

**Supplementary Information for: Micro- and nanoplastics' transfer in freezing saltwater:  
Implications for their fate in polar waters**

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*Table 1: Concentration of stock solutions or stock dispersions*

Stock solution or dispersion	Concentration
NaCl	100 g kg <sup>-1</sup>
SA	≈ 1 g kg <sup>-1</sup>
<i>nPSL-200</i>	100 mg kg <sup>-1</sup>
<i>nPSL-350</i>	100 mg kg <sup>-1</sup>
<i>nPS-360</i>	≈ 40 mg kg <sup>-1</sup>
$\mu$ PS	4.25 g kg <sup>-1</sup>

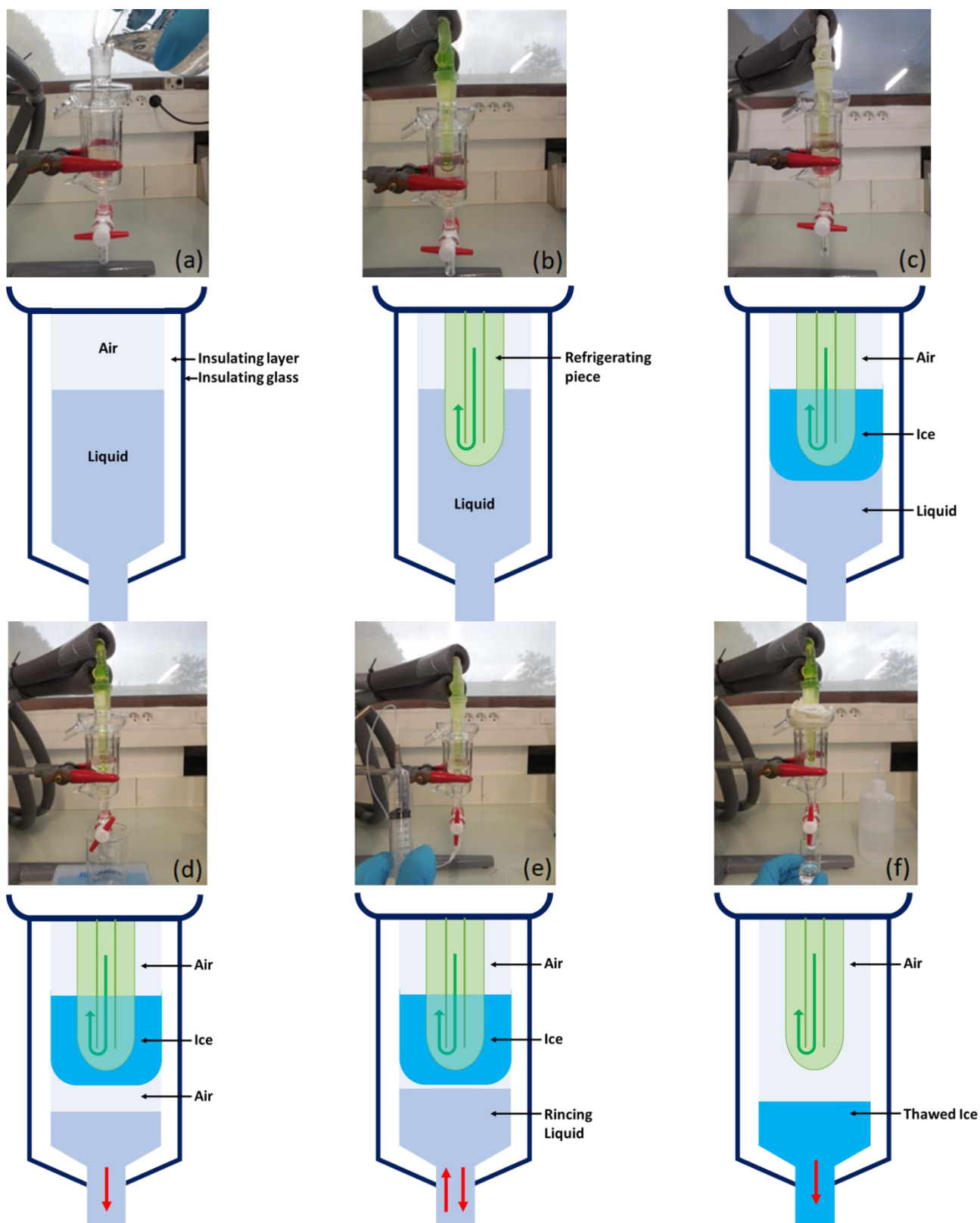


Figure S1: Steps of the progressive and partial freezing protocol in images above and corresponding diagrams below: a) insertion of the solution in the freezing reactor, b) insertion of the cold finger, c) solidification of the liquid, d) recovery of the liquid phase, e) rinsing of the bottom of the vessel, f) recovery of thawed ice.



