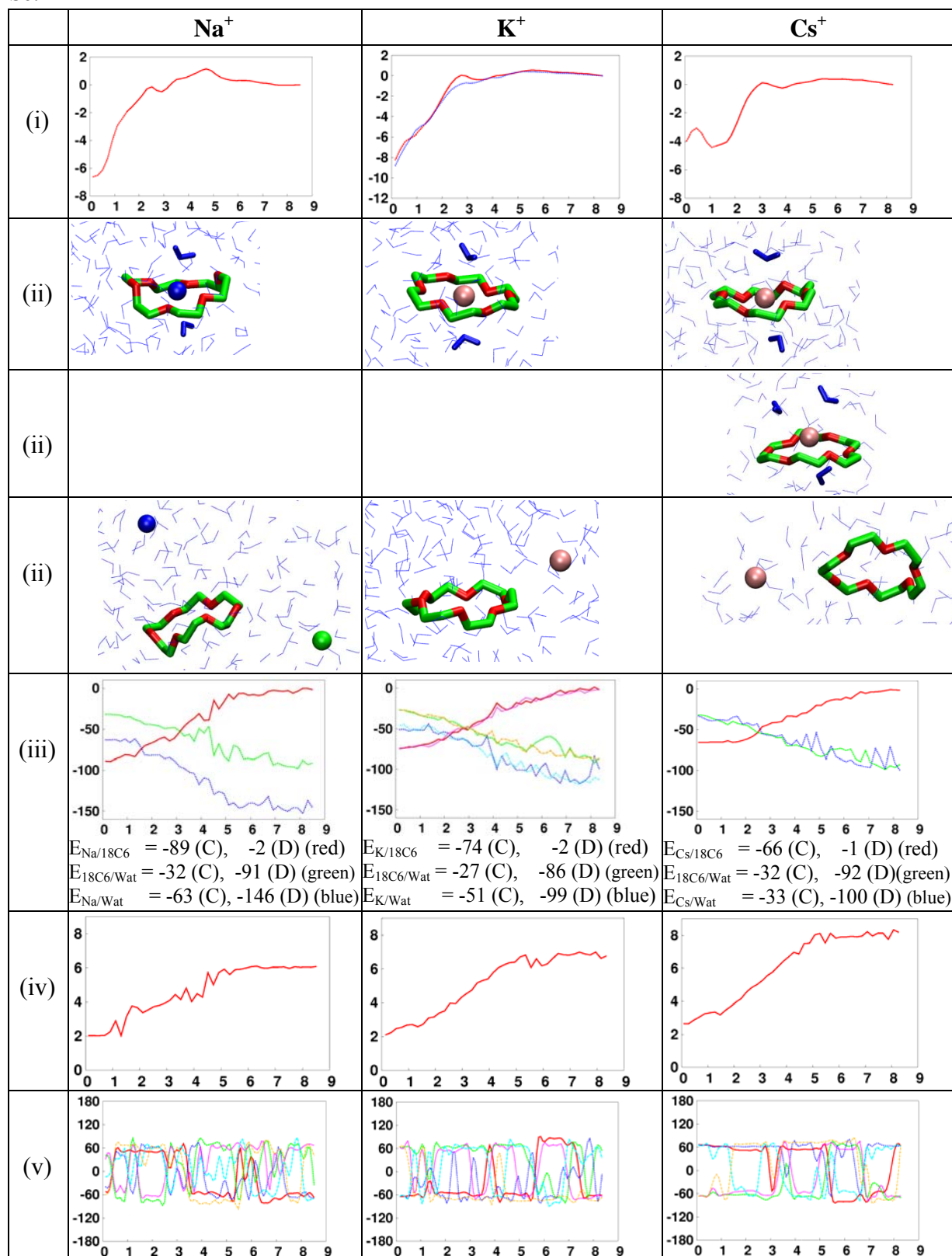
	Na^+	K^+	Cs^+
(i)			
(ii)			
(ii)			
(ii)			
(iii)	$E_{Na/18C6}$ = -89 (C), -2 (D) (red) $E_{18C6/Wat}$ = -32 (C), -91 (D) (green) $E_{Na/Wat}$ = -63 (C), -146 (D) (blue)	$E_{K/18C6}$ = -74 (C), -2 (D) (red) $E_{18C6/Wat}$ = -27 (C), -86 (D) (green) $E_{K/Wat}$ = -51 (C), -99 (D) (blue)	$E_{Cs/18C6}$ = -66 (C), -1 (D) (red) $E_{18C6/Wat}$ = -32 (C), -92 (D)(green) $E_{Cs/Wat}$ = -33 (C), -100 (D) (blue)
(iv)			
(v)			

