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**Supporting information for article:**

# Ce-exchange capacity of zeolite L in different cationic forms: a structural investigation

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**Table S1** XRF and LOI/TG analyses of K-LTL, Na-LTL and Na-LTL-80°C.

| | LOI/TG | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $K_2O$ | $TiO_2$ | MnO | $Fe_2O_3$ |
|---|---|---|---|---|---|---|---|---|---|
| K-LTL | 10.92 | 0.45 | 0 | 16.49 | 57.01 | 15.06 | 0.01 | 0.00 | 0.05 |
| Na-LTL | 12.51 | 3.28 | 0 | 17.33 | 56.89 | 10.09 | 0.02 | 0.00 | 0.03 |
| Na-LTL-80°C | 12.46 | 3.20 | 0.13 | 16.69 | 56.57 | 9.93 | 0.02 | 0.00 | 0.03 |

**Table S2** EDS analysis recalculated on the basis of $H_2O$ and $NH_4$ contents obtained by TG and elemental analysis, respectively.

| | $SiO_2$ | $K_2O$ | $Al_2O_3$ | $Ce_2O_3$ | $Na_2O$ | $H_2O$ | $(NH_4)_2O$ | $SiO_2$ esd | $K_2O$ esd | $Al_2O_3$ esd | $Ce_2O_3$ esd | $Na_2O$ esd |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $NH_4$-LTL | 60.49 | 3.97 | 17.33 | / | / | 11.46 | 6.67 | 0.06 | 0.08 | 0.07 | / | / |
| K-Ce-LTL | 55.29 | 8.57 | 16.74 | 6.58 | 0.23 | 12.60 | / | 0.16 | 0.06 | 0.06 | 0.14 | 0.02 |
| Na-Ce-LTL | 57.82 | 8.49 | 16.74 | 7.09 | 0.16 | 12.70 | / | 0.17 | 0.06 | 0.06 | 0.02 | 0.02 |
| $NH_4$-Ce-LTL | 57.02 | 3.03 | 16.28 | 6.77 | / | 13.29 | 3.60 | 0.10 | 0.06 | 0.08 | 0.19 | / |
| $NH_4$-Ce-LTL-rev | 74.42 | 4.03 | 20.77 | 0.71 | / | 11.63 | 6.62 | 0.09 | 0.02 | 0.03 | 0.05 | / |

**Table S3** Nitrogen (%) content from elemental analysis, and calculated $NH_4^+$ amount (%).

| Name | N % | $NH_4$ % |
|---|---|---|
| $NH_4$-LTL | 3.59 | 4.62 |
| $NH_4$-Ce-LTL | 1.99 | 2.56 |
| $NH_4$-Ce-LTL-rev | 3.56 | 4.58 |

**Table S4** $H_2O$ amount from L.O.I. or TG (measured at 290 °C) in the LTL samples.

| Sample | Technique | Water amount (%) |
|---|---|---|
| *K-LTL* | TG | 10.92 |
| *Na-LTL* | TG | 12.51 |
| *Na-LTL-80°C* | L.O.I. | 12.46 |
| *$NH_4$-LTL* | TG | 11.46 |
| *K-Ce-LTL* | TG | 12.60 |
| *Na-Ce-LTL* | TG | 12.70 |
| *$NH_4$-Ce-LTL* | TG | 13.29 |
| *$NH_4$-Ce-LTL-rev* | TG | 11.63 |

**Table S5** Structural refinement parameters of the LTL samples.

| | *K-LTL* | *Na-LTL* | *$NH_4$-LTL* | *K-Ce-LTL* | *Na-Ce-LTL* | *$NH_4$-Ce-LTL* |
|---|---|---|---|---|---|---|
| $R_{wp}$ (%) | 7.76 | 8.94 | 7.78 | 7.92 | 7.69 | 7.46 |
| $R_p$ (%) | 5.62 | 6.53 | 5.70 | 5.66 | 5.51 | 5.34 |
| $R_F^2$ (%) | 7.66 | 8.73 | 9.31 | 8.91 | 8.90 | 9.08 |
| $N_{obs}$ | 1641 | 1680 | 1651 | 1632 | 1631 | 1646 |
| $N_{var}$ | 67 | 67 | 67 | 67 | 67 | 67 |

