THE EFFECT OF HEAT- AND SALT-TREATMENT ON THE STABILITY AND RHEOLOGICAL PROPERTIES OF CHICKPEA PROTEINS-STABILIZED EMULSIONS

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Declarations of interest: none.

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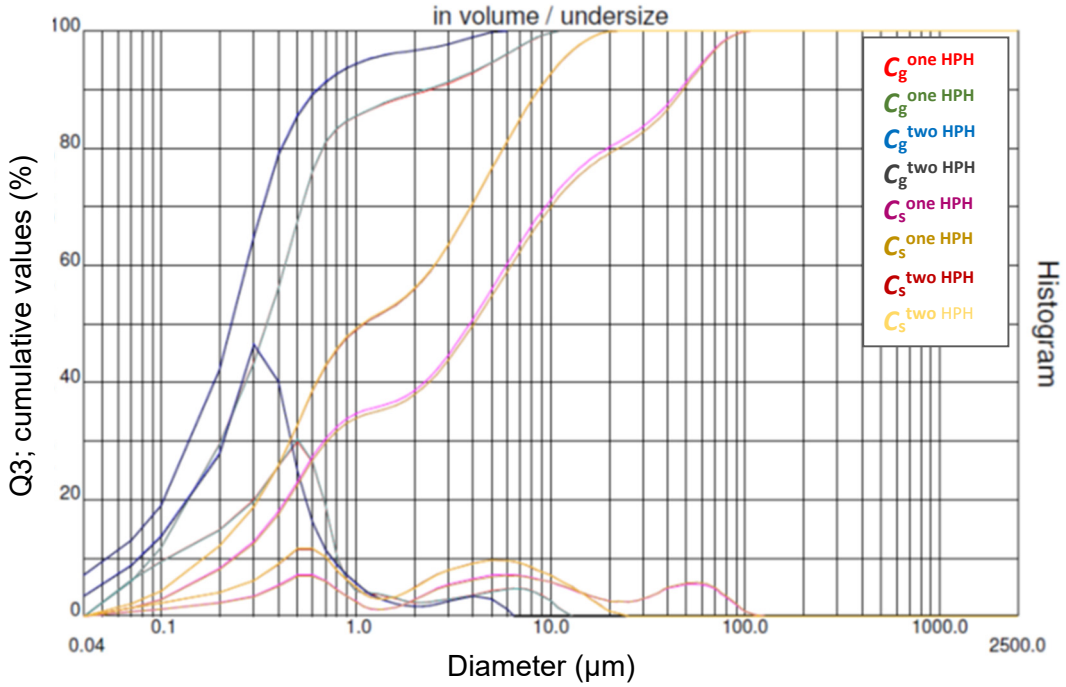
a)



b)

