# Electronic Supporting Information

## Nanometer-Sized Nickel and Cobalt Doped Forsterite Synthesis for Investigating Critical Element Recovery from Mafic and Ultramafic Rocks

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**This file contains 7 Pages, 5 Figures, and 1 Table.**

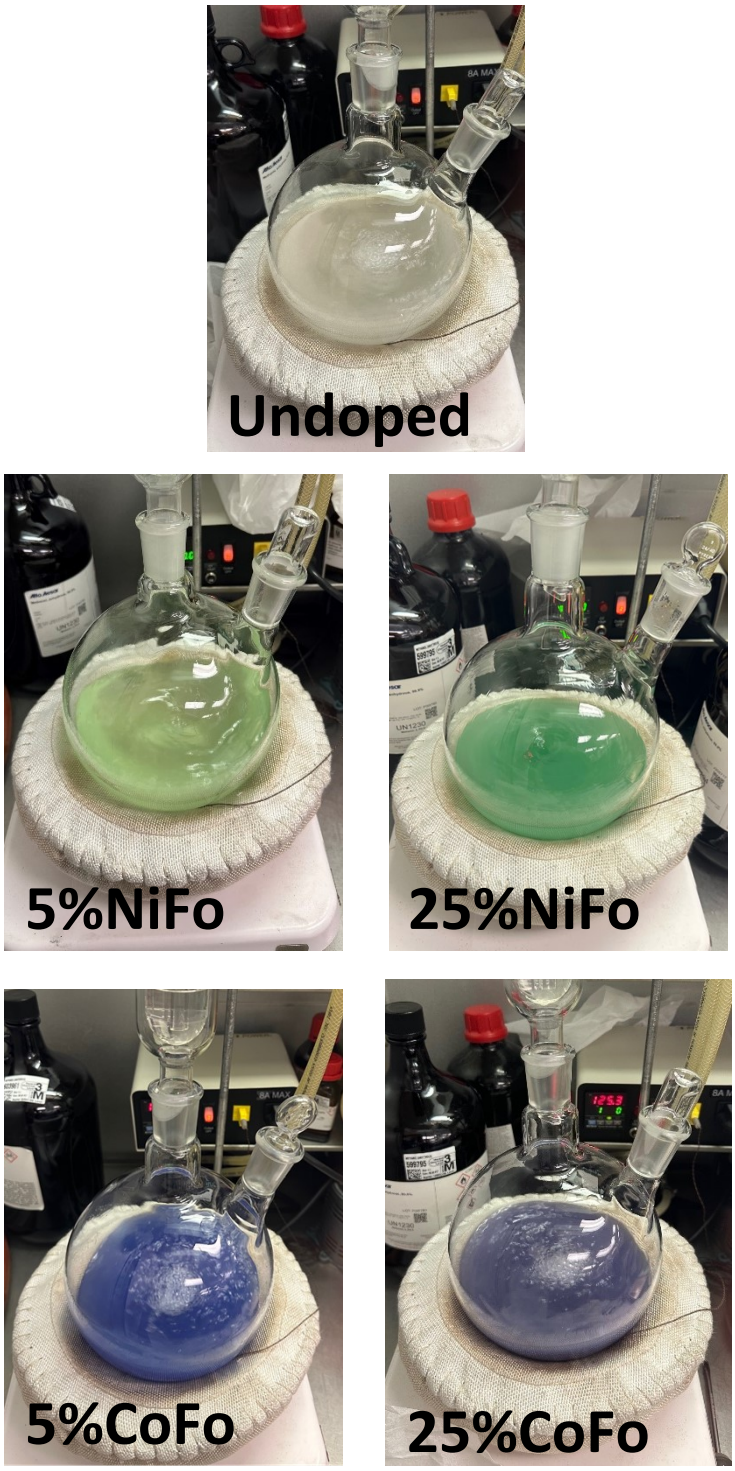


**Figure S1.** Pictures showing the reflux step for each of the undoped and metal doped forsterites after water additions.