**Table S6** Atomic coordinates, occupancy factors and isotropic thermal parameters of sample *K-LTL*.

| Site | | x/*a* | y/*b* | z/*c* | Occupancy factor | $U_{ISO}$ |
|---|---|---|---|---|---|---|
| Si1 | $Si^{4+}$ | 0.0932(1) | 0.3570(1) | 1/2 | 1 | 0.0125(2) |
| Si2 | $Si^{4+}$ | 0.1655(1) | 0.4980(1) | 0.2118(2) | 1 | 0.0125(2) |
| O1 | $O^{2-}$ | 0 | 0.2711(3) | 1/2 | 1 | 0.0254(5) |
| O2 | $O^{2-}$ | 0.1639(2) | 0.3277(3) | 1/2 | 1 | 0.0254(5) |
| O3 | $O^{2-}$ | 0.2628(1) | 0.5257(2) | 0.2573(5) | 1 | 0.0254(5) |
| O4 | $O^{2-}$ | 0.1026(2) | 0.4138(1) | 0.3291(3) | 1 | 0.0254(5) |
| O5 | $O^{2-}$ | 0.4246(1) | 0.8493(2) | 0.2766(5) | 1 | 0.0254(5) |
| O6 | $O^{2-}$ | 0.1437(2) | 0.4762(2) | 0 | 1 | 0.0254(5) |
| KB | $K^{+}$ | 1/3 | 2/3 | 1/2 | 1 | 0.026(1) |
| KC | $K^{+}$ | 0 | 1/2 | 1/2 | 0.954(4) | 0.027(1) |
| KD | $K^{+}$ | 0 | 0.2999(2) | 0 | 0.826(3) | 0.073(1) |
| W1 | O | 0.0595(7) | 0.119(1) | 1/2 | 0.333 | 0.13 |
| W2 | O | 0 | 0.127(3) | 1/2 | 0.166 | 0.13 |
| W3 | O | 0 | -0.1430(2) | 0.2019(6) | 0.5 | 0.13 |
| W4 | O | 0 | 0 | 0.210(4) | 0.58(1) | 0.13 |
| W5 | O | 0.1261(2) | 0.2523(4) | 0 | 1 | 0.13 |
| W6 | O | 0 | 0.0946(6) | 0 | 0.307(5) | 0.13 |

**Table S7** Selected framework and extraframework distances of sample *K-LTL*.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Si1_O1 | 1.649(3) | Si1_O2 | 1.635(2) | Si1_O4 x2 | 1.611(2) | Si2_O3 | 1.633(2) |
| Si2_O4 | 1.649(2) | Si2_O5 | 1.648(2) | Si2_O6 | 1.644(1) | | |
| KB_O3 x6 | 2.894(4) | | | | | | |
| KC_O4 x8 | 3.270(2) | KC_O5 x4 | 2.929(3) | | | | |
| KD_O4 x4 | 3.181(3) | KD_O6 x2 | 2.985(4) | KD_W3 x2 | 3.257(5) | KD_W5 x2 | 2.857(3) |
| W1_W2 x2 | 3.00(4) | W1_W3 x4 | 2.628(3) | W1_W4 x2 | 2.89(3) | | |
| W2_O1 | 2.65(6) | W2_W1 x2 | 3.00(4) | W2_W4 x2 | 3.19(5) | | |
| W3_KD | 3.257(5) | W3_W1 x2 | 2.628(3) | W3_W3 x2 | 2.628(3) | W3_W4 | 2.629(4) |
| W3_W5 x2 | 2.656(5) | W3_W6 x2 | 2.769(4) | | | | |
| W4_W1 x6 | 2.89(3) | W4_W2 x6 | 3.19(5) | W4_W3 x6 | 2.629(4) | W4_W4 | 3.16(6) |
| W5_KD x2 | 2.857(3) | W5_W3 x4 | 2.656(5) | W5_W6 x2 | 2.655(4) | | |
| W6_W3 x4 | 2.769(4) | W6_W5 x2 | 2.655(4) | W6_W6 x2 | 3.01(2) | | |

**Table S8** Atomic coordinates, occupancy factors and isotropic thermal parameters of sample *Na-LTL*.

| Site | | x/*a* | y/*b* | z/*c* | Occupancy factor | $U_{ISO}$ |
|---|---|---|---|---|---|---|
| Si1 | $Si^{4+}$ | 0.0929(1) | 0.3560(1) | 1/2 | 1 | 0.019(1) |
| Si2 | $Si^{4+}$ | 0.1661(1) | 0.4986(1) | 0.2123(2) | 1 | 0.019(1) |
| O1 | $O^{2-}$ | 0 | 0.2671(3) | 1/2 | 1 | 0.0245(6) |
| O2 | $O^{2-}$ | 0.1616(2) | 0.3233(4) | 1/2 | 1 | 0.0245(6) |
| O3 | $O^{2-}$ | 0.2627(1) | 0.5255(3) | 0.2579(5) | 1 | 0.0245(6) |
| O4 | $O^{2-}$ | 0.1032(2) | 0.4138(2) | 0.3280(3) | 1 | 0.0245(6) |
| O5 | $O^{2-}$ | 0.4243(1) | 0.8486(2) | 0.2811(6) | 1 | 0.0245(6) |
| O6 | $O^{2-}$ | 0.1429(3) | 0.4743(3) | 0 | 1 | 0.0245(6) |
| KB | $K^{+}$ | 1/3 | 2/3 | 1/2 | 1 | 0.021(1) |
| KC | $K^{+}$ | 0 | 1/2 | 1/2 | 0.939(4) | 0.018(1) |
| KD | $K^{+}$ | 0 | 0.2966(4) | 0 | 0.639(4) | 0.107(2) |
| W1 | O | 0.066(1) | 0.132(2) | 1/2 | 0.333 | 0.13 |
| W2 | O | 0 | 0.125(4) | 1/2 | 0.1666 | 0.13 |
| W3 | O | 0 | -0.1373(3) | 0.1947(4) | 0.5 | 0.13 |
| W4 | O | 0 | 0 | 0.3026(23) | 0.170(1) | 0.13 |
| W5 | O | 0.1214(1) | 0.2427(3) | 0 | 1 | 0.13 |
| W6 | O | 0 | 0.0833(2) | 0 | 0.422(6) | 0.13 |