Figure S6: Dissociation $PMF_{0.01+0.5}$ of 18C6/ $M^+ X^-$ complexes in water. (i) Free energy curves (ΔA in kcal / mol, as a function of the d distance in Å) with three models: 18C6(-0.6) (red), 18C6(-0.34) (blue) and POL (green). Snapshots along the PMF ("POL" model) at several d distances : (ii) $d \approx$ 0 Å (complexed state); (iii) $d \approx$ 2 Å ; (iv) $d \approx$ 8 Å (decomplexed state).
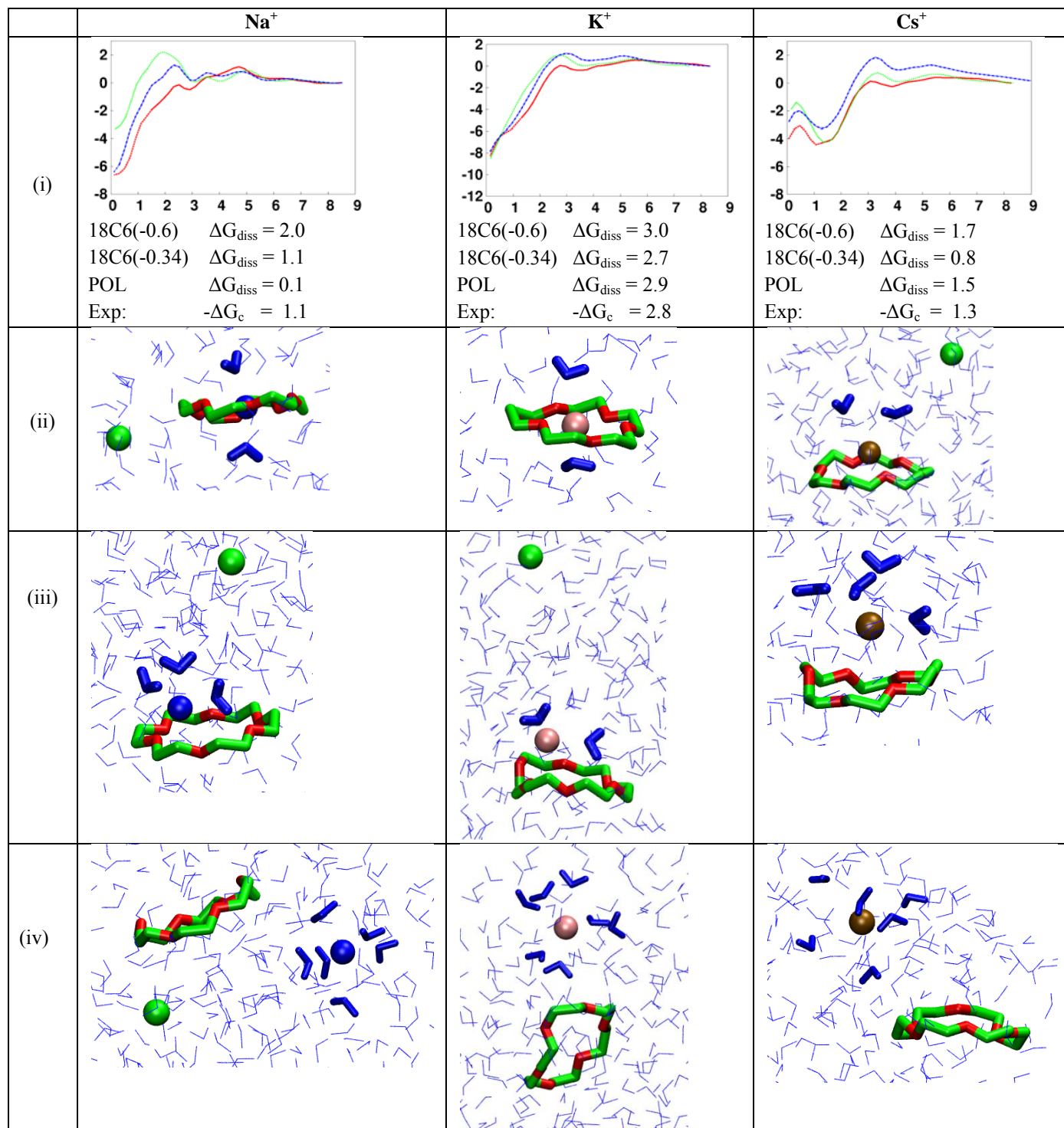
	Na^+	K^+	Cs^+
(i)	18C6(-0.6) ΔG_{diss} = 2.0 18C6(-0.34) ΔG_{diss} = 1.1 POL ΔG_{diss} = 0.1 Exp: $-\Delta G_c$ = 1.1	18C6(-0.6) ΔG_{diss} = 3.0 18C6(-0.34) ΔG_{diss} = 2.7 POL ΔG_{diss} = 2.9 Exp: $-\Delta G_c$ = 2.8	18C6(-0.6) ΔG_{diss} = 1.7 18C6(-0.34) ΔG_{diss} = 0.8 POL ΔG_{diss} = 1.5 Exp: $-\Delta G_c$ = 1.3
(ii)			
(iii)			
(iv)			

Figure S7: Dynamics of 18C6(-0.6)/M$^+$ Cl$^-$ complexes in SPC/E water. From top to bottom: (i) Snapshots after 2 ns. Time evolution of distances (in Å) (ii) M-O(18C6), (iii) M-Cl. (iv) Time evolution of: number of water molecules coordinated to M, (v) of OC-CO dihedrals. (vi) Energy components analysis (in kcal / mol, averages over the last 1.5 ns).
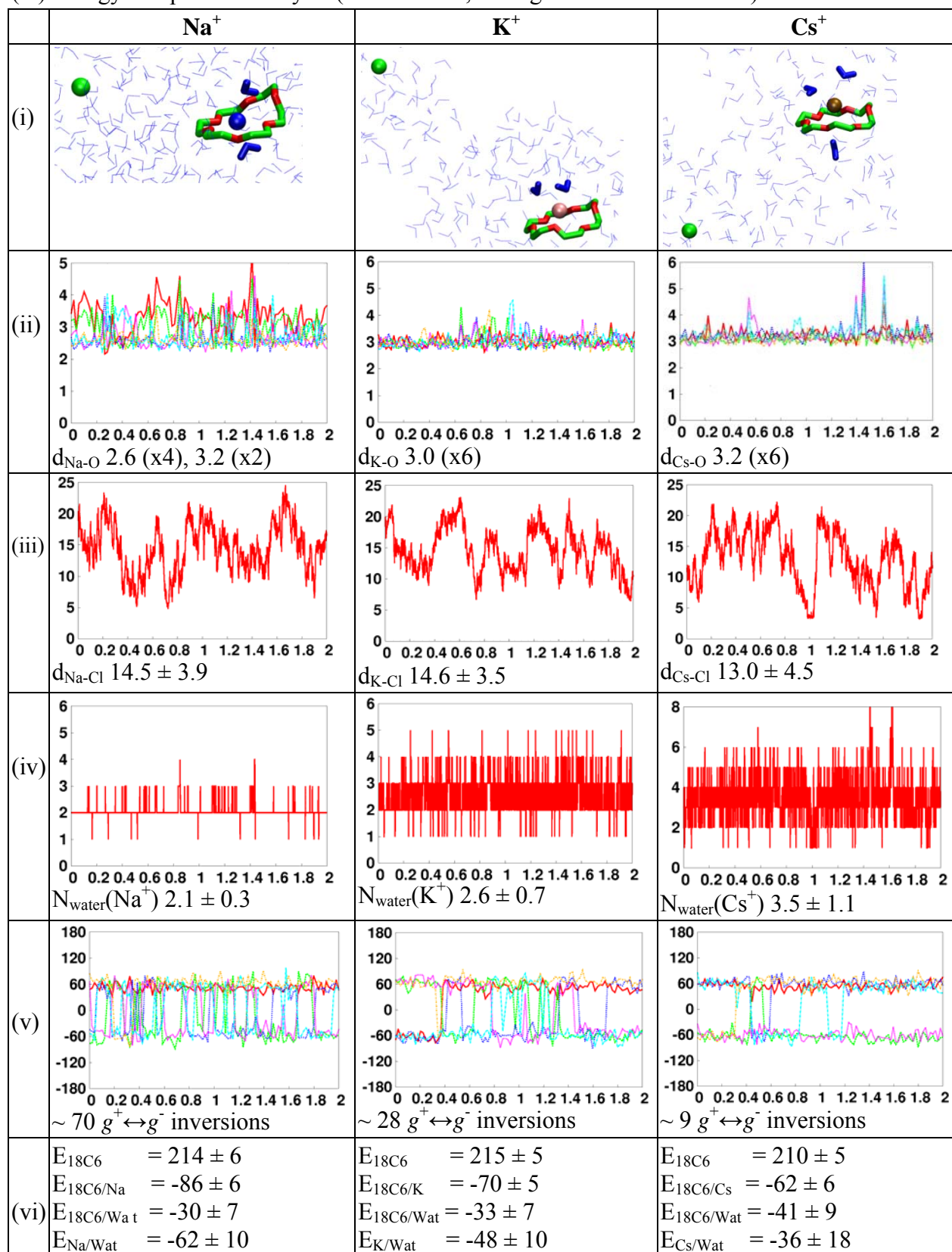

