

## Supplementary material

### Effect of sulfate, citrate, and tartrate anions on the liquid-liquid equilibrium behavior of water + surfactant

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**Table S1.** Coefficients from binodal curves for the salt rich-phase.

| Salt            | Temperature (K) | Coefficient - (Equation 3) |           |          |
|-----------------|-----------------|----------------------------|-----------|----------|
|                 |                 | a                          | b         | c        |
| Sodium citrate  | 283             | 1.92E-04                   | -1.90E-03 | 4.38E-03 |
|                 | 293             | 1.90E-04                   | -1.94E-03 | 5.08E-03 |
|                 | 303             | 1.86E-04                   | -2.38E-03 | 8.48E-03 |
| Sodium sulfate  | 283             | 1.87E-04                   | -2.92E-03 | 1.37E-02 |
|                 | 293             | 1.81E-04                   | -2.88E-03 | 1.44E-02 |
|                 | 303             | 1.89E-04                   | -2.99E-03 | 1.33E-02 |
| Sodium tartrate | 283             | 1.89E-04                   | -1.67E-03 | 3.17E-03 |
|                 | 293             | 1.86E-04                   | -1.74E-03 | 3.63E-03 |
|                 | 303             | 1.88E-04                   | -1.72E-03 | 2.74E-03 |

**Table S2.** Coefficients from binodal curves for the Triton X-114 ® rich-phase.

| Salt            | Temperature (K) | Coefficient - (Equation 4) |           |          |           |          |
|-----------------|-----------------|----------------------------|-----------|----------|-----------|----------|
|                 |                 | d                          | e         | f        | g         | h        |
| Sodium citrate  | 283             | 1.75E+01                   | -1.68E+03 | 6.00E+04 | -9.43E+05 | 5.54E+06 |
|                 | 293             | 1.47E-01                   | 2.75E+01  | 2.42E+03 | -7.37E+04 | 8.16E+05 |
|                 | 303             | 1.12E-01                   | 2.62E+00  | 6.10E+02 | -3.64E+05 | 7.19E+05 |
| Sodium sulfate  | 283             | 9.33E+00                   | -1.30E+03 | 6.65E+04 | -1.50E+06 | 1.26E+07 |
|                 | 293             | 3.83E-01                   | -9.59E+01 | 9.61E+03 | -3.76E+05 | 5.35E+06 |
|                 | 303             | 1.09E-01                   | 4.60E+00  | 1.00E+03 | -8.85E+04 | 2.55E+06 |
| Sodium tartrate | 283             | 6.48E+00                   | -6.19E+02 | 2.19E+04 | -3.40E+05 | 1.98E+00 |
|                 | 293             | 8.86E-02                   | -1.63E+01 | 1.56E+03 | -4.63E+04 | 4.94E+05 |
|                 | 303             | 1.15E-01                   | 2.00E+00  | 5.92E+02 | -3.27E+04 | 5.96E+05 |

**Table S3.** Molar fractions of the tie lines for the system citrate + triton X-114 ® + water at 283.2 K.

| Overall Composition |              |          | Triton-rich Phase |              |          | Salt-rich Phase |              |          |
|---------------------|--------------|----------|-------------------|--------------|----------|-----------------|--------------|----------|
| sodium citrate      | Triton X-114 | water    | sodium citrate    | Triton X-114 | water    | sodium citrate  | Triton X-114 | water    |
| 0.002414            | 0.000532     | 0.997054 | 0.003165          | 0.003006     | 0.993829 | 0.002254        | 0.000005     | 0.997741 |
| 0.002834            | 0.000926     | 0.996239 | 0.003683          | 0.004645     | 0.991672 | 0.002624        | 0.000004     | 0.997371 |
| 0.003102            | 0.001274     | 0.995624 | 0.004063          | 0.005798     | 0.990139 | 0.002832        | 0.000004     | 0.997163 |
| 0.003543            | 0.001669     | 0.994788 | 0.004402          | 0.007075     | 0.988523 | 0.003278        | 0.000004     | 0.996718 |
| 0.003988            | 0.002134     | 0.993878 | 0.004625          | 0.008105     | 0.987270 | 0.003761        | 0.000004     | 0.996235 |
| 0.004309            | 0.002453     | 0.993238 | 0.004864          | 0.009356     | 0.985780 | 0.004112        | 0.000004     | 0.995885 |
| 0.004626            | 0.002806     | 0.992568 | 0.004841          | 0.009233     | 0.985926 | 0.004532        | 0.000003     | 0.995465 |