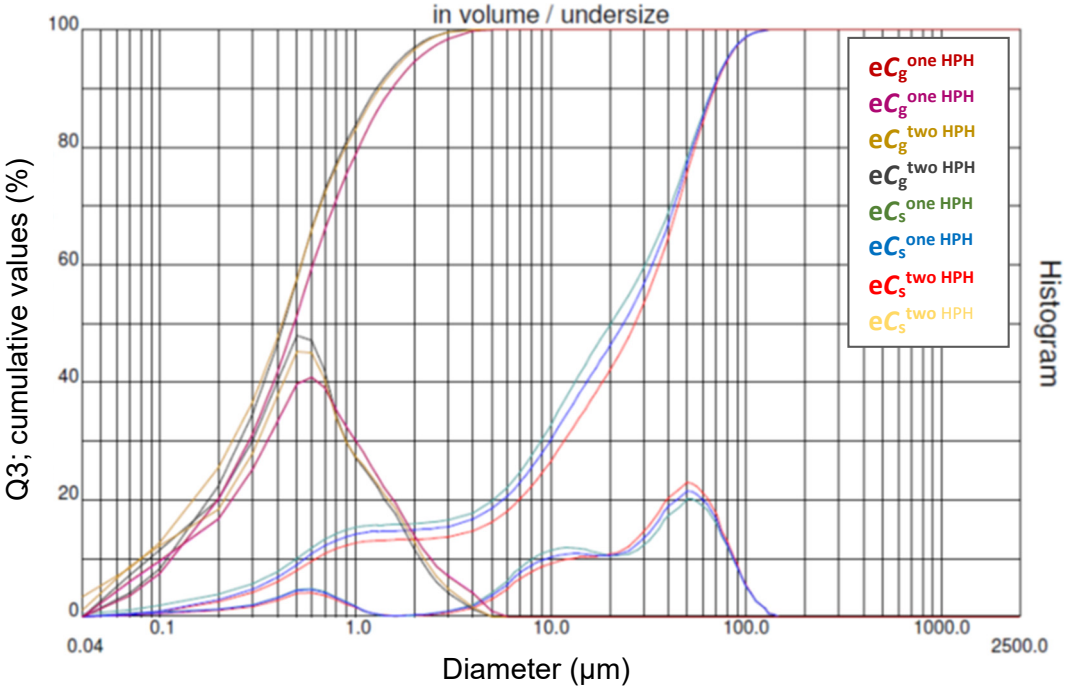
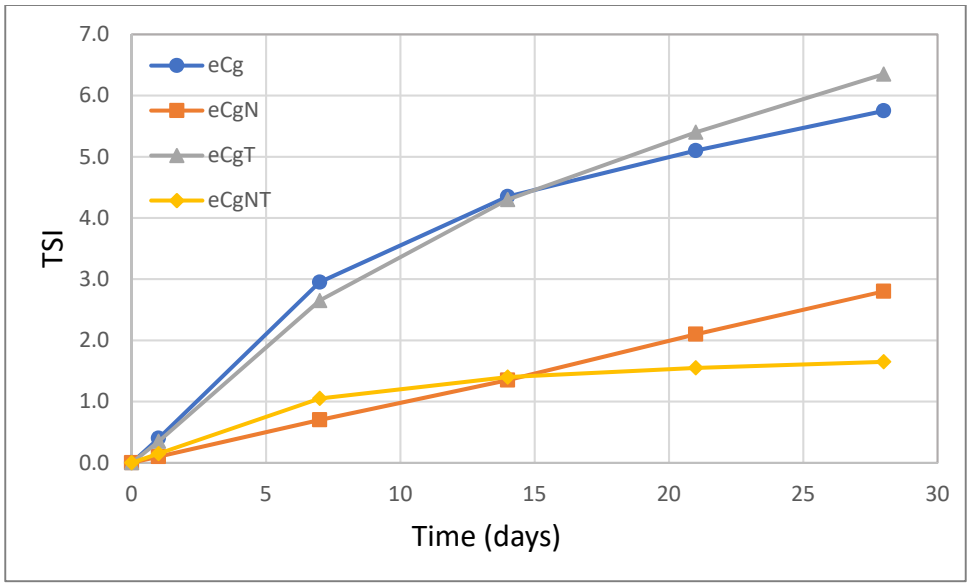


Figure S1. The PSD graphs (cumulative and histogram) for: CPC_s and CPC_g dispersions (C_s and C_g), pre-processed once ($^{one\ HPH}$) or twice ($^{two\ HPH}$) in high-pressure two stage homogenizer (a); and for corresponding emulsions, eC_s and eC_g, obtained from these dispersions (b).

a)