Figure S2: Examples of time-lapse photography, used to calculate speed and shape of freezing at 0 minutes, approximately 15 minutes and 40 minutes ( $35 \text{ g kg}^{-1} \text{ NaCl}$ )

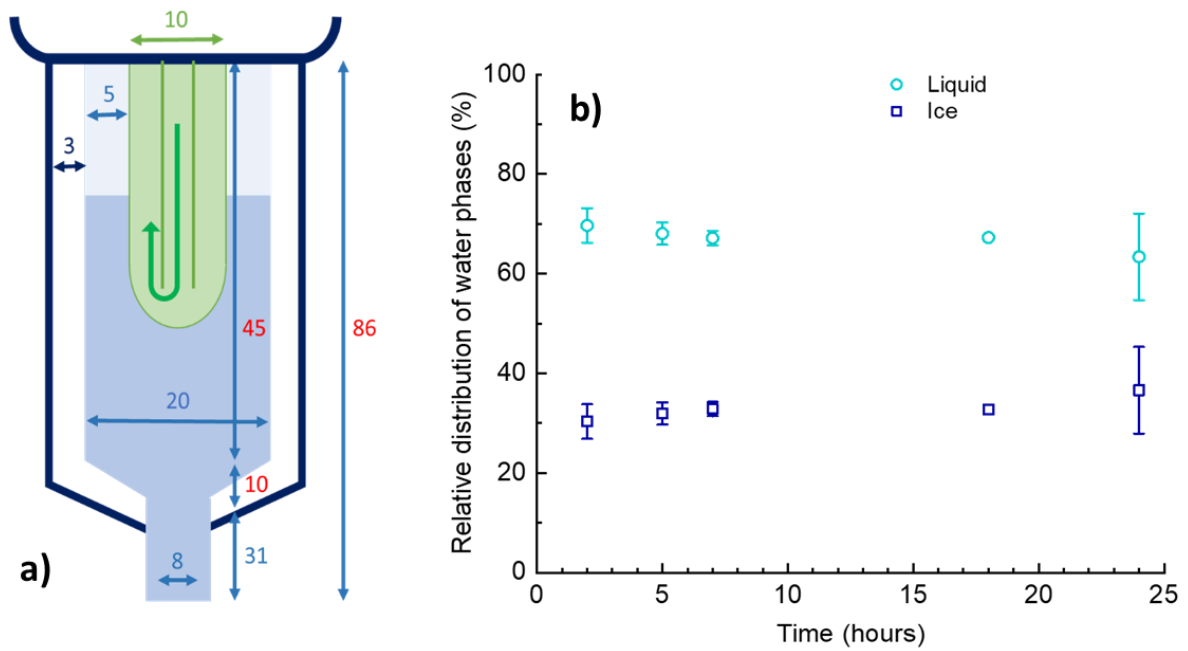


Figure S3: a) Dimensions of the system in mm (not to scale). From the exterior to the interior: the insulating layer of glass (dark blue), the inner vessel containing liquid (blue) and air (light blue), the refrigerating piece (green) with the direction of flow of the cooling liquid (bright green). Numbers in red represent dimensions that differed between the duplicate systems, with 86, 45 and 10 mm corresponding to 90, 52 and 7 mm, respectively. b) Evolution of the relative proportion of liquid and solid phases (m/m) for the  $35 \text{ g kg}^{-1} \text{ NaCl}$  solution.