	Na$^+$	K$^+$	Cs$^+$
(i)			
(ii)	d_{Na-O} 2.6 (x4), 3.2 (x2)	d_{K-O} 3.0 (x6)	d_{Cs-O} 3.2 (x6)
(iii)	d_{Na-Cl} 14.5 ± 3.9	d_{K-Cl} 14.6 ± 3.5	d_{Cs-Cl} 13.0 ± 4.5
(iv)	$N_{water}(Na^+)$ 2.1 ± 0.3	$N_{water}(K^+)$ 2.6 ± 0.7	$N_{water}(Cs^+)$ 3.5 ± 1.1
(v)	~ 70 $g^+ \leftrightarrow g^-$ inversions	~ 28 $g^+ \leftrightarrow g^-$ inversions	~ 9 $g^+ \leftrightarrow g^-$ inversions
(vi)	E_{18C6} = 214 ± 6 $E_{18C6/Na}$ = -86 ± 6 $E_{18C6/Wat}$ = -30 ± 7 $E_{Na/Wat}$ = -62 ± 10	E_{18C6} = 215 ± 5 $E_{18C6/K}$ = -70 ± 5 $E_{18C6/Wat}$ = -33 ± 7 $E_{K/Wat}$ = -48 ± 10	E_{18C6} = 210 ± 5 $E_{18C6/Cs}$ = -62 ± 6 $E_{18C6/Wat}$ = -41 ± 9 $E_{Cs/Wat}$ = -36 ± 18

Figure S8: Dynamics of 18C6(-0.34)/M$^+$ Cl$^-$ complexes in SPC/E water. From top to bottom:
(i) snapshots. Time evolution of distances (in Å) (ii) M-O(18C6), (iii) M-Cl. Time evolution
of (iv) number of water molecules coordinated to M, (v) OC-CO dihedrals.
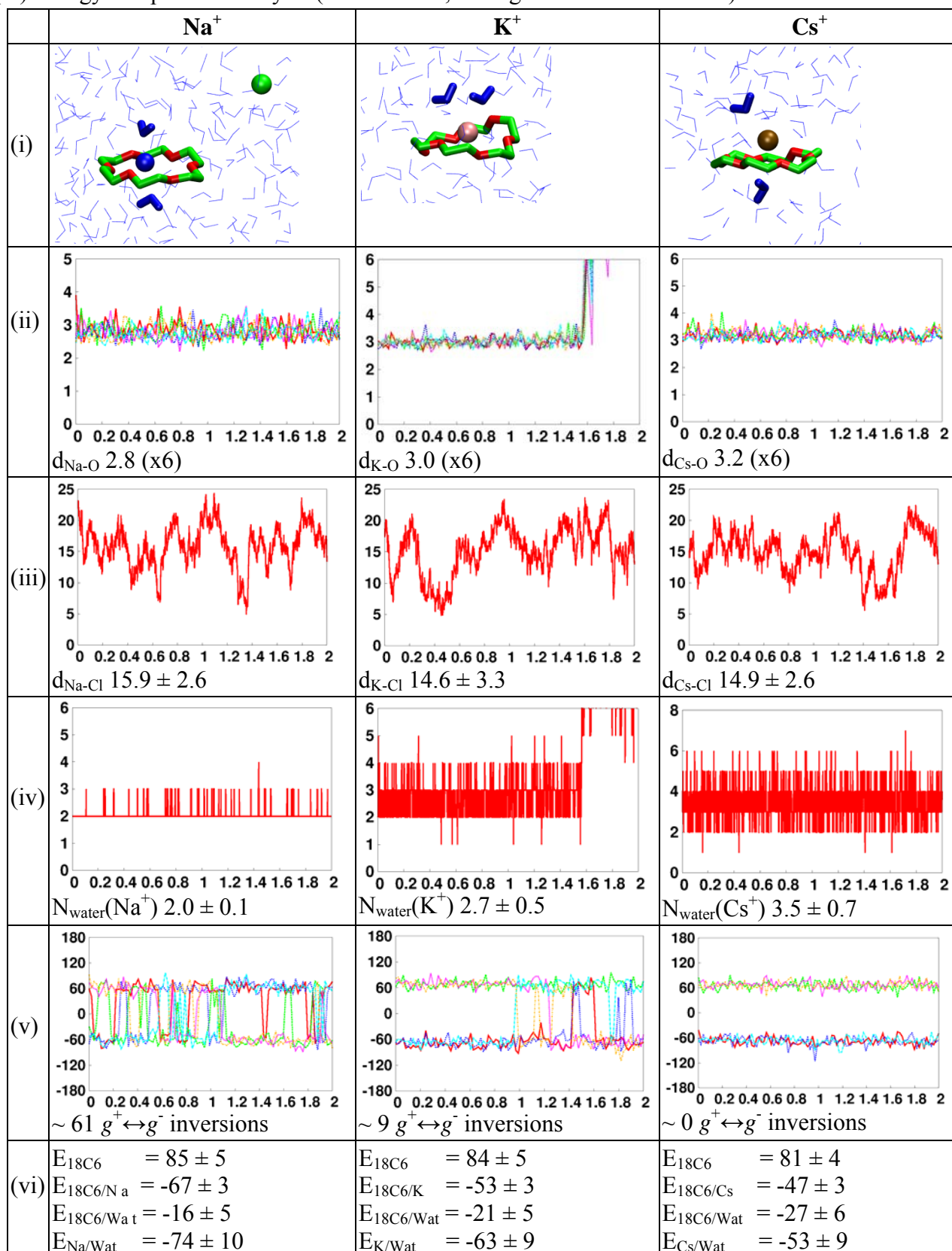(vi) Energy components analysis (in kcal / mol; averages over the last 1.5 ns).

