Supporting Information

Shape and structure controlling of calcium oxalate crystals by combinations of additives

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Figure S1. SEM image to show effects of D-aspartic acid on CaOx formation at pH 7. Panels (A1), (A2), (A3), (A4), (A5), (A6) show addition of D-aspartic acid at 0.1, 0.2, 0.4, 0.8, 1, 2 mmol/L.

Figure S2. SEM image to show effects of L-aspartic acid on CaOx formation at pH 7. Panels (A1), (A2), (A3), (A4), (A5), (A6) show addition of L-aspartic acid at 0.1, 0.2, 0.4, 0.8, 1, 2 mmol/L.
Figure S3. SEM image to show effects of Mg$^{2+}$ on CaOx formation at pH 7. Panels (A1), (A2), (A3), (A4), (A5), (A6) show addition of Mg$^{2+}$ at 0.1, 0.2, 0.4, 0.8, 1, 2 mmol/L.

Figure S4. SEM image to show effects of Na$_3$Citrate on CaOx formation at pH 7. Panels (A1), (A2), (A3), (A4), (A5) show addition of Na$_3$Citrate at 0.1, 0.2, 0.4, 0.8, 1 mmol/L. Panel (B) shows CaOx formation in the absence of additives.
Figure S5. SEM images of COM formed at different pH. Panels (A1), (A2), (A3), (A4), CaOx. Panels (B1), (B2), (B3), (B4), CaOx with addition of D-aspartic acid (2 mmol/L). Panels (C1), (C2), (C3), (C4), CaOx with addition of L-aspartic acid (2 mmol/L). Panels (D1), (D2), (D3), (D4), CaOx with addition of Mg$^{2+}$ (2 mmol/L). Panels (E1), (E2), (E3), (E4), CaOx with addition of Na$_3$Citrate (1 mmol/L). Numbers 1, 2, 3, 4 refer to pH 4, pH 5, pH 6, and pH 7, respectively.

Figure S6. Thermogravimetric analysis of CaOx formed in the presence or absence of additives. Commercial chiral aspartic acid from Sigma Aldrich was also tested to show that no detectable amount of aspartic acid was included in COM crystals.
Figure S7. SEM images of COM formation in the presence or absence of additives. Panels (A1), (A2), (A3), (A4), CaOx. Panels (B1), (B2), (B3), (B4), CaOx with addition of D-aspartic acid (2 mmol/L). Panels (C1), (C2), (C3), (C4), CaOx with addition of L-aspartic acid (2 mmol/L). Panels (D1), (D2), (D3), (D4), CaOx with addition of Mg$^{2+}$ (2 mmol/L). Panels (E1), (E2), (E3), (E4), CaOx with addition of Na$_3$Citrate (1 mmol/L). Numbers 1, 2, 3, 4, 5 refer to 0.25 hour, 0.5 hour, 1 hour, 2 hours, 4 hours, respectively.

Figure S8. SEM image of CaOx formed in the presence of 2 mmol/L L-aspartic acid and crystallization time elongated to 10 days.
Figure S9. Energy dispersive spectra (left) and SEM image (right) of CaOx formed in the presence of 2 mmol/L Mg$^{2+}$ in solution at pH 7.

Figure S10. Thermogravimetric analysis of CaOx in the present of casein.
Table S1. Weight loss (%) of CaOx formed in the presence or absence of additives.

| Sample                                           | 40-250 °C | 250-550 °C | 550-800 °C | Total  |
|--------------------------------------------------|-----------|------------|------------|--------|
| CaOx only                                        | 14.5      | 18.4       | 27.3       | 60.2   |
| D-aspartic acid from Sigma                        | 20.5      | 66.1       | 8.2        | 94.8   |
| L-aspartic acid from Sigma                        | 22.5      | 62.7       | 10.3       | 95.5   |
| CaOx formed in the presence of D-aspartic acid    | 14.7      | 17.5       | 26.7       | 58.9   |
| CaOx formed in the presence of L-aspartic acid    | 14.5      | 18.4       | 27.1       | 60.0   |
| CaOx formed in the presence of Mg²⁺              | 14.1      | 18.0       | 26.5       | 58.6   |
| CaOx formed in the presence of Na₃Citrate         | 16.0      | 18.9       | 26.9       | 61.8   |

Table S2. Weight loss (%) of CaOx in the presence of casein.

| Sample                                           | 40-250 °C | 250-550 °C | 550-800 °C | Total  |
|--------------------------------------------------|-----------|------------|------------|--------|
| CaOx only                                        | 14.5      | 18.4       | 27.3       | 60.2   |
| Casein from Sigma                                | 14.7      | 60.8       | 17.3       | 92.8   |
| CaOx formed in the presence of 4 g/L Casein      | 18.2      | 36.9       | 17.6       | 72.7   |
| CaOx formed in the presence of 2 g/L Casein      | 20.0      | 32.5       | 17.9       | 70.4   |
| CaOx formed in the presence of 0.8 g/L Casein    | 17.3      | 33.3       | 17.2       | 67.8   |
| CaOx formed in the presence of 0.2 g/L Casein    | 16.7      | 27.5       | 20.3       | 64.5   |
| CaOx formed in the presence of 0.1 g/L Casein    | 15.6      | 26.7       | 20.7       | 63.0   |

Table S3. Binding energy (eV) of CaOx formed in the presence or absence of additives.

| Sample                                           | C 1s  | Ca 2p | N 1s  | O 1s  | Mg 1s |
|--------------------------------------------------|-------|-------|-------|-------|-------|
| CaOx only                                        | 284.8 | 347.3 | 400.2 | 532.1 | 1308.2|
| CaOx formed in the presence of Casein            | 284.8 | 347.2 | 399.7 | 531.5 | 1299.7|
| CaOx formed in the presence of Casein and Mg²⁺   | 284.8 | 347.4 | 399.8 | 531.8 | 1301.9|
| CaOx formed in the presence of Casein and Na₃Citrate | 284.8 | 347.5 | 399.8 | 531.8 | 1309.2|