**Table S9** Selected framework and extraframework distances of sample *Na-LTL*.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Si1_O1 | 1.672(3) | Si1_O2 | 1.648(3) | Si1_O4 x2 | 1.624(2) | Si2_O3 | 1.623(2) |
| Si2_O4 | 1.649(3) | Si2_O5 | 1.653(2) | Si2_O6 | 1.656(2) | | |
| KB_O3 x6 | 2.893(4) | | | | | | |
| KC_O4 x8 | 3.284(3) | KC_O5 x4 | 2.918(4) | | | | |
| KD_O4 x4 | 3.200(4) | KD_O6 x2 | 2.996(6) | KD_W3 x2 | 3.273(8) | KD_W5 x2 | 2.856(5) |
| W1_W2 x2 | 3.11(4) | W1_W3 x4 | 2.623(3) | W1_W4 x2 | 2.57(3) | | |
| W2_O1 | 2.61(7) | W2_W1 x2 | 3.11(4) | W2_W4 x2 | 2.73(6) | | |
| W3_KD | 3.273(8) | W3_W1 x2 | 2.623(3) | W3_W3 x2 | 2.523(5) | W3_W4 | 2.650(5) |
| W3_W5 x2 | 2.559(4) | W3_W6 x2 | 2.644(3) | | | | |
| W4_W1 x6 | 2.57(3) | W4_W2 x6 | 2.73(6) | W4_W3 x6 | 2.650(5) | W4_W4 | 2.97(4) |
| W4_W6 x6 | 2.75(1) | | | | | | |
| W5_KD x2 | 2.856(5) | W5_W3 x4 | 2.559(4) | W5_W6 x2 | 2.648(4) | | |
| W6_W3 x4 | 2.644(3) | W6_W4 x2 | 2.75(1) | W6_W5 x2 | 2.648(4) | W6_W6 x2 | 2.652(7) |
| W6_W6 | 3.062(8) | | | | | | |

**Table S10** Atomic coordinates, occupancy factors and isotropic thermal parameters of sample *NH₄-LTL*.

| Site | | x/*a* | y/*b* | z/*c* | Occupancy factor | $U_{ISO}$ |
|---|---|---|---|---|---|---|
| Si1 | $Si^{4+}$ | 0.0938(1) | 0.3579(1) | 1/2 | 1 | 0.0145(2) |
| Si2 | $Si^{4+}$ | 0.1661(1) | 0.4987(1) | 0.2116(2) | 1 | 0.0145(2) |
| O1 | $O^{2-}$ | 0 | 0.2743(3) | 1/2 | 1 | 0.0262(5) |
| O2 | $O^{2-}$ | 0.1649(17) | 0.3298(3) | 1/2 | 1 | 0.0262(5) |
| O3 | $O^{2-}$ | 0.2635(1) | 0.5270(2) | 0.2539(5) | 1 | 0.0262(5) |
| O4 | $O^{2-}$ | 0.1039(2) | 0.4148(2) | 0.3267(3) | 1 | 0.0262(5) |
| O5 | $O^{2-}$ | 0.4249(1) | 0.8498(2) | 0.2809(5) | 1 | 0.0262(5) |
| O6 | $O^{2-}$ | 0.1451(2) | 0.4766(2) | 0 | 1 | 0.0262(5) |
| KB | $K^{+}$ | 1/3 | 2/3 | 1/2 | 1 | 0.034(1) |
| KC | $K^{+}$ | 0 | 1/2 | 1/2 | 0.515(4) | 0.058(3) |
| KD | $K^{+}$ | 0 | 0.2905(4) | 0 | 0.533(3) | 0.125(3) |
| W1 | O | 0.0611(9) | 0.122(2) | 1/2 | 0.333 | 0.13 |
| W2 | O | 0 | 0.122(3) | 1/2 | 0.166 | 0.13 |
| W3 | O | 0 | -0.1375(2) | 0.1939(5) | 0.5 | 0.13 |
| W4 | O | 0 | 0 | 0.291(3) | 0.31(1) | 0.13 |
| W5 | O | 0.1210(1) | 0.2420(2) | 0 | 0.950(7) | 0.13 |
| W6 | O | 0 | 0.0830(2) | 0 | 0.260(5) | 0.13 |