	Na$^+$	K$^+$	Cs$^+$
(i)			
(ii)	 d$_{Na-O}$ 2.8 (x6)	 d$_{K-O}$ 3.0 (x6)	 d$_{Cs-O}$ 3.2 (x6)
(iii)	 d$_{Na-Cl}$ 15.9 ± 2.6	 d$_{K-Cl}$ 14.6 ± 3.3	 d$_{Cs-Cl}$ 14.9 ± 2.6
(iv)	 N$_{water}$(Na$^+$) 2.0 ± 0.1	 N$_{water}$(K$^+$) 2.7 ± 0.5	 N$_{water}$(Cs$^+$) 3.5 ± 0.7
(v)	 ~ 61 $g^+ \leftrightarrow g^-$ inversions	 ~ 9 $g^+ \leftrightarrow g^-$ inversions	 ~ 0 $g^+ \leftrightarrow g^-$ inversions
(vi)	E_{18C6} = 85 ± 5 $E_{18C6/Na}$ = -67 ± 3 $E_{18C6/Wat}$ = -16 ± 5 $E_{Na/Wat}$ = -74 ± 10	E_{18C6} = 84 ± 5 $E_{18C6/K}$ = -53 ± 3 $E_{18C6/Wat}$ = -21 ± 5 $E_{K/Wat}$ = -63 ± 9	E_{18C6} = 81 ± 4 $E_{18C6/Cs}$ = -47 ± 3 $E_{18C6/Wat}$ = -27 ± 6 $E_{Cs/Wat}$ = -53 ± 9

Figure S9: Dynamics of 18C6(-0.4)/M$^+$ Cl$^-$ complexes in POL3 water ("POL model"). From top to bottom: (i) snapshots of the