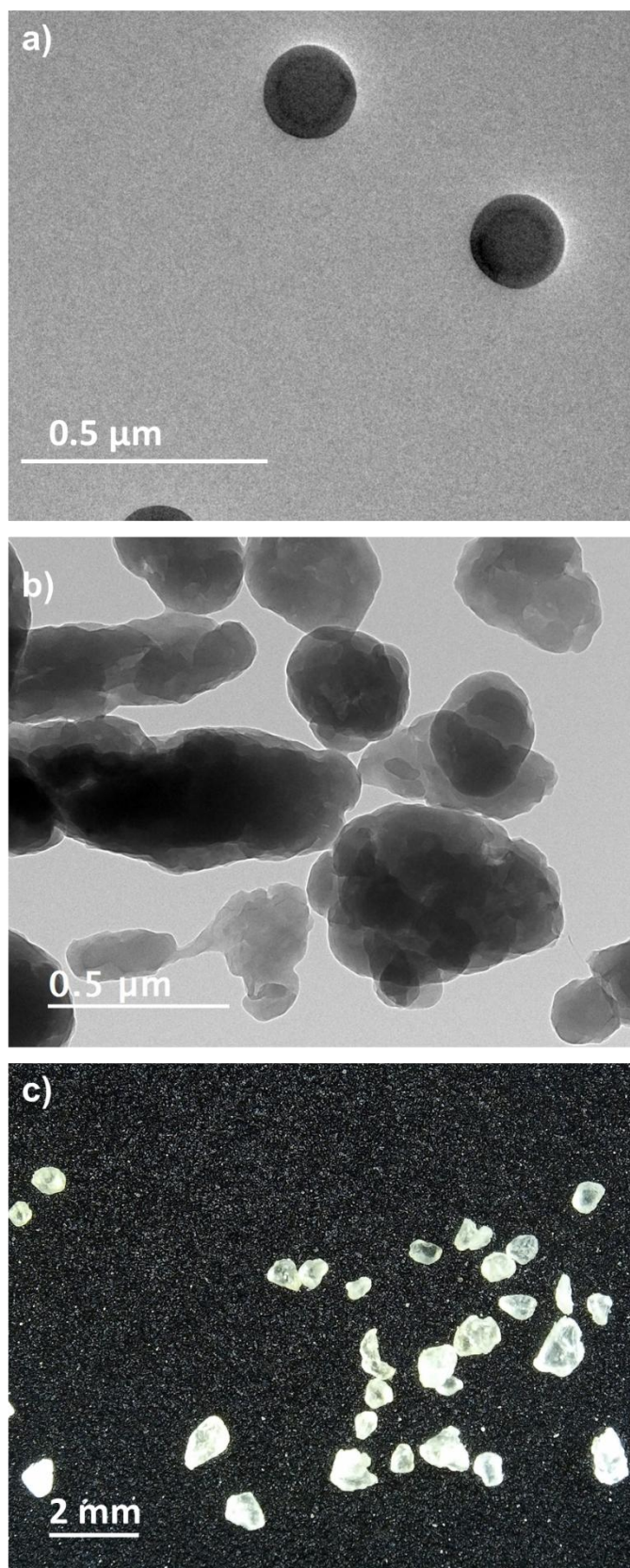


Figure S4: TEM images of a) nPSL-200 and b) nPS-360. c) Digital photography of  $\mu$ PS.