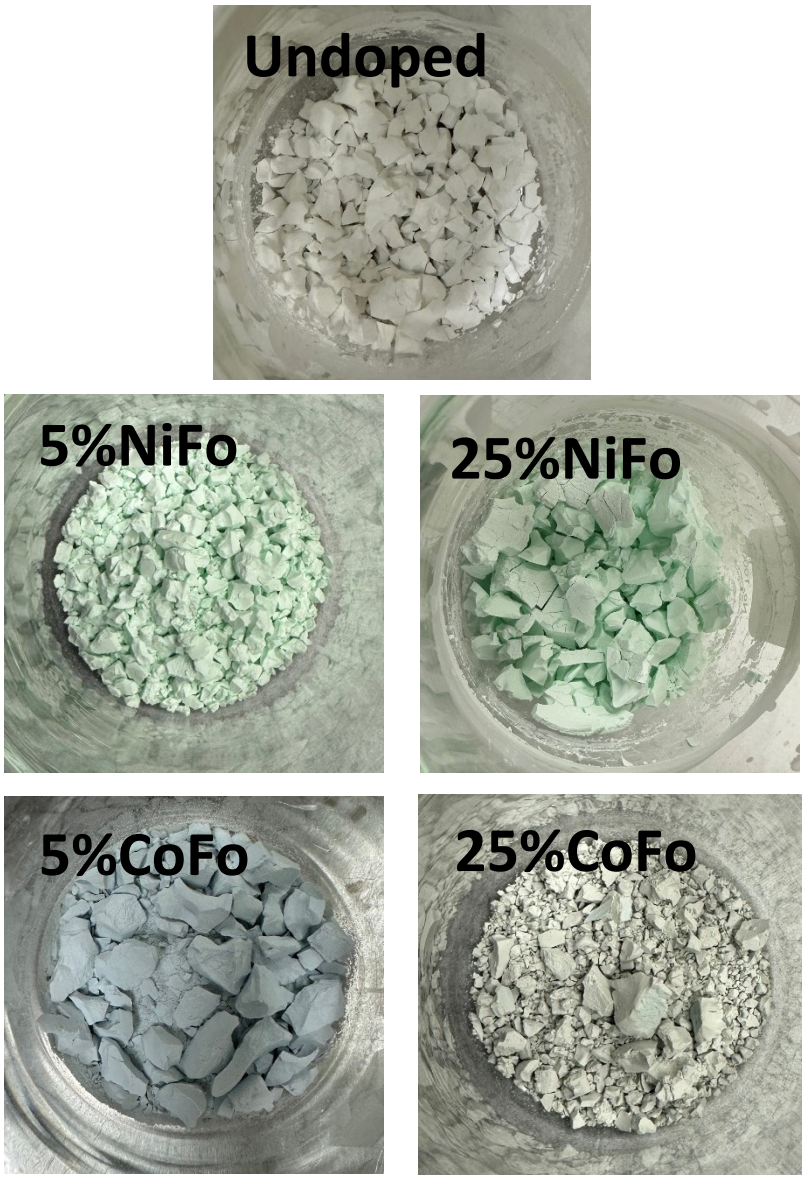


**Figure S2.** Pictures showing the dried gel after the washing step of the synthesis of undoped and metal doped forsterites.