**Table S4.** Molar fractions of the tie lines for the system citrate + triton X-114 ® + water at 293.2 K.

| Overall Composition |              |          | Triton-rich Phase |              |          | Salt-rich Phase |              |          |
|---------------------|--------------|----------|-------------------|--------------|----------|-----------------|--------------|----------|
| sodium citrate      | Triton X-114 | water    | sodium citrate    | Triton X-114 | water    | sodium citrate  | Triton X-114 | water    |
| 0.001725            | 0.001648     | 0.996627 | 0.001937          | 0.005078     | 0.992985 | 0.001624        | 0.000005     | 0.998371 |
| 0.002283            | 0.002253     | 0.995464 | 0.002455          | 0.006581     | 0.990964 | 0.002193        | 0.000005     | 0.997803 |
| 0.002955            | 0.002900     | 0.994145 | 0.003037          | 0.008546     | 0.988417 | 0.002913        | 0.000004     | 0.997083 |
| 0.003553            | 0.003759     | 0.992689 | 0.003370          | 0.010016     | 0.986614 | 0.003662        | 0.000004     | 0.996334 |
| 0.004083            | 0.004121     | 0.991796 | 0.003848          | 0.012619     | 0.983533 | 0.004196        | 0.000003     | 0.995800 |

**Table S5.** Molar fractions of the tie lines for the system citrate + triton X-114 ® + water at 303.2 K.

| Overall Composition |              |          | Triton-rich Phase |              |          | Salt-rich Phase |              |          |
|---------------------|--------------|----------|-------------------|--------------|----------|-----------------|--------------|----------|
| sodium citrate      | Triton X-114 | water    | sodium citrate    | Triton X-114 | water    | sodium citrate  | Triton X-114 | water    |
| 0.000576            | 0.002504     | 0.996920 | 0.000635          | 0.006105     | 0.993261 | 0.000535        | 0.000006     | 0.999459 |
| 0.001164            | 0.003212     | 0.995625 | 0.001018          | 0.007507     | 0.991475 | 0.001272        | 0.000005     | 0.998723 |
| 0.002014            | 0.004301     | 0.993685 | 0.001826          | 0.010218     | 0.987956 | 0.002151        | 0.000004     | 0.997845 |
| 0.002954            | 0.005439     | 0.991607 | 0.002466          | 0.012835     | 0.984699 | 0.003312        | 0.000003     | 0.996685 |
| 0.003452            | 0.006145     | 0.990402 | 0.002749          | 0.014359     | 0.982893 | 0.003979        | 0.000003     | 0.996018 |