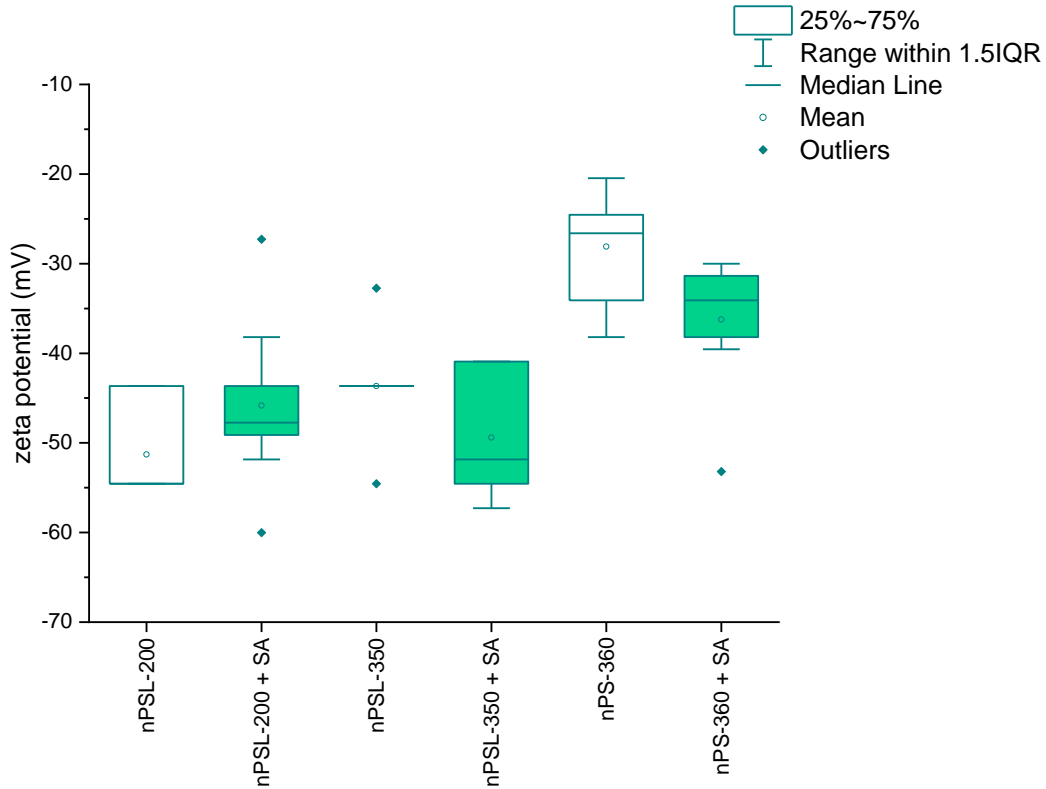


Figure S5: Zeta potential of  $10 \text{ mg kg}^{-1}$  of nanoplastic (nP) models in  $4 \text{ mmol kg}^{-1}$  NaCl, alone and with  $50 \text{ mg kg}^{-1}$  SA. Results are composed of 10 measurements in medium resolution mode.

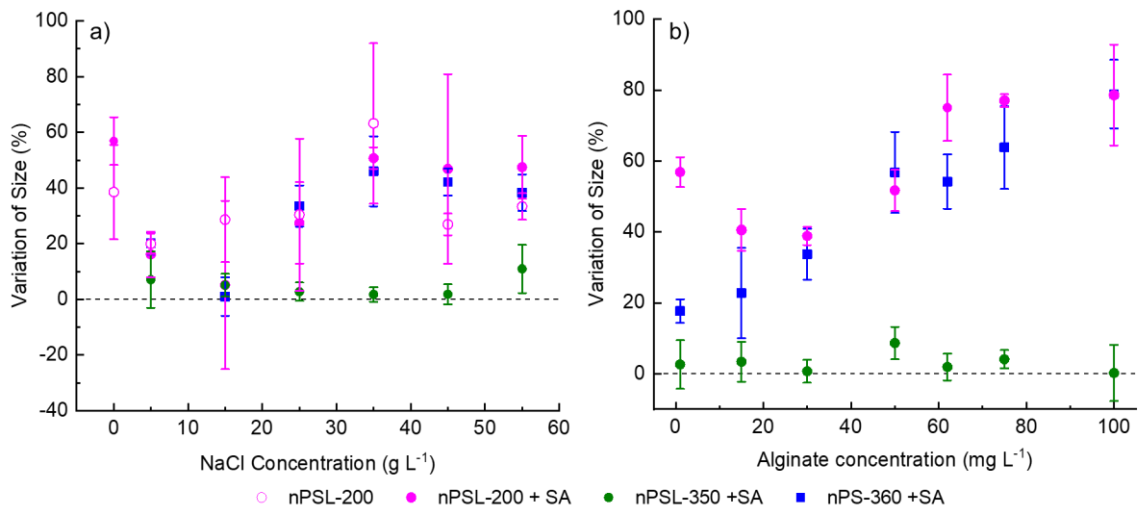


Figure S6: Variations of size of nanoplastics (nPs) after bulk freeze/thaw a) as a function of NaCl concentration (keeping SA at  $50 \text{ mg kg}^{-1}$ , if present) and b) as a function SA (keeping NaCl at  $35 \text{ g kg}^{-1}$  NaCl).