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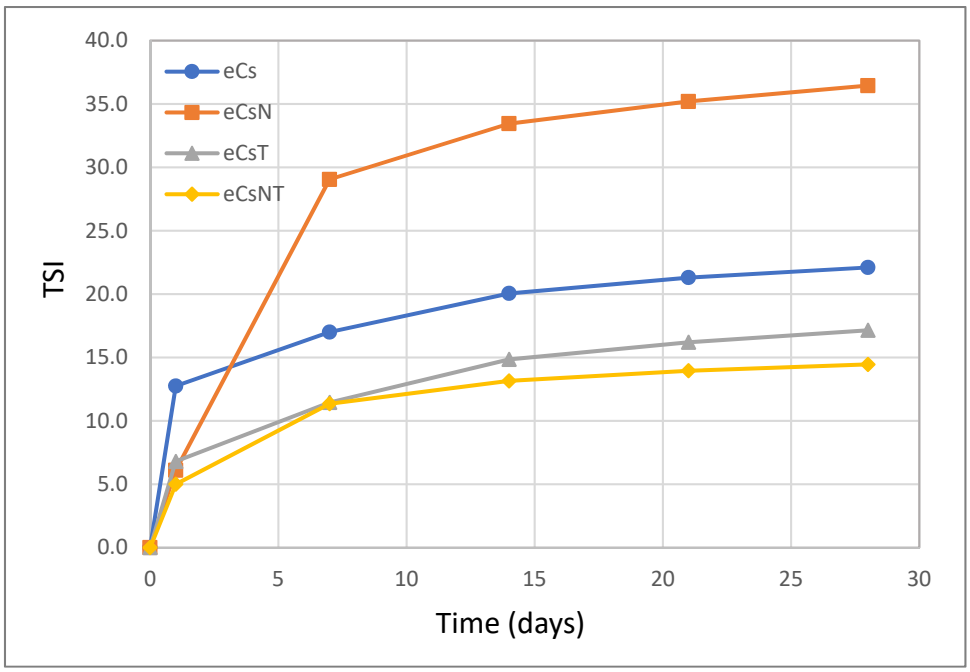
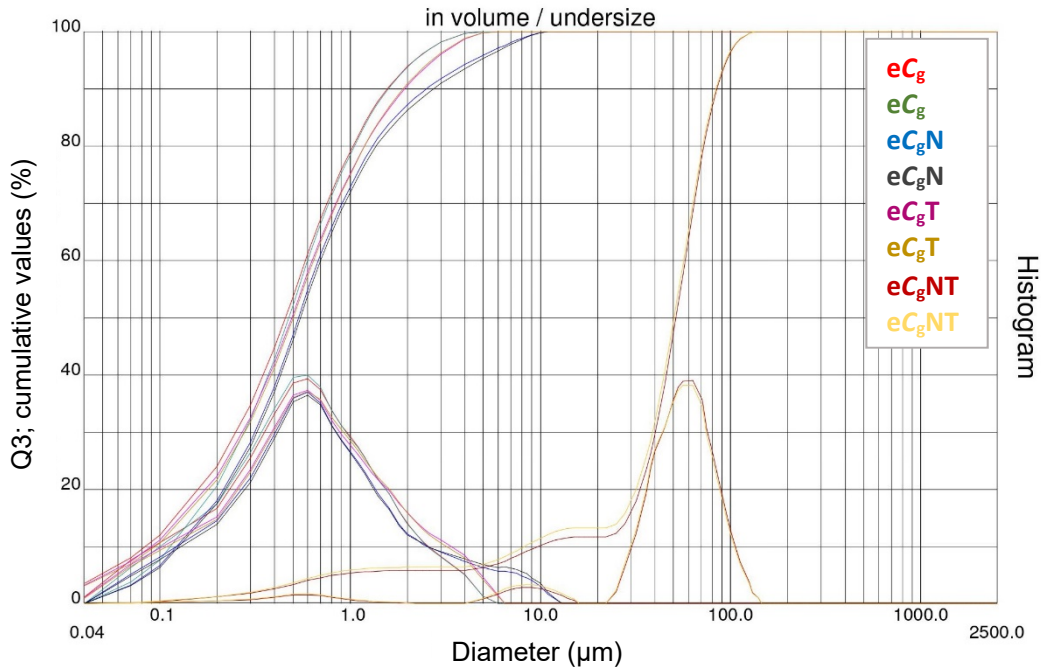