complexes. Time evolution of distances (in Å) of (ii) M-O(18C6), (iii) M-Cl. Time evolution of (iv) number of water molecules coordinated to M, (v) of OC-CO dihedrals.
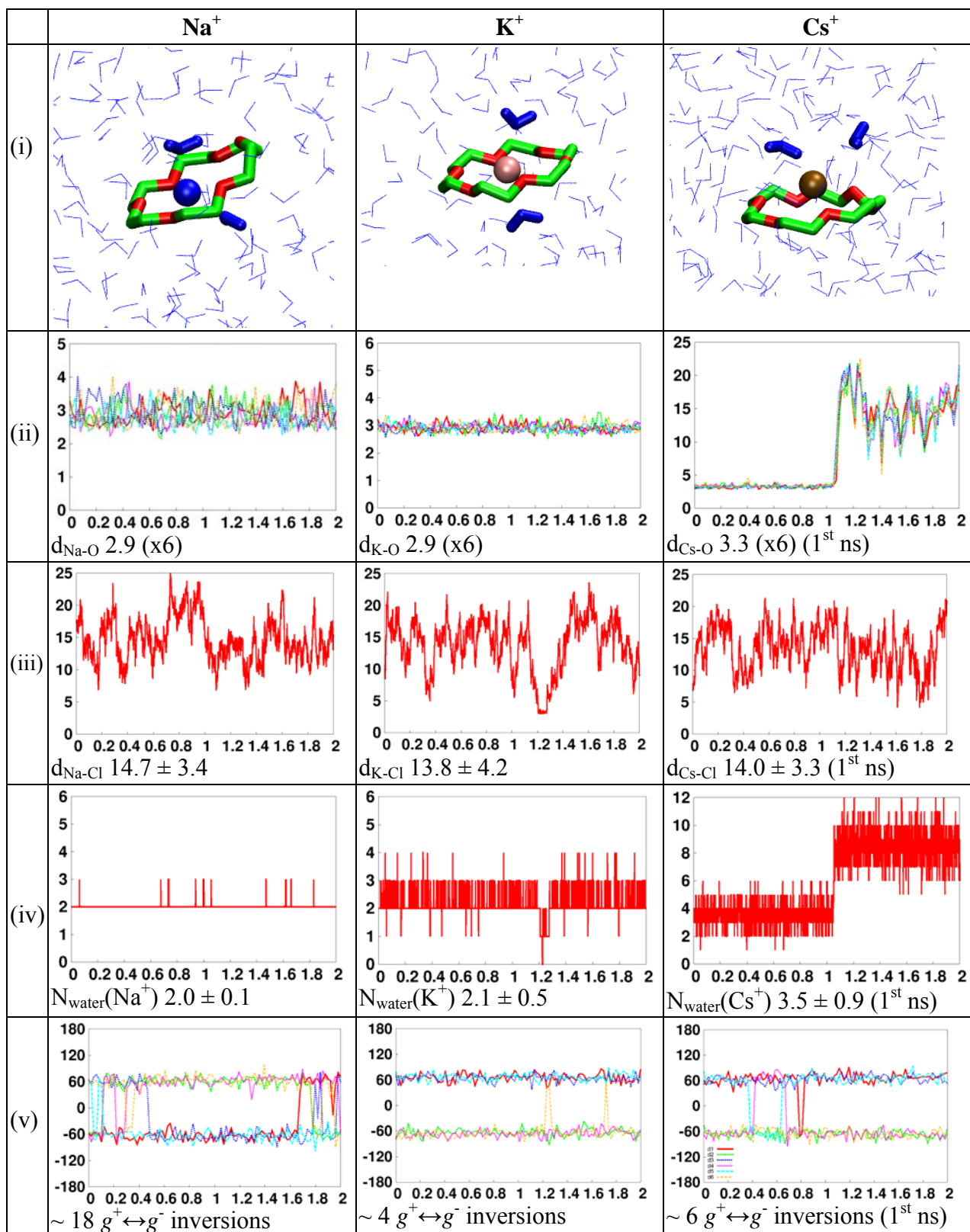
Figure S10: Dynamics of 18C6(-0.34)/M^+ Pic^- complexes at the chloroform / water (SPC/E) interface. From top to bottom: (i) snapshots. Time evolution of (ii) distances (in Å) M-O(18C6), (iii) of M-Pic; (iv) of the number of H_2O molecules coordinated to M^+, (v) of OC-CO dihedral angles.
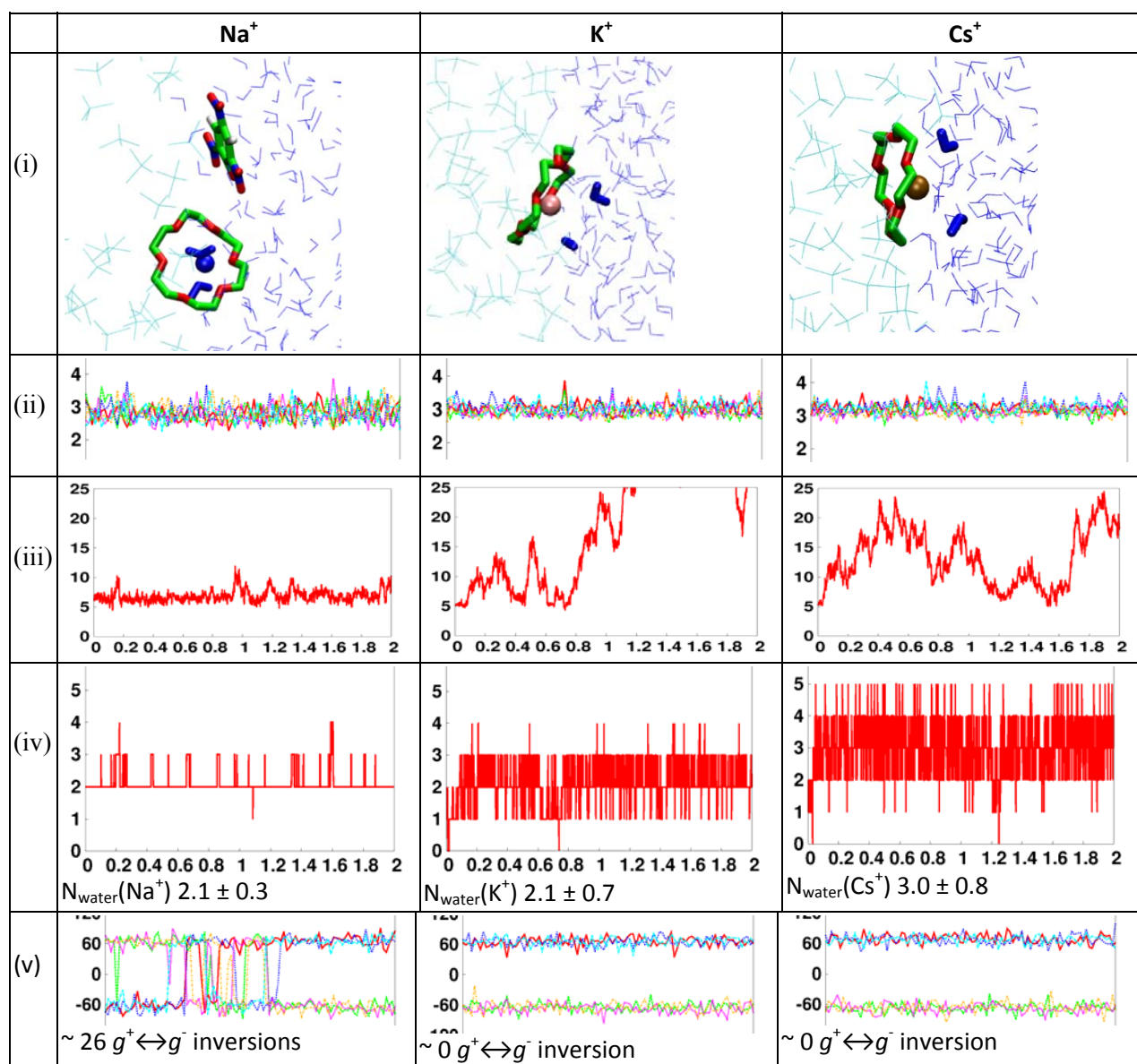
	Na^+	K^+	Cs^+
(i)			
(ii)			
(iii)			
(iv)			
	$N_{water}(Na^+)$ 2.1 ± 0.3	$N_{water}(K^+)$ 2.1 ± 0.7	$N_{water}(Cs^+)$ 3.0 ± 0.8
(v)			
	~ 26 $g^+ \leftrightarrow g^-$ inversions	~ 0 $g^+ \leftrightarrow g^-$ inversion	~ 0 $g^+ \leftrightarrow g^-$ inversion