While *nPSL-200* and *nPS-360* form aggregates (+20 to 50%  $d_{zH}$ ), *nPSL-350*, does not form aggregates ( $\leq 10\%$   $d_{zH}$ ) whether or not it has been purified by dialysis (data not shown).

Table 2: Summary of mass of initial solution ( $M_{Init}$ ), liquid ( $M_{Liq}$ ) and ice ( $M_{Ice}$ ) solutions recovered from the freezing reactor, losses of liquid or NaCl recovered, SA or particle concentrations measured in the initial solution ( $C_{Init}$ ), and in the Liquid ( $C_{Liq}$ ) and Ice ( $C_{Ice}$ ) solutions recovered from the freezing reactor; and proportion of initial SA or particle masses recovered in liquid and in ice. For nPSL-200 and nPS-360 with NaCl and SA, concentrations in ice are the average of ice recovered in the two duplicate experiments. Since SA is very stable when frozen in NaCl (mass balance of  $-1 \pm 4\%$ ), for mixtures containing plastics and SA in NaCl, for simplicity we only showed the concentrations and mass balances of particles.

	Freezing duration (hours)	Mass of solution (g)				NaCl Losses	Alginate Concentration ( $\text{mg kg}^{-1}$ )			Distribution of Initial Alginate Mass		
		Initial	Liquid	Ice	Losses		Initial	Liquid	Ice	Liquid	Ice	Losses
SA	2	12.04	6.09	5.93	0%		21.49	31.57	11.20	74%	26%	0%
	2	12.01	5.50	6.75	-2%		21.49	30.45	9.13	65%	24%	11%
	5	12.01	5.75	6.08	1%		21.70	31.78	3.87	70%	9%	21%
	5	12.03	6.13	6.11	-2%		21.70	30.49	7.83	72%	18%	10%
	7	12.03	5.38	6.82	-1%		28.71	50.04	9.64	78%	19%	3%
	7	12.03	3.57	7.92	5%		28.71	48.99	12.69	51%	29%	20%
	24	12.02	4.82	6.63	5%		20.67	29.82	6.14	58%	16%	26%
	24	12.04	3.95	7.34	6%		20.67	49.26	6.56	78%	19%	2%
SA + NaCl	2	12.02	7.22	4.20	5%	8%	20.38	25.29	11.65	74%	27%	-1%
	2	12.00	8.00	3.65	3%	5%	20.38	24.52	11.84	80%	22%	-2%
	5	12.05	7.69	3.97	3%	9%	25.03	28.98	15.37	74%	27%	-1%
	5	12.01	7.59	4.09	3%	9%	25.03	31.36	16.19	79%	28%	-7%
	7	12.01	8.22	4.21	-3%	3%	25.54	26.57	12.42	71%	24%	5%
	7	12.00	7.83	3.94	2%	4%	25.54	31.48	15.96	80%	26%	-6%
	24	12.01	7.48	3.84	6%	9%	20.56	29.73	5.00	90%	9%	1%
	24	12.00	7.87	3.54	5%	10%	20.56	27.40	5.69	87%	9%	3%
	Freezing duration (hours)	Mass of solution (g)				NaCl Losses	Particle Concentration ( $\text{mg/kg}$ )			Distribution of Initial Particle Mass		
		Initial	Liquid	Ice	Losses		Initial	Liquid	Ice	Liquid	Ice	Losses
nPSL-200	2	12.00	6.29	4.71	8%		10.18	13.93	1.46	72%	6%	23%
	2	12.00	4.23	5.13	22%		10.18	10.81	2.68	37%	32%	31%
	5	12.04	5.10	6.15	7%		10.90	14.43	1.74	56%	8%	36%
	5	12.03	4.46	7.00	5%		10.90	14.99	1.61	51%	9%	40%
	7	12.02	6.09	6.08	-1%		10.95	13.75	1.38	64%	6%	30%
	7	12.02	5.17	6.39	4%		10.95	14.70	1.35	58%	7%	36%
	24	12.02	6.29	6.01	-2%		14.08	18.33	2.44	68%	9%	23%
	24	12.03	6.12	5.51	3%		14.08	18.84	2.52	68%	8%	24%
nPSL-200 + NaCl	2	10.31	8.17	1.99	2%	4%	9.16	9.77	3.19	85%	7%	9%
	2	12.11	8.21	3.83	1%	4%	9.16	10.19	3.89	75%	13%	11%
	5	12.02	7.51	4.14	3%	6%	9.24	9.25	3.21	63%	12%	25%
	5	12.03	7.94	3.69	3%	12%	9.24	8.28	2.67	59%	9%	32%
	7	12.01	7.60	3.70	6%	8%	8.01	8.25	2.75	65%	11%	24%
	7	12.01	8.26	3.42	3%	6%	8.01	7.54	3.01	65%	11%	25%
	24	12.02	7.39	3.88	6%	12%	8.76	5.74	1.63	40%	6%	54%
	24	12.02	8.33	3.38	3%	9%	8.76	5.50	2.14	44%	7%	50%

