

Supplementary Materials



Permeability and Adsorption–Desorption Behavior of Rare Earth in Laboratory Leaching Tests

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| Compound | Calibration | Concentration | . Unit | |
|----------|-------------|---------------|--------|--|
| Formula | Status | Concentration | Uiiit | |
| 0 | Calibrated | 39.985 | % | |
| F | Calibrated | 0.164 | % | |
| Na | Calibrated | 0.136 | % | |
| Al | Calibrated | 12.435 | % | |
| Si | Calibrated | 26.388 | % | |
| Р | Calibrated | 0.008 | % | |
| S | Calibrated | 0.013 | % | |
| Cl | Calibrated | 0.012 | % | |
| K | Calibrated | 4.800 | % | |
| Ca | Calibrated | 0.036 | % | |
| Ti | Calibrated | 0.015 | % | |
| Mn | Calibrated | 0.069 | % | |
| Fe | Calibrated | 1.005 | % | |
| Zn | Calibrated | 0.013 | % | |
| Ga | Calibrated | 0.005 | % | |
| As | Calibrated | 0.005 | % | |
| Rb | Calibrated | 0.119 | % | |
| Y | Calibrated | 0.020 | % | |
| Zr | Calibrated | 0.007 | % | |
| W | Calibrated | 0.010 | % | |
| Pb | Calibrated | 0.021 | % | |
| Th | Calibrated | 0.003 | % | |
| Su | m | 85.3 | % | |

Table S1. Contents of elements in rare earth ore powder samples.

Table S2. Total amount and weight percentage of rare earth elements in rare earth ore powder samples (%).

| Analyte | Y_2O_3 | La ₂ O ₃ | CeO ₂ | Pr ₆ O ₁₁ | Nd ₂ O ₃ | Sm_2O_3 | Eu ₂ O ₃ |
|----------|----------|--------------------------------|------------------|---|--------------------------------|-----------|--------------------------------|
| Sample 1 | 0.0256 | 0.00492 | 0.0132 | 0.00171 | 0.00717 | 0.00333 | 0.000076 |
| Sample 2 | 0.0244 | 0.00454 | 0.0077 | 0.0016 | 0.00661 | 0.00308 | 0.00007 |
| Sample 3 | 0.0253 | 0.00478 | 0.00905 | 0.00166 | 0.00687 | 0.0032 | 0.000074 |
| Average | 0.0251 | 0.00475 | 0.00998 | 0.00166 | 0.00688 | 0.0032 | 0.000073 |

| Gd2O3 | Tb4O7 | Dy2O3 | Ho2O3 | Er2O3 | Tm2O3 | Yb2O3 | Lu2O3 | REO |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 0.00386 | 0.00071 | 0.00432 | 0.00087 | 0.00257 | 0.00041 | 0.00294 | 0.00044 | 0.07213 |
| 0.00355 | 0.00065 | 0.00406 | 0.00083 | 0.00246 | 0.0004 | 0.00284 | 0.00042 | 0.06321 |
| 0.00369 | 0.00068 | 0.0042 | 0.00085 | 0.00251 | 0.00041 | 0.00288 | 0.00042 | 0.06657 |
| 0.0037 | 0.00068 | 0.00419 | 0.00085 | 0.00251 | 0.00041 | 0.00289 | 0.00043 | 0.0673 |

Continue the table:



Figure S1. Pore structure evolutions of rare earth ore samples during the leaching tests were monitored by a PQ-OO1-type Mini-NMR with a magnetic field intensity of 0.52 T.



Figure S2. The inversion images, projections of pores in a 10-mm-thick cross-sectional layer in the middle of samples, were calculated from obtained NMR data.

| NMImaging-V1.23.02D [C:\Us | ers\Administrator\Desktop\20171118\201712 | 19\sj3.img] | | |
|----------------------------|---|--------------------------------------|---|-------------------------------------|
| NMI-V1.23.02D MiniMR60 | Ocalizer / Parameters Image | | | |
| i se anti | Sagittal (YZ) | Coronal (XY) | Axial (XZ) | |
| D NEW SAMPLE | | AND TRANSPORT OF TAXABLE | | |
| 🗎 OPEN 🛛 🖺 SAVE | | | | Z. |
| SAVE TO DICOM | | | | A. |
| Save Raw Fid File | 3 | | 3 | |
| Open Without Filtering | 22 | 2 | Y Z Z | |
| Sample: Time | 0 | | | |
| Tester: | | | | |
| + 1-PRESCAN | | | ^ | |
| | | $\times \longrightarrow$ | | |
| Status: Completed 100% | LOCALIZER (SCOUT) | Official Class Invol | TABLE ALL. | MODE |
| TO 2 SCOUT | 100.0 | -5.3 | -91 | Reverse Slice |
| 10 2 30001 V 3101 | Offset Read [mm] | Slices | Beta Angle | Draw Cross |
| Status: Completed 100% | | | | Draw Projection SCDUT RG(dB) |
| No com | FUV Phase (mm) | Slice Width [mm] | Gama Angle | 0.000, 0.017, 1.000 |
| → 3-SCAN Ø STOP | Offset Phase (mm) | Slice Gap (mm) | P | 0.000, -1.000, -0.017 Test SCOUT RG |
| Status: Completed 100% | | 0.5 | Sagittal Coronal Axial R | 1.000, 0.000, 0.000 PRG: HIGH 💌 |
| | SYSTEM PRESCAN | SEQUENCE | T FSE | |
| SYSTEM | RF Col Selection RF Coil 1# | Sequence SPIN ECHO | (SE) ETL 1 | TEeff(ms) ESP(ms) |
| | Gx0//set -1200 | Flip Angle [deg] 90.0 | TR [ms] 500.000 MinTE_GRE(ms) | 4.047 MinTE_SE(ms) 5.884 |
| | Auto Shimming GyOffset 1420 | View AutoShim Refor Flip Angle 180.0 | TE [ms] 5.885 Optimization | |
| CONFIG PS D0/TR | GzOffset -1110 | Averages 3 | TI_IR[ms] 20.000 No optimization | FOV Center |
| | Auto RFAmp RFA90 [%] 8.0 | View AutoAmp Proven | Phase Size 192 Manual Optimize seque | zabon |
| | RFA180 [%] 11.7 | 10(00) 20.0 | Refocus Slice Grad | Amp(%) 0.0 |
| | Auto Tuning Matching Save To (| Configuration Test RG Use F | Preemphasis Auto 01 Refocus Read Grad Correction Street Internet 1 | D10/D111 (ms) 5.0 |
| | | | Sice Sice Interval (| |

Figure 3. NMR imaging software operation interface.



Figure S4. The sample was removed from the leaching test and evenly divided into three pieces, used for analyzing REO content by ICP-MS.

inversion image leaching time 0.5h

Figure S5. The specimens for SEM imaging was collected from the center of the rare earth ore samples in the (NH4)2SO4 leaching test at different leaching time of 0.5 h, 1 h, and 2 h.



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