**Table S11** Selected framework and extraframework distances for the structural refinement of sample *NH₄-LTL*.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Si1_O1 | 1.642(2) | Si1_O2 | 1.630(2) | Si1_O4 x2 | 1.627(2) | Si2_O3 | 1.630(2) |
| Si2_O4 | 1.639(2) | Si2_O5 | 1.659(2) | Si2_O6 | 1.645(1) | | |
| KB_O3 x6 | 2.901(4) | | | | | | |
| KC_O4 x8 | 3.292(2) | KC_O5 x4 | 2.910(4) | | | | |
| KD_O4 x4 | 3.254(4) | KD_O6 x2 | 3.119(6) | KD_W3 x2 | 3.175(8) | KD_W5 x2 | 2.786(5) |
| W1_W2 x2 | 2.97(3) | W1_W3 x4 | 2.644(3) | W1_W4 x2 | 2.51(3) | | |
| W2_O1 | 2.81(6) | W2_W1 x2 | 2.97(3) | W2_W4 x2 | 2.74(5) | | |
| W3_KD | 3.175(8) | W3_W1 x2 | 2.644(3) | W3_W3 x2 | 2.534(4) | W3_W4 | 2.638(4) |
| W3_W5 x2 | 2.554(4) | W3_W6 x2 | 2.650(3) | | | | |
| W4_W1 x6 | 2.51(3) | W4_W2 x6 | 2.74(5) | W4_W3 x6 | 2.638(4) | W4_W4 | 3.15(4) |
| W4_W6 x6 | 2.68(2) | | | | | | |
| W5_KD x2 | 2.786(5) | W5_W3 x4 | 2.554(4) | W5_W6 x2 | 2.649(3) | | |
| W6_W3 x4 | 2.650(3) | W6_W4 x2 | 2.68(2) | W6_W5 x2 | 2.649(3) | W6_W6 x2 | 2.648(5) |

| | |
|---|---|
| W6_W6 | 3.058(6) |

**Table S12** Atomic coordinates, occupancy factors and isotropic thermal parameters of sample *K-Ce-LTL*.

| Site | | x/*a* | y/*b* | z/*c* | Occupancy factor | $U_{ISO}$ |
|---|---|---|---|---|---|---|
| Si1 | $Si^{4+}$ | 0.0929(1) | 0.3560(1) | 1/2 | 1 | 0.0100(2) |
| Si2 | $Si^{4+}$ | 0.1645(1) | 0.4970(1) | 0.2105(2) | 1 | 0.0100(2) |
| O1 | $O^{2-}$ | 0 | 0.2693(3) | 1/2 | 1 | 0.0138(5) |
| O2 | $O^{2-}$ | 0.1626(2) | 0.3252(4) | 1/2 | 1 | 0.0138(5) |
| O3 | $O^{2-}$ | 0.2624(1) | 0.5248(2) | 0.2536(5) | 1 | 0.0138(5) |
| O4 | $O^{2-}$ | 0.1034(2) | 0.4126(2) | 0.3286(3) | 1 | 0.0138(5) |
| O5 | $O^{2-}$ | 0.4240(1) | 0.8479(2) | 0.2729(5) | 1 | 0.0138(5) |
| O6 | $O^{2-}$ | 0.1464(3) | 0.4777(2) | 0 | 1 | 0.0138(5) |
| KB | $K^{+}$ | 1/3 | 2/3 | 1/2 | 1 | 0.028(1) |
| KC | $K^{+}$ | 0 | 1/2 | 1/2 | 0.929(4) | 0.014(1) |
| KD | $Ce^{3+}$ | 0 | 0.2907(3) | 0 | 0.231(1) | 0.163(3) |
| Ce | $Ce^{3+}$ | 0 | 0 | 1/2 | 0.882(2) | 0.07(1) |
| W2 | O | 0 | 0.126(1) | 1/2 | 0.5 | 0.13 |
| W3 | O | 0 | -0.1050(6) | 0.282(1) | 0.5 | 0.13 |
| W5 | O | 0.1129(2) | 0.2257(4) | 0 | 1 | 0.13 |
| W6 | O | 0 | 0.0652(6) | 0 | 0.1666 | 0.13 |

**Table S13** Selected framework and extraframework distances for the structural refinement of sample *K-Ce-LT L*.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Si1_O1 | 1.651(3) | Si1_O2 | 1.636(3) | Si1_O4 x2 | 1.605(2) | Si2_O3 | 1.636(2) |
| Si2_O4 | 1.646(3) | Si2_O5 | 1.645(2) | Si2_O6 | 1.621(2) | | |
| KB_O3 x6 | 2.920(4) | | | | | | |
| KC_O4 x8 | 3.299(3) | K2_O5 x4 | 2.960(4) | | | | |
| KD_O4 x4 | 3.236(4) | KD_O6 x2 | 3.127(5) | KD_W5 x2 | 2.859(5) | | |
| Ce_W2 x6 | 2.30(2) | Ce_W3 x12 | 2.53(1) | | | | |
| W2_O1 | 2.64(2) | W2_Ce | 2.30(2) | W2_W3 x4 | 2.695(8) | | |
| W3_W2 x2 | 2.695(8) | W3_Ce | 2.53(1) | W3_W3 x2 | 3.28(2) | W3_W5 x2 | 3.019(9) |
| W3_W6 x2 | 2.711(9) | | | | | | |
| W5_KD | 2.859(5) | W5_W3 x4 | 3.019(9) | W5_W6 x2 | 2.619(6) | | |
| W6_W3 x4 | 2.711(9) | W6_W5 x2 | 2.619(6) | | | | |