**Table S6.** Molar fractions of the tie lines for the system sulfate + triton X-114 ® + water at 283.2 K.

| Overall Composition |              |          | Triton-rich Phase |              |          | Salt-rich Phase |              |          |
|---------------------|--------------|----------|-------------------|--------------|----------|-----------------|--------------|----------|
| sodium citrate      | Triton X-114 | water    | sodium citrate    | Triton X-114 | water    | sodium citrate  | Triton X-114 | water    |
| 0.003422            | 0.000525     | 0.996053 | 0.004074          | 0.002772     | 0.993154 | 0.003270        | 0.000004     | 0.996726 |
| 0.003722            | 0.000703     | 0.995576 | 0.004312          | 0.003352     | 0.992336 | 0.003566        | 0.000004     | 0.996430 |
| 0.004336            | 0.001235     | 0.994429 | 0.005255          | 0.005652     | 0.989093 | 0.004079        | 0.000004     | 0.995917 |
| 0.004914            | 0.001487     | 0.993600 | 0.005393          | 0.006055     | 0.988552 | 0.004758        | 0.000003     | 0.995239 |
| 0.005553            | 0.001832     | 0.992615 | 0.005845          | 0.007577     | 0.986578 | 0.005460        | 0.000003     | 0.994537 |
| 0.006150            | 0.002168     | 0.991682 | 0.006058          | 0.008398     | 0.985544 | 0.006182        | 0.000003     | 0.993815 |
| 0.006400            | 0.002441     | 0.991159 | 0.006255          | 0.009210     | 0.984535 | 0.006452        | 0.000003     | 0.993545 |

**Table S7.** Molar fractions of the tie lines for the system sulfate + triton X-114 ® + water at 293.2 K.

| Overall Composition |                 |          | Triton-rich Phase |                 |          | Salt-rich Phase   |                 |          |
|---------------------|-----------------|----------|-------------------|-----------------|----------|-------------------|-----------------|----------|
| sodium<br>citrate   | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    |
| 0.002061            | 0.001501        | 0.996437 | 0.002497          | 0.004940        | 0.992563 | 0.001872          | 0.000005        | 0.998123 |
| 0.002804            | 0.001801        | 0.995395 | 0.002951          | 0.005983        | 0.991066 | 0.002741          | 0.000004        | 0.997255 |
| 0.004258            | 0.002800        | 0.992941 | 0.004077          | 0.008678        | 0.987245 | 0.004344          | 0.000003        | 0.995652 |
| 0.005121            | 0.003398        | 0.991481 | 0.004824          | 0.011606        | 0.983571 | 0.005243          | 0.000003        | 0.994754 |
| 0.005869            | 0.003890        | 0.990241 | 0.005120          | 0.013043        | 0.981836 | 0.006187          | 0.000003        | 0.993811 |

**Table S8.** Molar fractions of the tie lines for the system sulfate + triton X-114 ® + water at 303.2 K.

| Overall Composition |                 |          | Triton-rich Phase |                 |          | Salt-rich Phase   |                 |          |
|---------------------|-----------------|----------|-------------------|-----------------|----------|-------------------|-----------------|----------|
| sodium<br>citrate   | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    |
| 0.001478            | 0.002739        | 0.995783 | 0.001348          | 0.007447        | 0.991206 | 0.001553          | 0.000005        | 0.998442 |
| 0.002918            | 0.003729        | 0.993353 | 0.002571          | 0.010533        | 0.986896 | 0.003108          | 0.000004        | 0.996888 |
| 0.003660            | 0.004197        | 0.992143 | 0.003109          | 0.012281        | 0.984610 | 0.003946          | 0.000004        | 0.996051 |
| 0.004517            | 0.004824        | 0.990659 | 0.003608          | 0.014389        | 0.982003 | 0.004975          | 0.000003        | 0.995022 |
| 0.005284            | 0.005395        | 0.989320 | 0.003919          | 0.015942        | 0.980139 | 0.005983          | 0.000003        | 0.994015 |

**Table S9.** Molar fractions of the tie lines for the system tartrate + triton X-114 ® + water at 283.2 K.

| Overall Composition |                 |          | Triton-rich Phase |                 |          | Salt-rich Phase   |                 |          |
|---------------------|-----------------|----------|-------------------|-----------------|----------|-------------------|-----------------|----------|
| sodium<br>citrate   | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    |
| 0.005035            | 0.001275        | 0.993690 | 0.006649          | 0.008980        | 0.984372 | 0.004769          | 0.000004        | 0.995227 |
| 0.005286            | 0.001436        | 0.993279 | 0.006832          | 0.009648        | 0.983520 | 0.005016          | 0.000004        | 0.994980 |
| 0.005875            | 0.001782        | 0.992343 | 0.007401          | 0.011884        | 0.980714 | 0.005606          | 0.000004        | 0.994390 |
| 0.006245            | 0.002001        | 0.991754 | 0.007349          | 0.011671        | 0.980980 | 0.006016          | 0.000004        | 0.993980 |
| 0.006465            | 0.002120        | 0.991415 | 0.007502          | 0.012301        | 0.980197 | 0.006250          | 0.000003        | 0.993747 |
| 0.006638            | 0.002220        | 0.991143 | 0.007654          | 0.012940        | 0.979407 | 0.006428          | 0.000003        | 0.993569 |