Figure S2. The Turbiscan Stability Index (TSI) kinetics of global destabilization for CPC_g- and CPC_s-stabilized emulsion (a and b, respectively), where: eC_g and eC_s – untreated samples; eC_gN and eC_sN – samples with 0.1M NaCl; eC_gT and eC_sT – sample heated to 95°C; eC_gNT and eC_sNT – samples with 0.1M NaCl heated to 95°C.

a)



b)

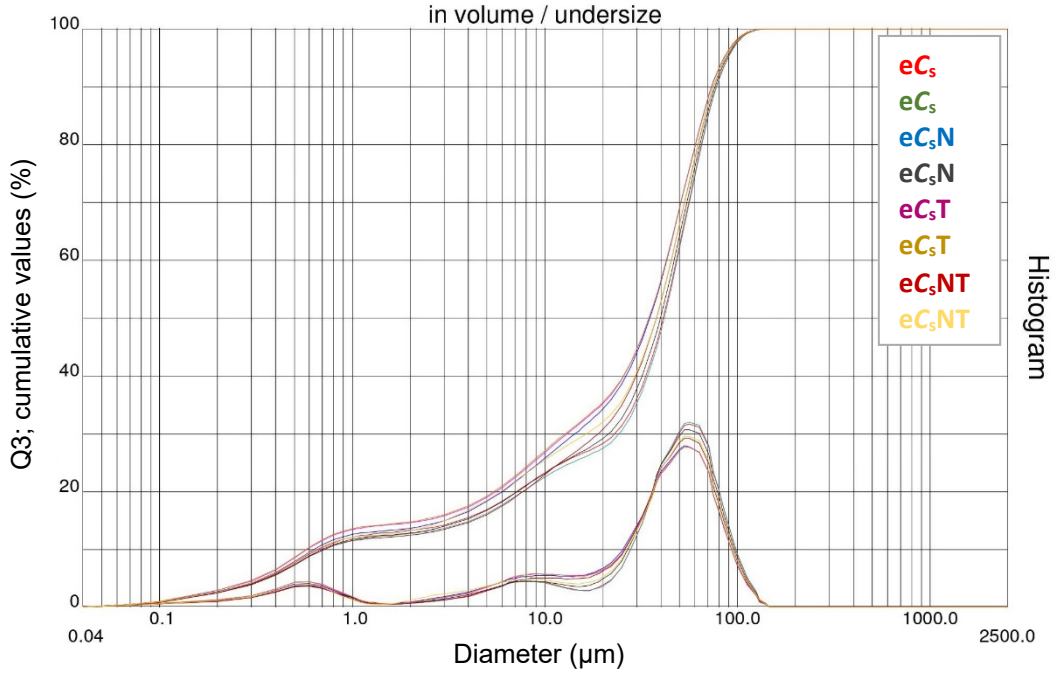


Figure S3. The PSD graphs (cumulative and histogram) for CPC_g- and CPC_s-stabilized emulsions (a and b, respectively), where: eC_g and eC_s – untreated samples; eC_gN and eC_sN – samples with 0.1M NaCl; eC_gT and eC_sT – samples heated to 95°C; eC_gNT and eC_sNT – samples with 0.1M NaCl heated to 95°C.