**Table S14** Atomic coordinates, occupancy factors and isotropic thermal parameters of sample *Na-Ce-LTL*.

| Site | | x/*a* | y/*b* | z/*c* | Occupancy factor | $U_{ISO}$ |
|---|---|---|---|---|---|---|
| Si1 | $Si^{4+}$ | 0.0927(1) | 0.3556(1) | 1/2 | 1 | 0.0106(2) |
| Si2 | $Si^{4+}$ | 0.1645(1) | 0.4973(1) | 0.2106(2) | 1 | 0.0106(2) |
| O1 | $O^{2-}$ | 0 | 0.2689(3) | 1/2 | 1 | 0.0155(4) |
| O2 | $O^{2-}$ | 0.1628(2) | 0.3256(4) | 1/2 | 1 | 0.0155(4) |
| O3 | $O^{2-}$ | 0.2622(2) | 0.5243(2) | 0.2553(5) | 1 | 0.0155(4) |
| O4 | $O^{2-}$ | 0.1040(2) | 0.4133(2) | 0.3287(3) | 1 | 0.0155(4) |
| O5 | $O^{2-}$ | 0.4238(1) | 0.8476(2) | 0.2742(5) | 1 | 0.0155(4) |
| O6 | $O^{2-}$ | 0.1463(3) | 0.4768(2) | 0 | 1 | 0.0155(4) |
| KB | $K^{+}$ | 1/3 | 2/3 | 1/2 | 1 | 0.022(1) |
| KC | $K^{+}$ | 0 | 1/2 | 1/2 | 0.935(4) | 0.015(1) |
| KD | $Ce^{3+}$ | 0 | 0.2922(3) | 0 | 0.225(1) | 0.181(2) |
| Ce | $Ce^{3+}$ | 0 | 0 | 1/2 | 0.979(2) | 0.089(1) |
| W2 | O | 0 | 0.1259(4) | 1/2 | 0.5 | 0.13 |
| W3 | O | 0 | -0.1023(5) | 0.261(1) | 0.5 | 0.13 |
| W5 | O | 0.1098(2) | 0.2197(4) | 0 | 1 | 0.13 |
| W6 | O | 0 | 0.0564(7) | 0 | 0.1666 | 0.13 |

**Table S15** Selected framework and extraframework distances for the structural refinement of sample *Na-Ce-LTL*.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Si1_O1 | 1.649(3) | Si1_O2 | 1.633(3) | Si1_O4 x2 | 1.615(2) | Si2_O3 | 1.637(2) |
| Si2_O4 | 1.639(3) | Si2_O5 | 1.641(2) | Si2_O6 | 1.625(2) | | |
| KB_O3 x6 | 2.917(4) | | | | | | |
| KC_O4 x8 | 3.296(3) | K2_O5 x4 | 2.959(4) | | | | |
| KD_O4 x4 | 3.233(4) | KD_O6 x2 | 3.096(5) | KD_W5 x2 | 2.918(5) | | |
| Ce_W2 x6 | 2.309(8) | Ce_W3 x12 | 2.60(1) | | | | |
| W2_O1 | 2.624(7) | W2_Ce | 2.309(8) | W2_W3 x4 | 2.786(7) | | |
| W3_W2 x2 | 2.786(7) | W3_Ce | 2.60(1) | W3_W3 x2 | 3.25(2) | W3_W5 x2 | 2.865(8) |
| W3_W6 x2 | 2.550(9) | | | | | | |
| W5_KD x2 | 2.918(5) | W5_W3 x4 | 2.865(8) | W5_W6 x2 | 2.645(7) | | |
| W6_W3 x4 | 2.550(9) | W6_W5 x2 | 2.645(7) | | | | |

**Table S16** Atomic coordinates, occupancy factors and isotropic thermal parameters of sample *NH₄-Ce-LTL*.

| Site | | x/*a* | y/*b* | z/*c* | Occupancy factor | $U_{ISO}$ |
|---|---|---|---|---|---|---|
| Si1 | $Si^{4+}$ | 0.0926(1) | 0.3561(1) | 1/2 | 1 | 0.010(2) |
| Si2 | $Si^{4+}$ | 0.1651(1) | 0.4975(1) | 0.2096(2) | 1 | 0.010(2) |
| O1 | $O^{2-}$ | 0 | 0.2701(3) | 1/2 | 1 | 0.0152(3) |
| O2 | $O^{2-}$ | 0.1625(2) | 0.3251(3) | 1/2 | 1 | 0.0152(3) |
| O3 | $O^{2-}$ | 0.2625(1) | 0.5250(2) | 0.2559(6) | 1 | 0.0152(3) |
| O4 | $O^{2-}$ | 0.1046(2) | 0.4142(2) | 0.3283(3) | 1 | 0.0152(3) |
| O5 | $O^{2-}$ | 0.4239(1) | 0.8477(2) | 0.2710(5) | 1 | 0.0152(3) |
| O6 | $O^{2-}$ | 0.1474(3) | 0.4766(2) | 0 | 1 | 0.0152(3) |
| KB | $K^{+}$ | 1/3 | 2/3 | 1/2 | 0.973(5) | 0.019(1) |
| KC | $K^{+}$ | 0 | 1/2 | 1/2 | 0.532(5) | 0.036(3) |
| KD | $Ce^{3+}$ | 0 | 0.2875(4) | 0 | 0.200(1) | 0.198(3) |
| Ce | $Ce^{3+}$ | 0 | 0 | 1/2 | 0.961(2) | 0.107(1) |
| W2 | O | 0 | 0.1270(4) | 1/2 | 0.5 | 0.13 |
| W3 | O | 0 | -0.1013(5) | 0.2572(14) | 0.5 | 0.13 |
| W5 | O | 0.1086(2) | 0.2171(4) | 0 | 1 | 0.13 |
| W6 | O | 0 | 0.0536(6) | 0 | 0.1666 | 0.13 |