Figure S11 . "Transfer" $PMF_{0.5+1.0}$ of K^+ Pic^- across the interface. From top to bottom: free energy curve (ΔA in kcal / mol, as a function of the z distance in Å) and snapshots at the O, I and W positions.
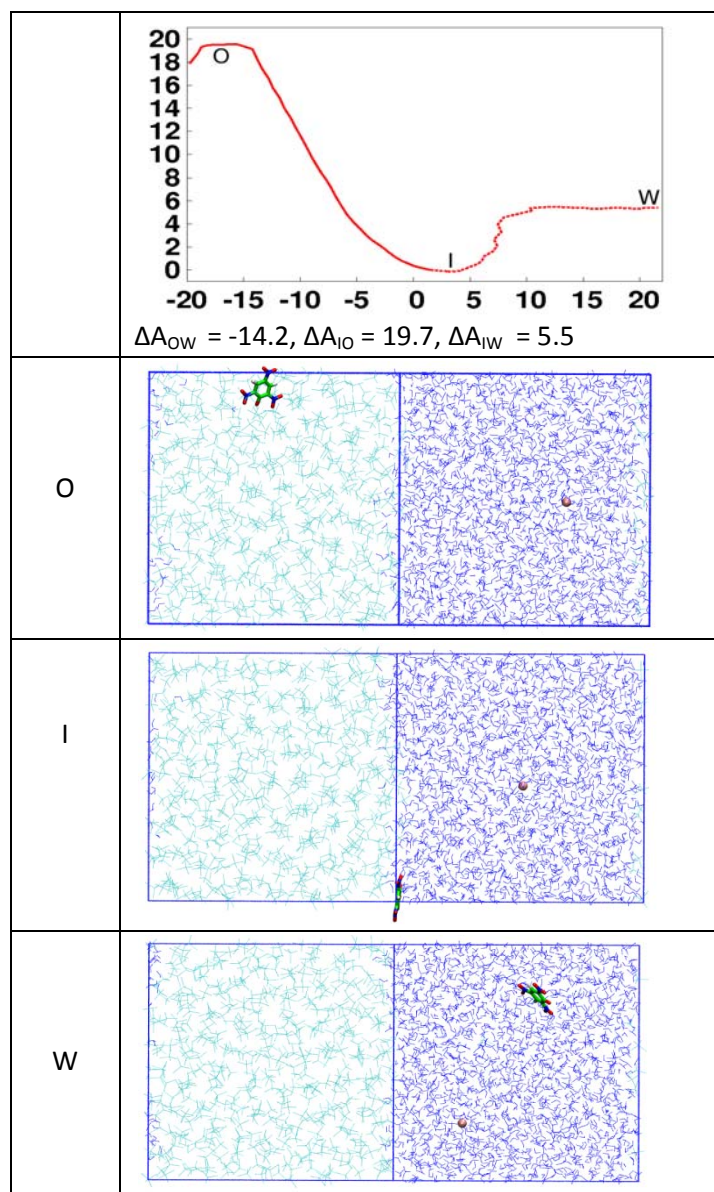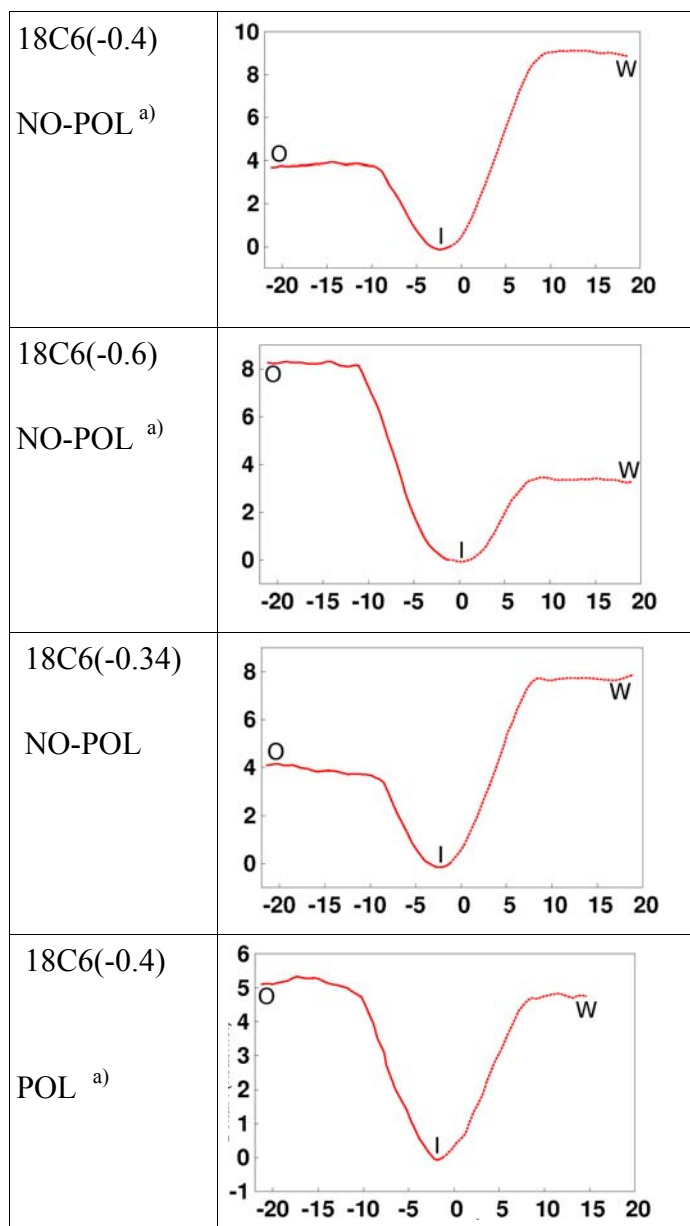
Figure S12: Transfer $PMF_{0.5+1.0}$ of 18C6 across the chloroform / water interface. Free energy curves (ΔA in kcal / mol, as a function of the z distance in Å) with different charge models.