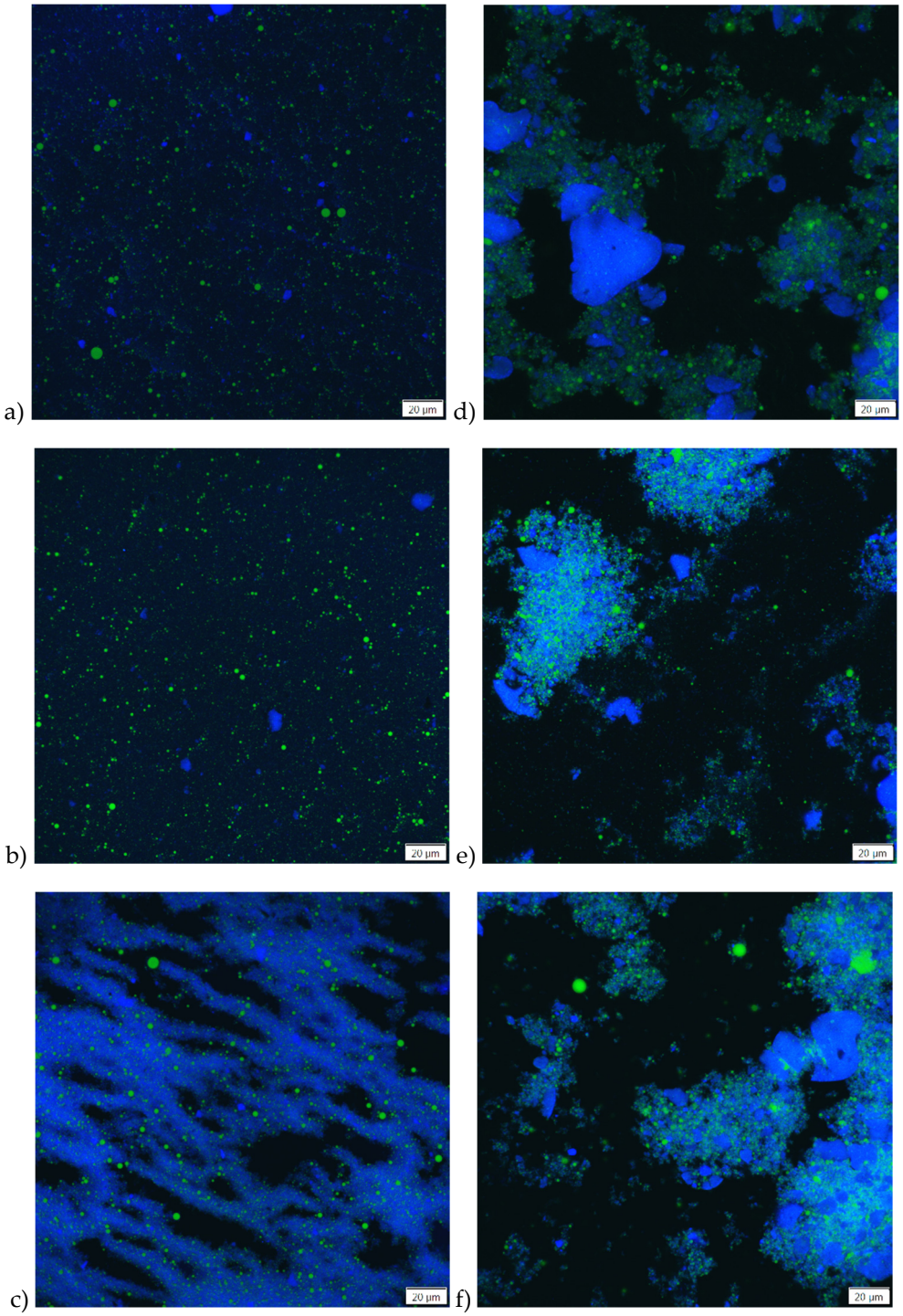


Figure S4. CLSM images of CPC_g-stabilized emulsions (a-c) and CPC_s-stabilized emulsions (d-f), where: a and d) untreated emulsions; b and e) emulsions heated to 95°C c and f) emulsions with 0.1M NaCl heated to 95°C. The green regions represent lipid and blue means the protein. The scale bar is 20 µm.

a)

b)