**Table S17** Selected framework and extraframework distances for the structural refinement of sample *NH₄-Ce-LTL*.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Si1_O1 | 1.645(3) | Si1_O2 | 1.647(3) | Si1_O4 x2 | 1.623(2) | Si2_O3 | 1.637(2) |
| Si2_O4 | 1.637(3) | Si2_O5 | 1.643(2) | Si2_O6 | 1.621(1) | | |
| KB_O3 x6 | 2.913(4) | | | | | | |
| KC_O4 x8 | 3.301(3) | K2_O5 x4 | 2.977(4) | | | | |
| KD_O4 x4 | 3.283(4) | KD_O6 x2 | 3.163(6) | KD_W5 x2 | 2.871(6) | | |
| Ce_W2 x6 | 2.336(8) | Ce_W3 x12 | 2.61(1) | | | | |
| W2_O1 | 2.631(6) | W2_Ce | 2.336(8) | W2_W3 x4 | 2.816(7) | | |
| W3_W2 x2 | 2.816(7) | W3_Ce | 2.61(1) | W3_W3 x2 | 3.23(2) | W3_W5 x2 | 2.834(9) |
| W3_W6 x2 | 2.523(9) | | | | | | |
| W5_KD x2 | 2.871(6) | W5_W3 x4 | 2.834(9) | W5_W6 x2 | 2.649(6) | | |
| W6_W3 x4 | 2.523(9) | W6_W5 x2 | 2.649(6) | | | | |

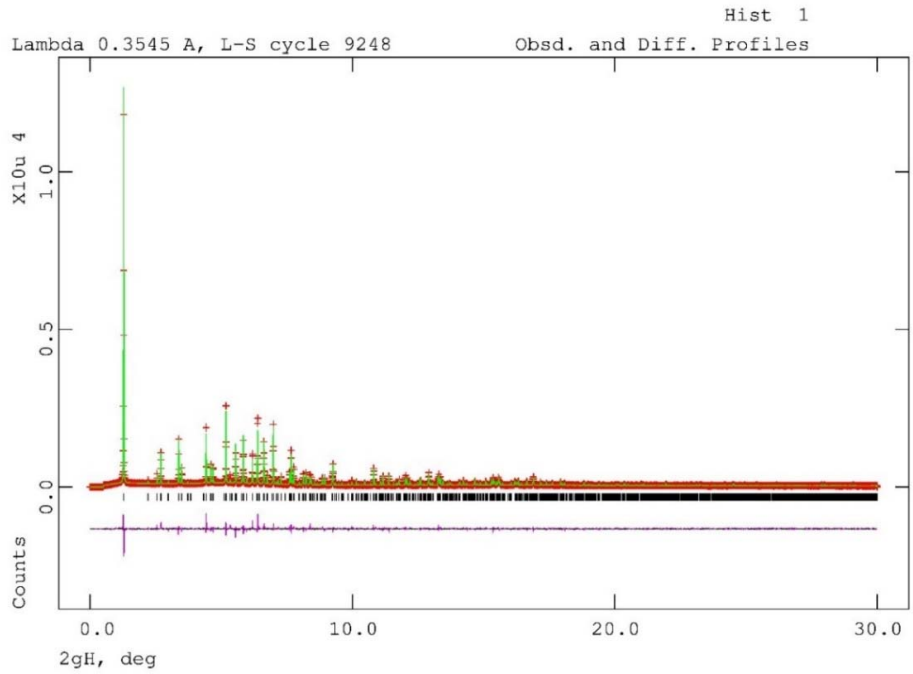


**Figure S1** Observed (red dash marks) and calculated (green line) diffraction patterns and final difference curve (purple line) from Rietveld refinement of *K-LTL*