Table 1: Continued

	Freezing duration (hours)	Mass of solution (g)				NaCl Losses	Particle Concentration (mg/kg)			Distribution of Initial Particle Mass		
		Initial	Liquid	Ice	Losses		Initial	Liquid	Ice	Liquid	Ice	Losses
nPSL-200 + NaCl + SA	2	10.30	7.46	2.56	3%	11%	8.87	9.21	3.86	75%	11%	14%
	2	11.19	8.34	3.29	-4%	5%	8.87	9.83	3.86	83%	13%	5%
	5	11.13	7.79	3.30	0%	7%	8.95	9.83	4.78	77%	16%	7%
	5	11.63	8.36	3.27	0%	5%	8.95	10.06	4.78	81%	15%	4%
	7	10.88	7.56	3.28	0%	8%	8.96	9.87	3.32	77%	11%	12%
	7	12.01	8.67	5.48	-18%	3%	8.96	10.10	3.32	81%	17%	2%
	24	12.59	7.72	4.12	6%	15%	8.71	10.28	2.41	72%	9%	19%
	24	11.15	7.51	3.38	2%	6%	8.71	10.79	2.41	83%	8%	8%
nPS-360 + NaCl + SA	2	11.08	7.58	3.23	2%	11%	8.78	10.04	5.39	78%	18%	4%
	2	11.85	7.79	3.64	4%	10%	8.78	10.01	5.39	75%	19%	6%
	5	11.34	8.20	5.16	-18%	6%	10.25	10.81	3.79	76%	17%	7%
	5	10.80	8.66	2.66	-5%	6%	10.25	10.62	3.79	83%	9%	8%
	7	11.51	7.88	3.52	1%	8%	10.93	12.28	5.18	77%	14%	9%
	7	12.27	8.01	4.14	1%	8%	10.93	12.59	5.18	75%	16%	9%
	24	9.94	7.76	2.26	-1%	1%	10.68	12.62	1.00	92%	2%	6%
	24	10.76	7.65	2.56	5%	14%	10.68	12.78	1.00	85%	2%	13%
nPSL-350 + NaCl + SA	2	12.04	6.96	4.21	7%	11%	9.73	11.17	5.78	66%	21%	13%
	2	12.03	8.00	3.43	5%	7%	9.73	10.92	5.12	75%	15%	10%
	5	12.05	7.36	4.29	3%	6%	9.64	11.30	4.36	72%	16%	12%
	5	12.02	7.99	3.83	2%	4%	9.64	10.92	3.62	75%	12%	13%
	7	12.03	7.44	4.05	4%	9%	9.39	11.21	3.78	74%	14%	13%
	7	12.01	7.86	3.84	3%	6%	9.39	10.72	3.37	75%	11%	14%
	24	12.02	7.78	3.76	4%	10%	9.60	12.40	3.71	84%	12%	4%
	24	12.03	8.22	3.45	3%	9%	9.60	11.53	3.33	82%	10%	8%
μPS + NaCl + SA	2	12.00	7.93	3.77	3%	8%	4351	756	10396	11%	75%	14%
	2	12.00	8.28	3.38	3%	7%	4382	1063	9446	17%	61%	23%
	5	12.01	8.33	4.25	-5%	5%	4075	712	8016	12%	70%	18%
	5	12.01	8.83	3.67	-4%	-1%	4103	862	10948	15%	82%	3%
	7	12.02	8.09	3.40	4%	14%	4141	1065	9037	17%	62%	21%
	7	12.00	7.91	4.43	-3%	12%	4340	1545	8952	23%	76%	0%
	24	12.03	7.23	4.32	4%	NA	4451	427	9859	6%	80%	15%
	24	12.02	8.00	3.43	5%	6%	4443	707	11621	11%	75%	15%