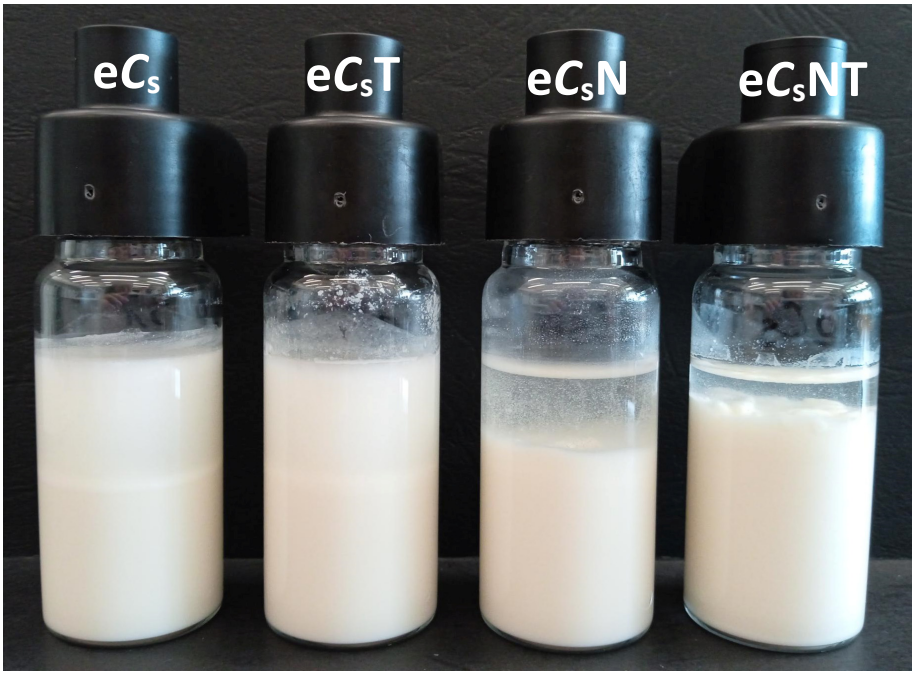


Figure S5. Photographs of CPC_g- and CPC_s-stabilized emulsion (a and b, respectively) after storage, where: eC_g and eC_s – untreated samples; eC_gN and eC_sN – samples with 0.1M NaCl; eC_gT and eC_sT – sample heated to 95°C; eC_gNT and eC_sNT – samples with 0.1M NaCl heated to 95°C. Emulsions are presented in Turbiscan glass cells.