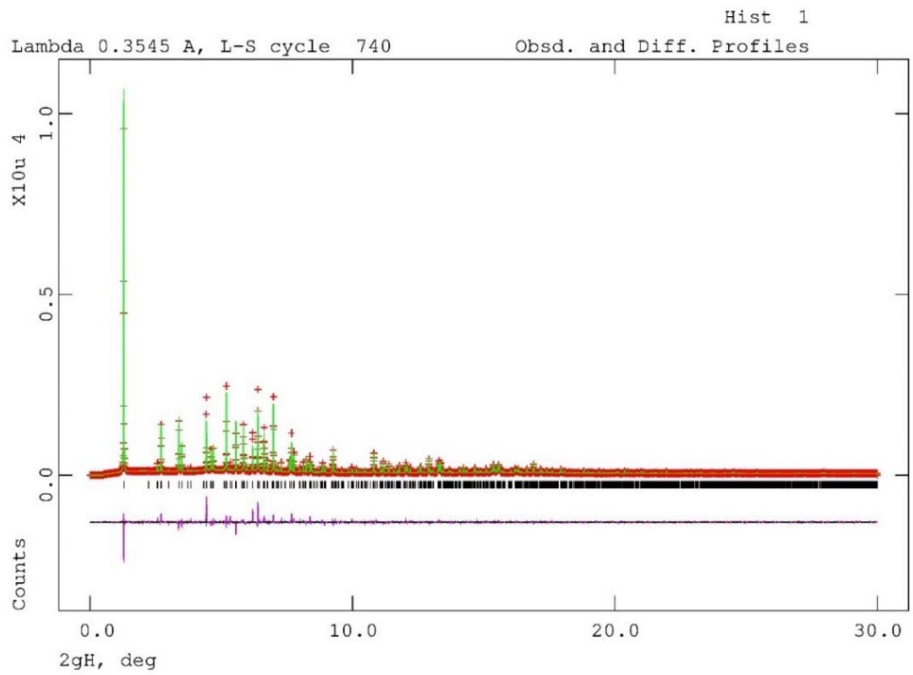


**Figure S2** Observed (red dash marks) and calculated (green line) diffraction patterns and final difference curve (purple line) from Rietveld refinement of *Na-LTL.*

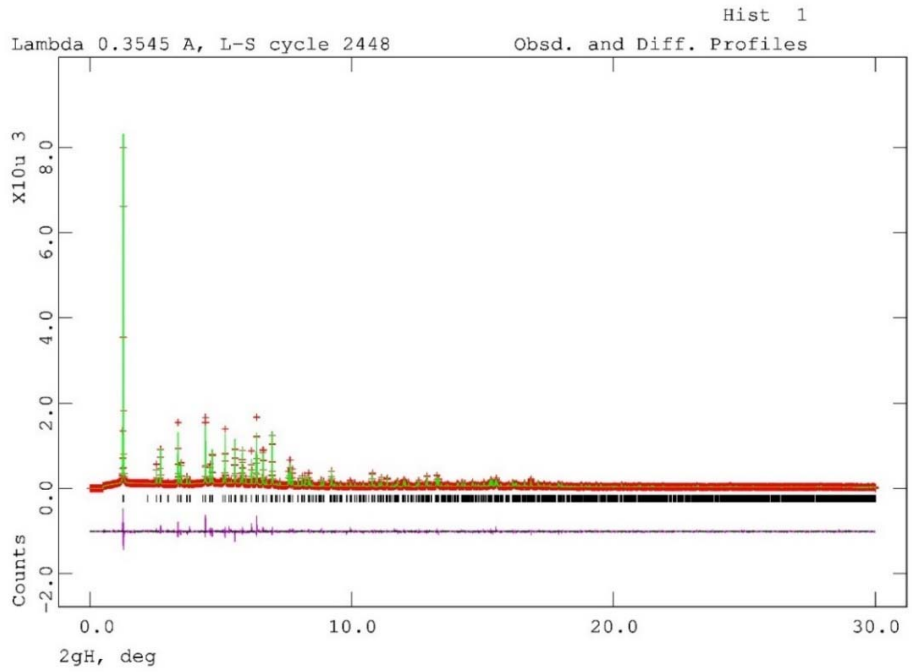


**Figure S3** Observed (red dash marks) and calculated (green line) diffraction patterns and final difference curve (purple line) from Rietveld refinement of *$NH_4$-LTL*.

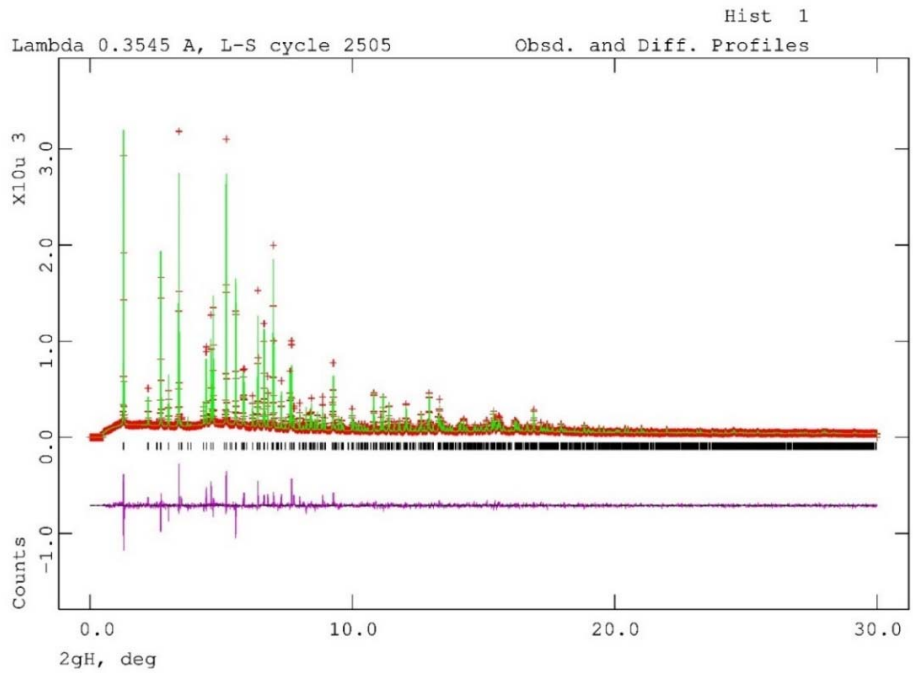


**Figure S4** Observed (red dash marks) and calculated (green line) diffraction patterns and final difference curve (purple line) from Rietveld refinement of *K-Ce-LTL*.