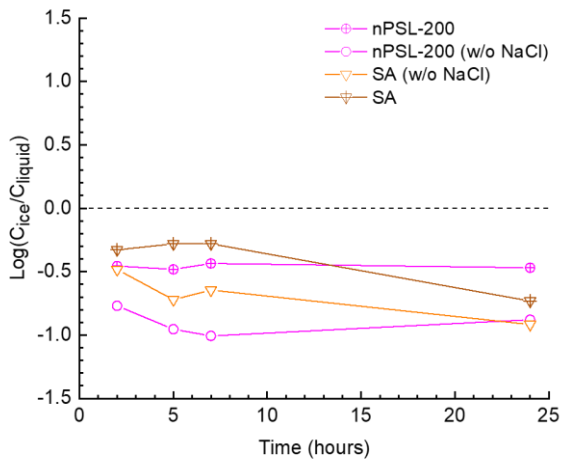


Figure S7: Logarithm of the partition coefficient between ice and liquid phase ( $C_{ice}/C_{liquid}$ ) of nanoplastic nPSL-200 and SA, dispersed in deionized water at pH 8 or NaCl  $35 \text{ g kg}^{-1}$  pH 8, as a function of duration of the freezing experiment

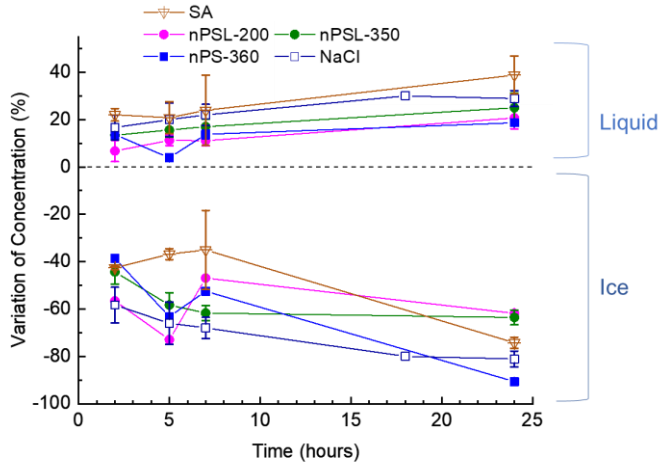


Figure S8: Variation of the concentrations of different species in liquid and ice, as a function of the duration of the freezing in the reactor. All experiments were conducted with  $35 \text{ g kg}^{-1}$  NaCl and  $50 \text{ mg kg}^{-1}$  SA at pH 8.

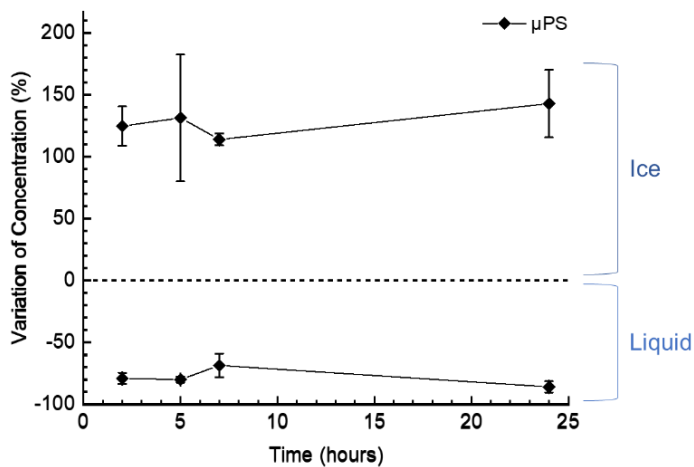


Figure S9: Variation of the concentration of polystyrene microplastics ( $\mu\text{PS}$ ) dispersed in  $35 \text{ g kg}^{-1}$  NaCl at pH 8, and recovered in liquid and ice, as a function of the duration of freezing in the reactor