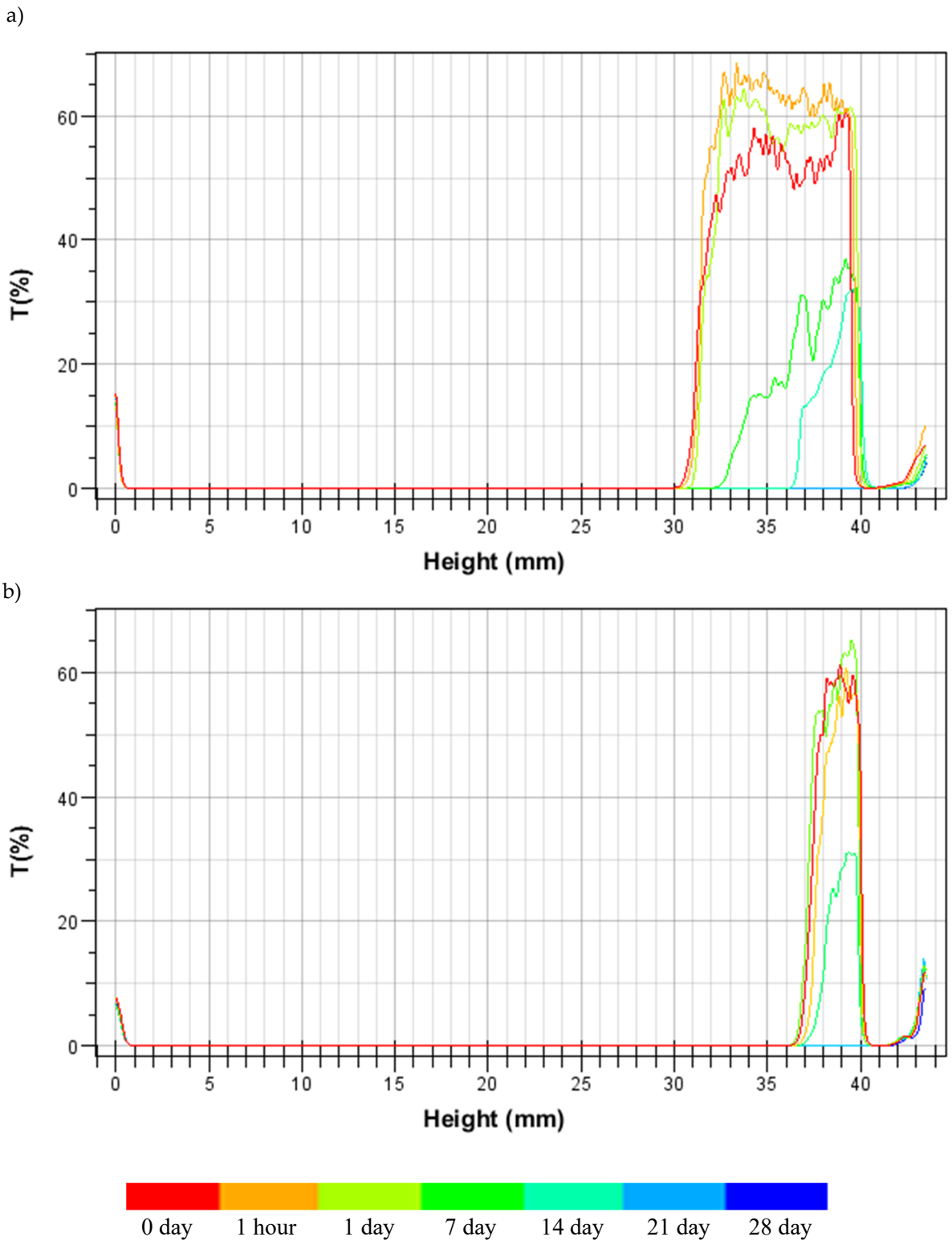


Figure S6. The transmission (%T) as a function of sample height for eC_s during storage within 28 days: sample with 0.1M NaCl (a), sample with 0.1M NaCl heated to 95°C (b).

Table S1. The results of the volume PSD (d_{10}, d_{50}, d_{90} and span) for CPC_g and CPC_s dispersions after once and twice passing through the high-pressure homogenizer and for emulsions prepared from these dispersions. Table shows mean values and statistics ANOVA (η^2 – coefficient indicating the extent of the effect of factors CPC and H).

Sample[1]	d_{10} [μm]	d_{50} [μm]	d_{90}[μm]	span [-]
$C_g^{\text{one HPH}}$	0.09^b	0.35^a	2.36^a	6.51^b
$C_g^{\text{two HPH}}$	0.05^a	0.23^a	0.64^a	2.56^a
$C_s^{\text{one HPH}}$	0.24^d	3.96^c	47.19^c	11.87^d
$C_s^{\text{two HPH}}$	0.17^c	1.10^b	8.72^b	7.82^c
Statistics ANOVA, η^2 [-]				
CPC	0.999	0.998	0.999	0.998
H	0.997	0.995	0.998	0.997
CPC*H	0.967	0.995	0.997	ns
$eC_g^{\text{one HPH}}$	0.10^a	0.45^a	1.44^a	2.96^a
$eC_g^{\text{two HPH}}$	0.11^a	0.46^a	1.42^a	2.85^a
$eC_s^{\text{one HPH}}$	0.53^b	21.92^b	67.76^b	3.08^a
$eC_s^{\text{two HPH}}$	0.64^b	27.08^b	69.05^b	2.53^a
Statistics ANOVA, η^2 [-]				
CPC	0.943	0.921	0.999	ns
H	ns	ns	ns	ns
CPC*H	ns	ns	ns	ns