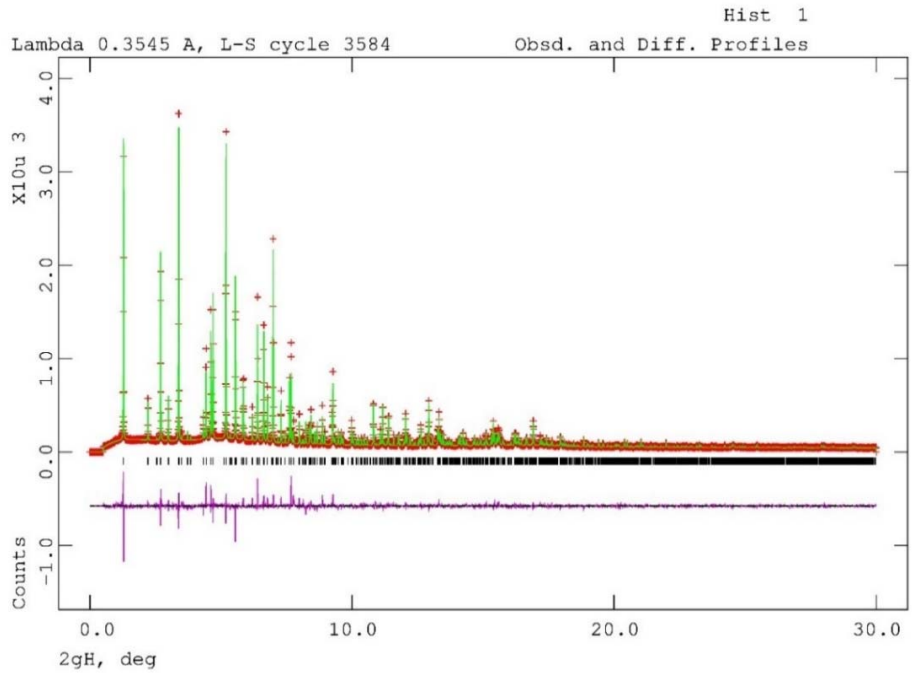


**Figure S5** Observed (red dash marks) and calculated (green line) diffraction patterns and final difference curve (purple line) from Rietveld refinement of *Na-Ce-LTL.*

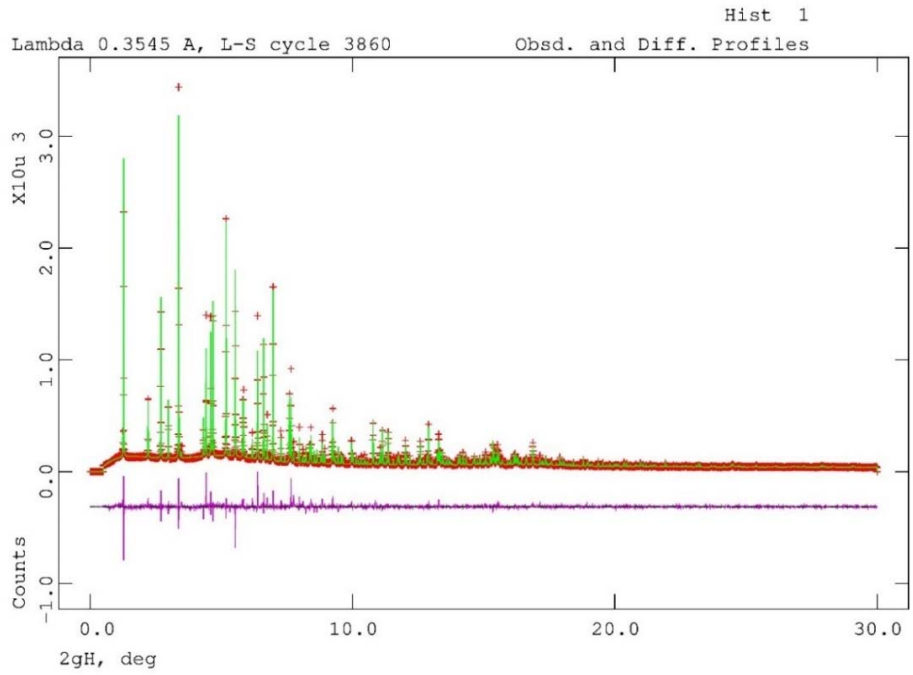


**Figure S6** Observed (red dash marks) and calculated (green line) diffraction patterns and final difference curve (purple line) from Rietveld refinement of *$NH_4$-Ce-LTL.*