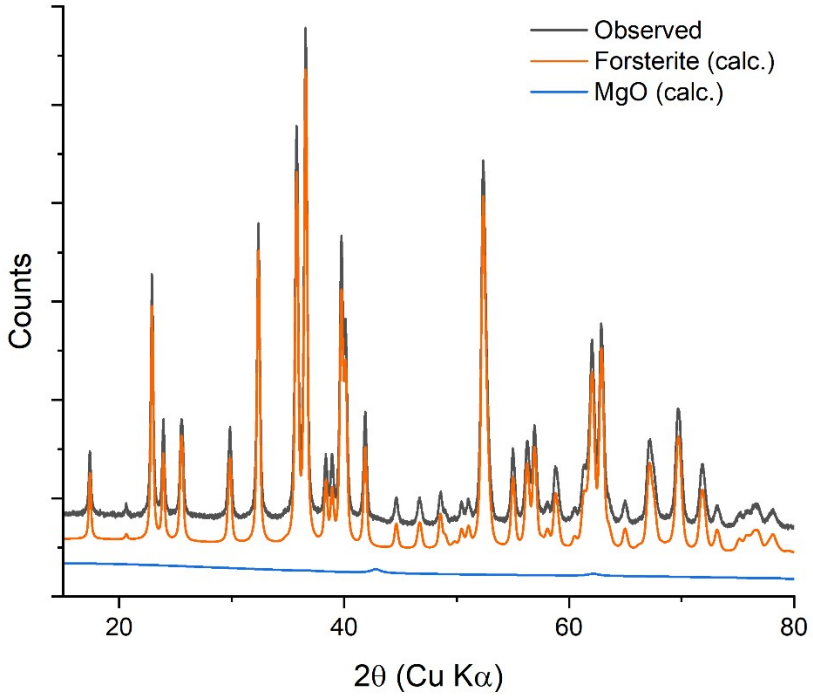


**Figure S3.** Experimental X-Ray diffraction pattern of undoped forsterite (black trace) shown with Rietveld refinement calculations of forsterite (orange trace) and MgO (blue trace) contributions.

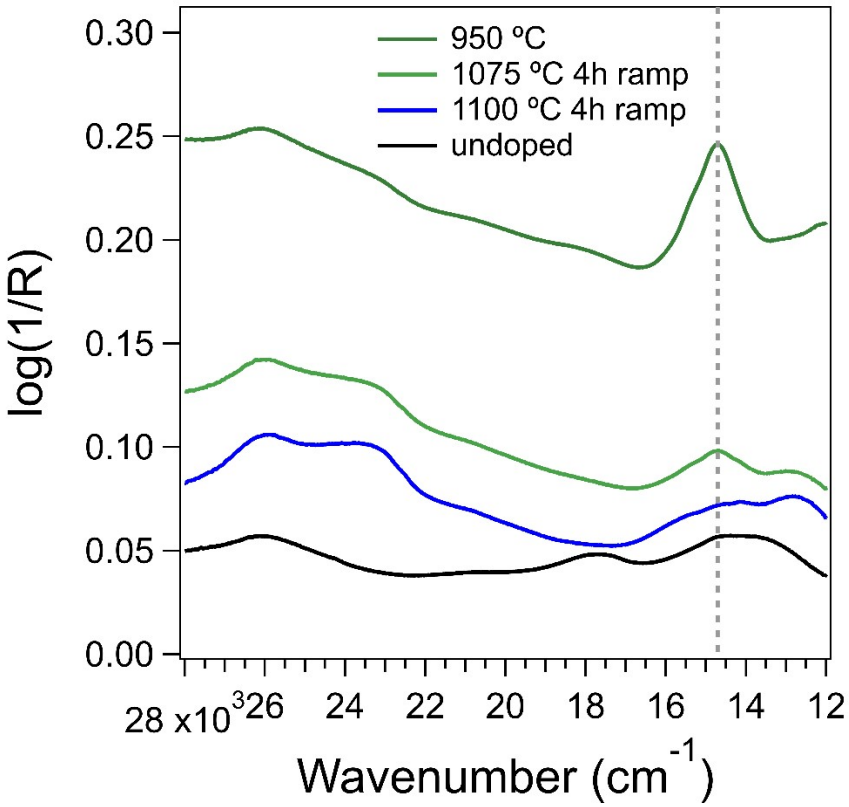


**Figure S4.** UV-Vis absorbance spectra of 5% Ni-doped forsterites synthesized under different calcination conditions. Absorbance band at 14,700 $cm^{-1}$ (marked with gray dashed line) was assigned to (Mg,Ni)O secondary phase.