$^{a, b, c, d}$ - mean values in columns denoted by different letters differ significantly ($p \leq 0.05$)

ANOVA factors: CPC – type of CPC (CPC_g or CPC_s), H – homogenization (one pass or two passes through high-pressure homogenizer)

[1] C_s and C_g – CPC_s and CPC_g dispersions; eC_s and eC_g – CPC_s- and CPC_g-stabilized emulsions; $^{\text{one HPH}}$ and $^{\text{two HPH}}$ – one pass or two passes of the sample through the HP homogenizer

Table S2. The calculated values of viscosity and rheological model parameters derived from fitting the shear curve according to the Newton, Ostwald-de Waele or Herschel–Bulkley model of the flow behavior for the CPC_g and CPC_s dispersions. Table shows mean values and standard deviations (SD) range, and statistics ANOVA.

Sample[1]	μ 100[§] [mPa·s]	VRI[†] [-]	Model[‡] (r ≥ 0,999)	μ [mPa·s]	k [mPa·s^n]	n [-]	τ_0 [mPa]
C_g	2.51 ±0.00^{abc}	0 ^{a}	Newton	2.51 ±0.00		1	
C_gN	2.73 ±0.01^{abc}	0.080 ±0.004^{a}	Ostwald-de Waele		3.22 ±0.02	0.964 ±0.002	
C_gT	2.83 ±0.02^{abc}	0 ^{a}	Newton	2.83 ±0.02		1	
C_gTN	19.18 ±0.61^{f}	0.655 ±0.006^{d}	Herschel-Bulkley		108 ±5	0.612 ±0.005	115 ±11
C_s	1.66 ±0.01^{a}	0 ^{a}	Newton	1.66 ±0.01		1	
C_sN	1.94 ±0.06^{ab}	0.069 ±0.019^{a}	Ostwald-de Waele		2.24 ±0.02	0.969 ±0.009	
C_sT	2.39 ±0.00^{abc}	0.069 ±0.009^{a}	Ostwald-de Waele		2.76 ±0.05	0.969 ±0.004	
C_sTN	3.09 ±0.26^{bc}	0.371 ±0.023^{b}	Herschel-Bulkley		5.6 ±0.8	0.866 ±0.014	8.2 ±1.1

$^{a, b, c, d, f}$ - mean values in columns denoted by different letters differ significantly ($p \leq 0.05$)

[1] C_g – water dispersion of CPC_g; C_s – water dispersion of CPC_s; C_gT and C_sT – C_g and C_s dispersions heated to 95°C; C_gN and C_sN – C_g and C_s dispersions with 0.1M NaCl; C_gNT and C_sNT – C_g and C_s dispersions with 0.1M NaCl heated to 95°C

[§] μ100 – viscosity at share rate = 100 s^{-1}

[†] the decreasing rate index (VRI) of viscosity: VRI=1-(μ100/μ10), where μ10 – viscosity at share rate = 10 s^{-1}

[‡] model: Newton: $\tau = \mu \cdot \dot{\gamma}$; Ostwald-de Waele: $\tau = k \cdot \dot{\gamma}^n$; Herschel-Bulkley: $\tau = \tau_0 + k \cdot \dot{\gamma}^n$, where: τ – shear stress, μ – viscosity coefficient, $\dot{\gamma}$ – shear rate, k – consistency index, n – flow index, τ_0 – yield stress; $\tau_0 \geq 0$ and $n < 1$ for a shear-thinning fluid, while for a Newtonian fluid $\tau_0 = 0$ and $n = 1$.