**Table S10.** Molar fractions of the tie lines for the system tartrate + triton X-114 ® + water at 293.2 K.

| Overall Composition |                 |          | Triton-rich Phase |                 |          | Salt-rich Phase   |                 |          |
|---------------------|-----------------|----------|-------------------|-----------------|----------|-------------------|-----------------|----------|
| sodium<br>citrate   | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    |
| 0.002197            | 0.001258        | 0.996545 | 0.003623          | 0.006995        | 0.989382 | 0.001886          | 0.000005        | 0.998109 |
| 0.003127            | 0.001852        | 0.995021 | 0.004036          | 0.007955        | 0.988008 | 0.002852          | 0.000005        | 0.997143 |
| 0.004369            | 0.002674        | 0.992957 | 0.004791          | 0.010127        | 0.985082 | 0.004218          | 0.000004        | 0.995778 |
| 0.005230            | 0.003200        | 0.991570 | 0.005181          | 0.011505        | 0.983314 | 0.005249          | 0.000004        | 0.994747 |
| 0.006603            | 0.004099        | 0.989298 | 0.005699          | 0.013580        | 0.980721 | 0.006994          | 0.000003        | 0.993003 |

**Table S11.** Molar fractions of the tie lines for the system tartrate + triton X-114 ® + water at 303.2 K.

| Overall Composition |                 |          | Triton-rich Phase |                 |          | Salt-rich Phase   |                 |          |
|---------------------|-----------------|----------|-------------------|-----------------|----------|-------------------|-----------------|----------|
| sodium<br>citrate   | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    | sodium<br>citrate | Triton<br>X-114 | water    |
| 0.001025            | 0.002792        | 0.996182 | 0.000838          | 0.006050        | 0.993112 | 0.001185          | 0.000006        | 0.998809 |
| 0.001553            | 0.003299        | 0.995149 | 0.001267          | 0.007166        | 0.991568 | 0.001796          | 0.000005        | 0.998198 |
| 0.002111            | 0.003812        | 0.994077 | 0.001603          | 0.008006        | 0.990391 | 0.002571          | 0.000005        | 0.997424 |
| 0.002679            | 0.004358        | 0.992962 | 0.001996          | 0.008925        | 0.989079 | 0.003331          | 0.000005        | 0.996665 |
| 0.003271            | 0.004911        | 0.991818 | 0.002281          | 0.009564        | 0.988156 | 0.004316          | 0.000004        | 0.995680 |
| 0.003886            | 0.005478        | 0.990637 | 0.002946          | 0.011144        | 0.985910 | 0.004793          | 0.000004        | 0.995203 |
| 0.004520            | 0.006042        | 0.989438 | 0.003262          | 0.012034        | 0.984705 | 0.005789          | 0.000003        | 0.994208 |

**Table S12.** Thickness of immobilized water spherical shell surrounding the ion and effective radius of anions.

| Anion  | V (cm <sup>3</sup> mol <sup>-1</sup> ) | r (nm) | Δr (nm) | (r + Δr) (nm) |
|--|--|--------|---------|---------------|
| C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> <sup>3-</sup> | 72.0                                   | 0.3056 | 0.0301  | 0.3357        |
| SO <sub>4</sub> <sup>2-</sup>                              | 36.5                                   | 0.2437 | 0.0375  | 0.2812        |
| C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> <sup>2-</sup> | 60.1                                   | 0.2878 | 0.0243  | 0.3121        |