**Table S1.** Mid-IR and far IR peak locations in wavenumber ($cm^{-1}$) of undoped and doped forsterite FTIR-ATR spectra. Peaks assigned based on assignments by Hofmeister and Pitman (*Phys. Chem. Miner.*, 2007).

| Assignment | undoped | 5%CoFo | 5%NiFo | 25%CoFo | 25%NiFo |
|---|---|---|---|---|---|
| | 1103.364 | 1102.239 | 1106.351 | | |
| | 1005.193 | 1001.749 | 1002.509 | 1003.453 | 1004.626 |
| $\nu_3(3)$ | 987.072 | 983.32 | 986.867 | 973.281 | 979.803 |
| $\nu_3(2)$ | | 956.132 | 956.433 | | |
| $\nu_3(1)$ | 871.848 | 870.062 | 874.602 | 870.668 | 873.465 |
| $\nu_1$ | 840.278 | 838.567 | 842.274 | 838.195 | 840.448 |
| $\nu_4(3)$ | 613.672 | 611.732 | 613.855 | 604.505 | 603.128 |
| | | 547.11 | 547.691 | | |
| $\nu_4(2)$ | 524.564 | 524.155 | 524.45 | 520.22 | 521.491 |
| $\nu_4(3)$ | 504.343 | 501.582 | 504.756 | 492.806 | 496.032 |
| $\nu_2(3)$ | 471.011 | 468.073 | 471.418 | 457.024 | 462.014 |
| LO or $\nu_2$ | 415.511 | 413.61 | 414.638 | | |
| R | 396.887 | 394.042 | 397.326 | 400.094 | 405.104 |
| M(7) | 381.463 | 379.651 | 381.711 | | 381.332 |
| M(6) | 353.526 | 347.219 | 354.124 | 339.634 | 345.091 |
| M(4) | 319.645 | | | | |
| M(5) | | | | 295.779 | 304.181 |
| M(3)+LO | 287.41 | 281.844 | 286.816 | | |
| M(1) | 271.624 | 272.555 | 272.196 | 263.69 | 267.526 |
| T(2) | 200.996 | 197.094 | 200.469 | | |
| T(1) | 142.125 | 137.87 | 139.228 | 128.935 | 131.301 |

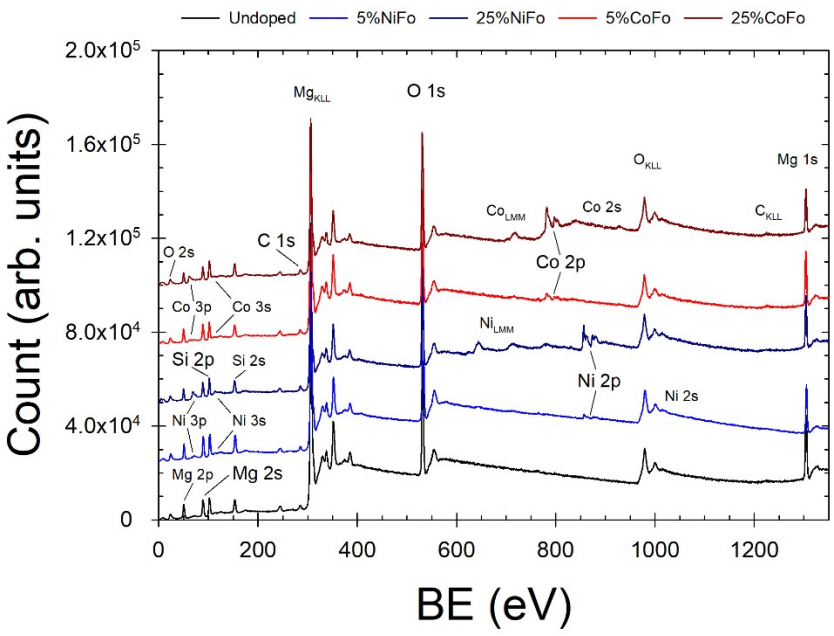


**Figure S5.** XPS spectra (survey scans) of undoped, 5% Ni-doped, 25% Ni-doped, 5% Co-doped, and 25% Co-doped forsterites. C, O, Mg, Si, Ni, and Co photoelectron lines are labeled. Larger font size is used to indicate the photoelectron lines used in the regional scans.