18C6(-0.4) NO-POL [a]	
18C6(-0.6) NO-POL [a]	
18C6(-0.34) NO-POL	
18C6(-0.4) POL [a]	

a) G. Benay and G. Wipff *J. Phys. Chem. B* **2014,** 118, 13913.

Figure S13. Transfer PMF$_{0.5+1.0}$ of the 18C6(0.6)/M$^+$ Pic$^-$ complex across the chloroform / water interface. Free energy curves (ΔA in kcal / mol, as a function of the z distance in Å) and snapshots at the O, I and W positions.

Na$^+$	K$^+$	Cs$^+$
NO-POL: $\Delta A_{OW} = -2.5$, $\Delta A_{IO} = 11.8$, $\Delta A_{IW} = 9.3$	NO-POL: $\Delta A_{OW} = -0.3$, $\Delta A_{IO} = 9.7$, $\Delta A_{IW} = 9.4$ POL: $\Delta A_{OW} = -0.8$, $\Delta A_{IO} = 7.6$, $\Delta A_{IW} = 6.8$	NO-POL: $\Delta A_{OW} = -1.4$, $\Delta A_{IO} = 11.4$, $\Delta A_{IW} = 10.0$
O	O	O
I	I	I
W	W	W

Figure S14: Transfer PMF of 18C6/K^{+} Pic[-] across the chloroform / water interface. Free energy curves (ΔA in kcal / mol, as a function of the z distance in Å) and snapshots at the O, I and W positions. Comparison of four models.
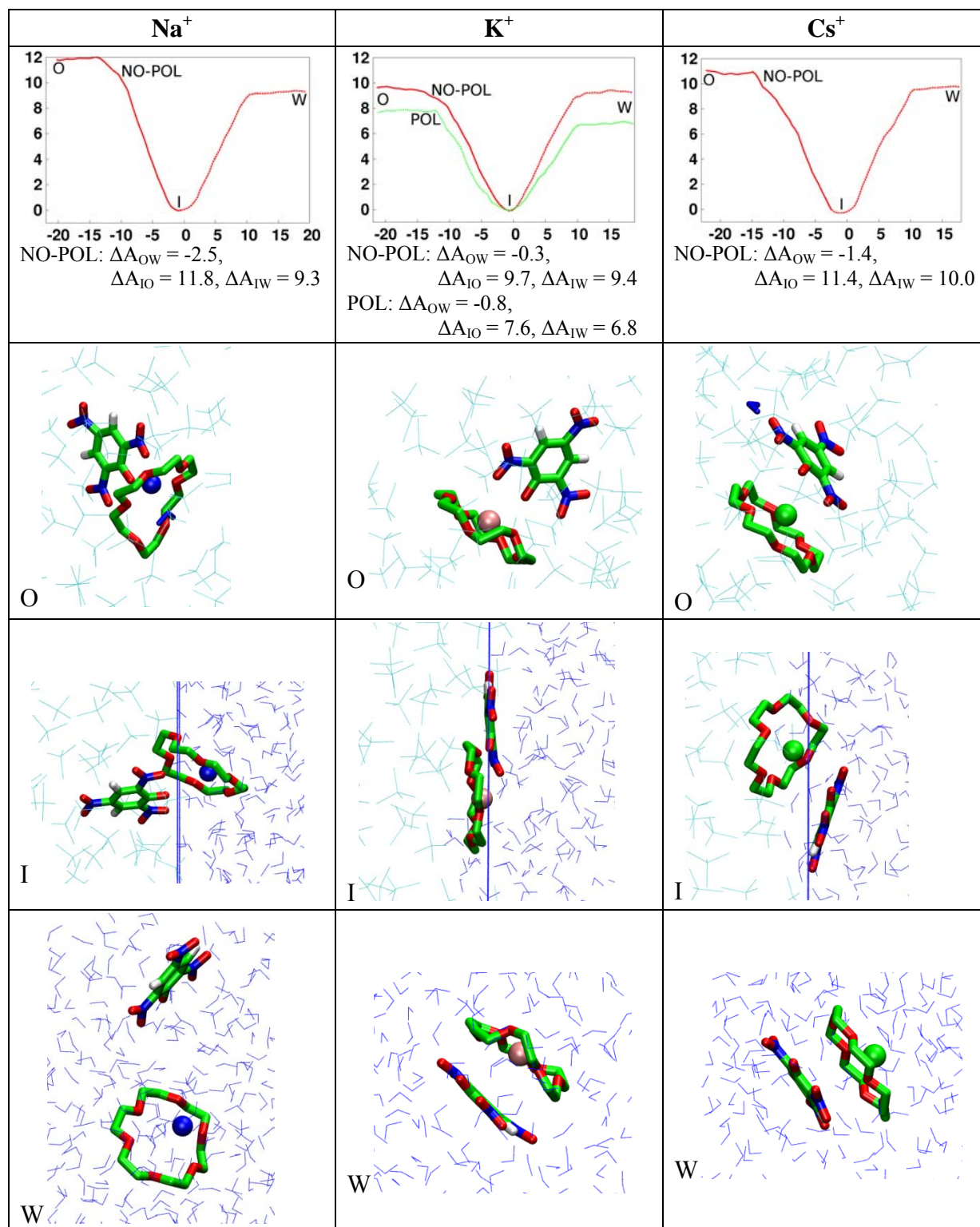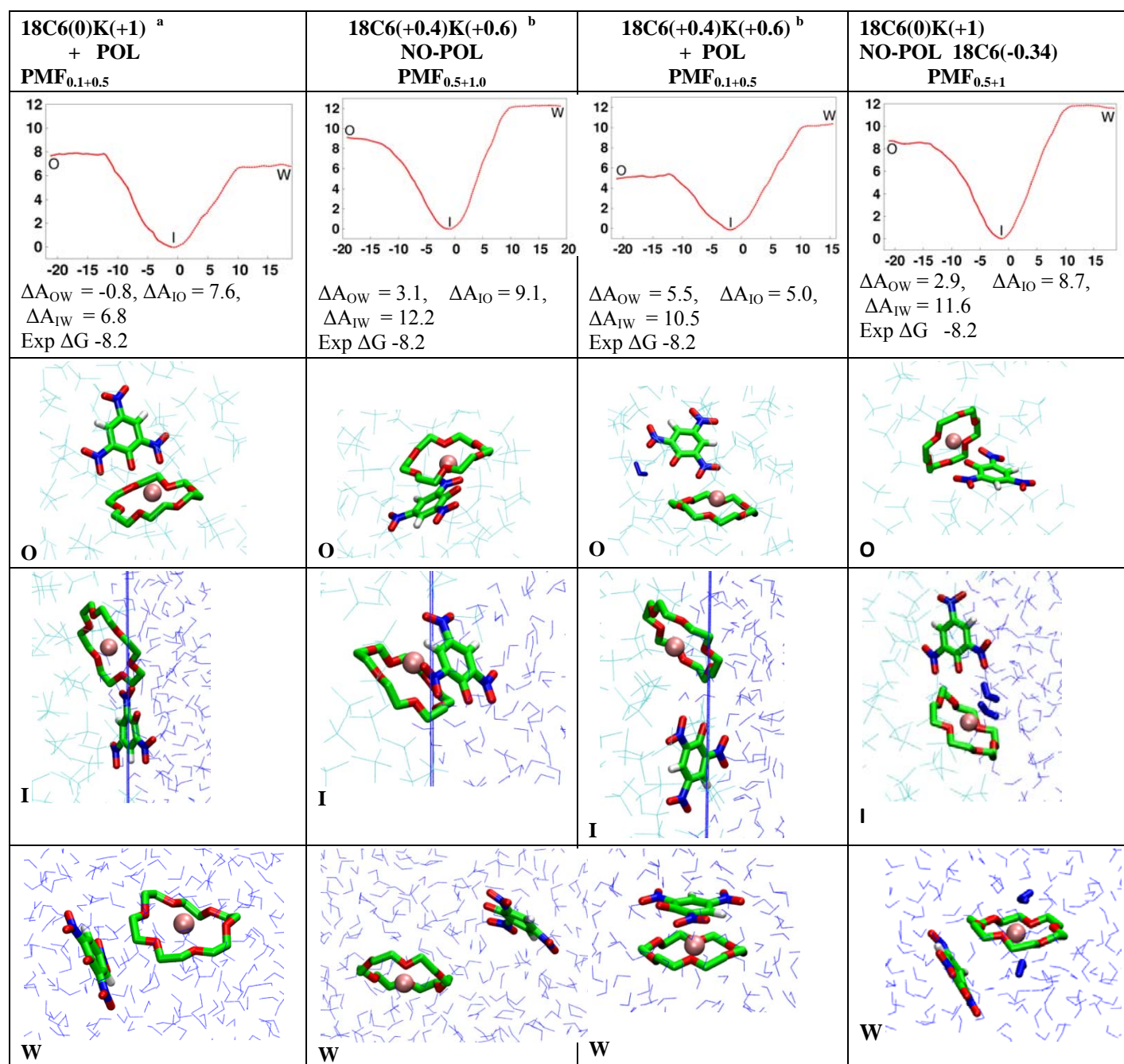
18C6(0)K(+1) [a] + POL PMF$_{0.1+0.5}$	18C6(+0.4)K(+0.6) [b] NO-POL PMF$_{0.5+1.0}$	18C6(+0.4)K(+0.6) [b] + POL PMF$_{0.1+0.5}$	18C6(0)K(+1) NO-POL 18C6(-0.34) PMF$_{0.5+1}$
$\Delta A_{OW} = -0.8$, $\Delta A_{IO} = 7.6$, $\Delta A_{IW} = 6.8$ Exp ΔG -8.2	$\Delta A_{OW} = 3.1$, $\Delta A_{IO} = 9.1$, $\Delta A_{IW} = 12.2$ Exp ΔG -8.2	$\Delta A_{OW} = 5.5$, $\Delta A_{IO} = 5.0$, $\Delta A_{IW} = 10.5$ Exp ΔG -8.2	$\Delta A_{OW} = 2.9$, $\Delta A_{IO} = 8.7$, $\Delta A_{IW} = 11.6$ Exp ΔG -8.2
O	**O**	**O**	**O**
I	**I**	**I**	**I**
W	**W**	**W**	**W**

[a] 18C6(-0.6) charge set, and +1 charged K^{+}

[b] ESP charges on the whole 18C6/K^{+} complex.

Figure S15: 30 K$^+$ 18C6 Pic$^-$ species at the interface (18C6(-0.4) POL model). Zooms from Figure 8. (ii) Snapshot of the solvent box after 5 ns of dynamics; (iii) K$^{+\cdots}$Interface distance (in Å) for the eleven complexes (color coded and labelled from 1 to 11) as a function of time (in ns), starting from the time of their formation along the dynamics (excluding the complex preformed at 0 ns)
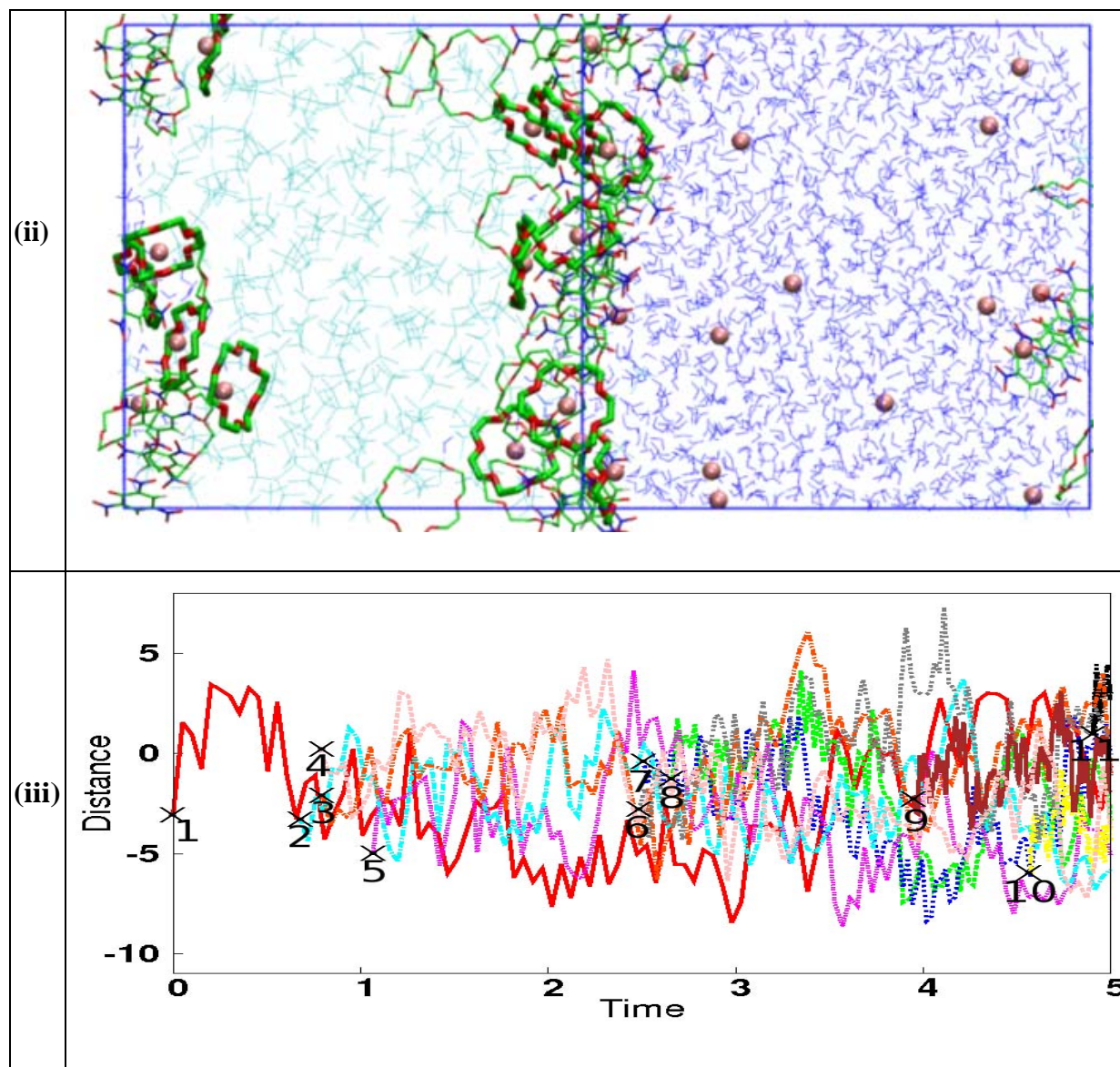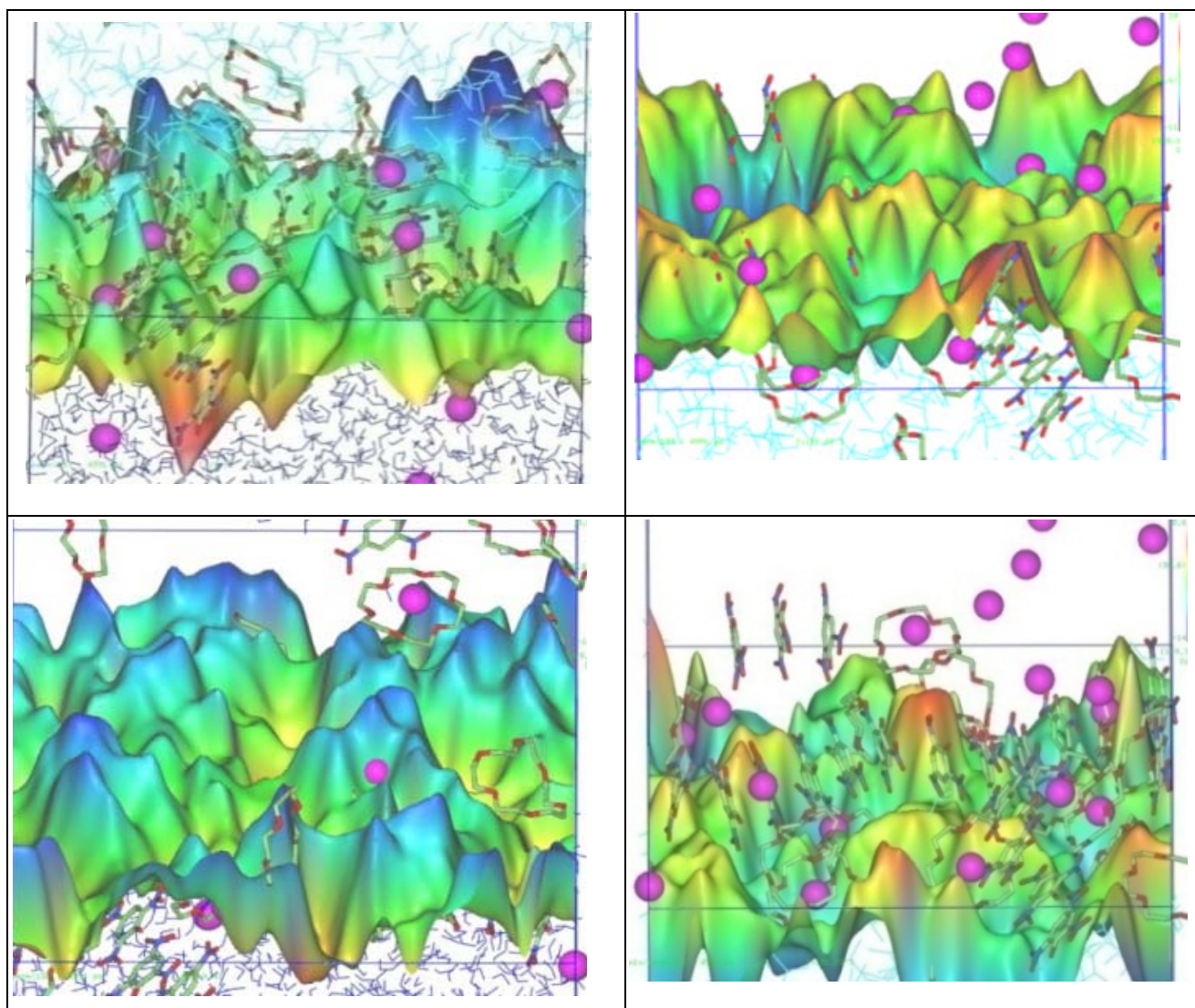
Figure S16: Views of the interfacial surface with 30 K$^+$ 18C6 Pic$^-$ species (POL force field). The interface is shown "horizontally" with the water phase either below (left side) or on top (right side). Line 1: water surface; line 2: chloroform surface. The surface of a given liquid L is defined by the z$_{max}$ positions of the L molecules that are not "isolated", but connected to the bulk L via other L molecules.