**Effect of Carrier-Gas on the Sensitivity of Co1-2xNixMnxFe2-yCeyO4 Double-Substitution Spinel to Flammable Gases and Volatile Organic Compounds**

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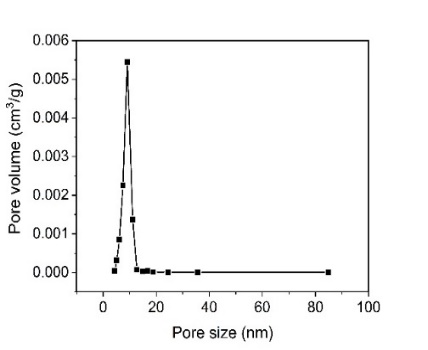
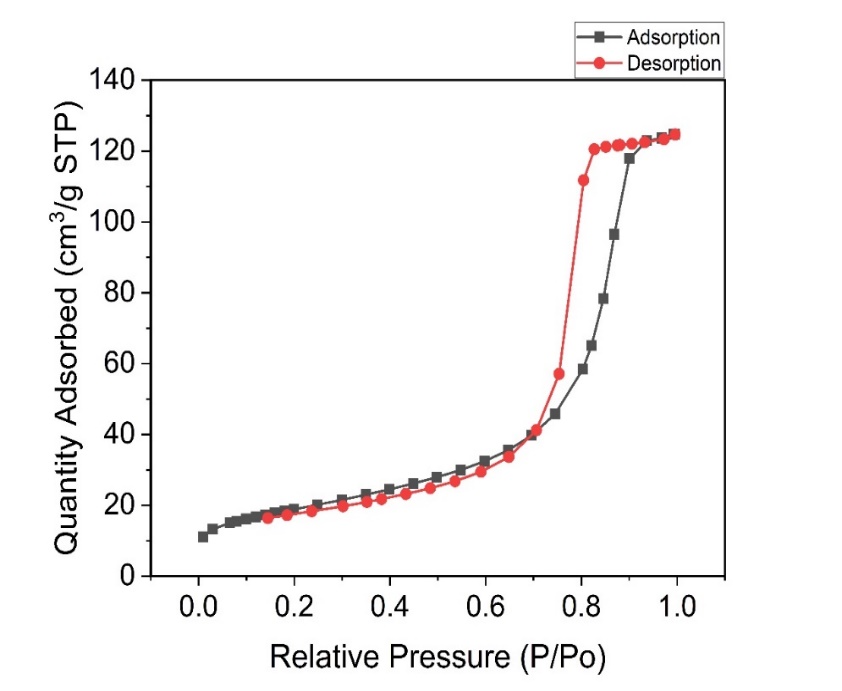
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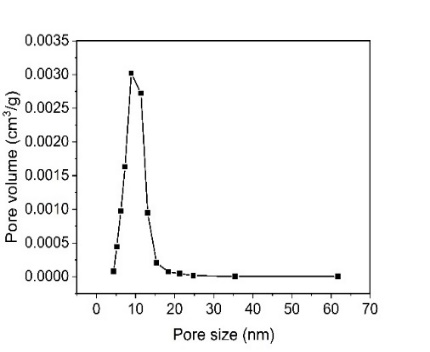
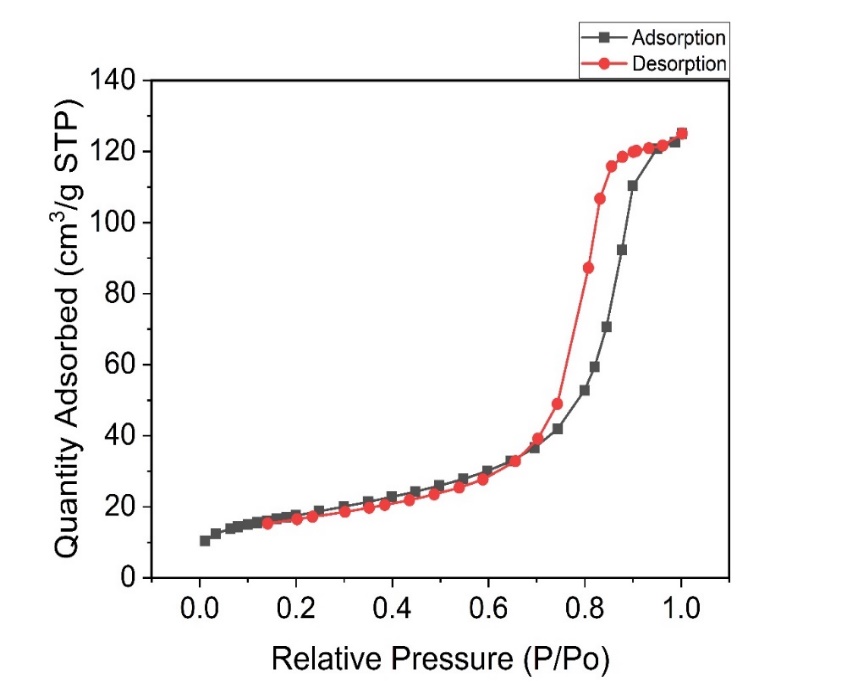
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dNational Metrology Institute of South Africa (NMISA), CSIR Campus, Building 5, Meiring Naude Road, Brummeria, Pretoria, ZA0182, South Africa

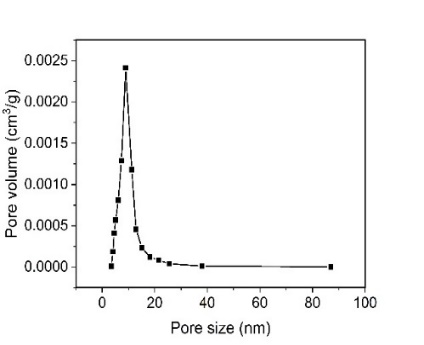
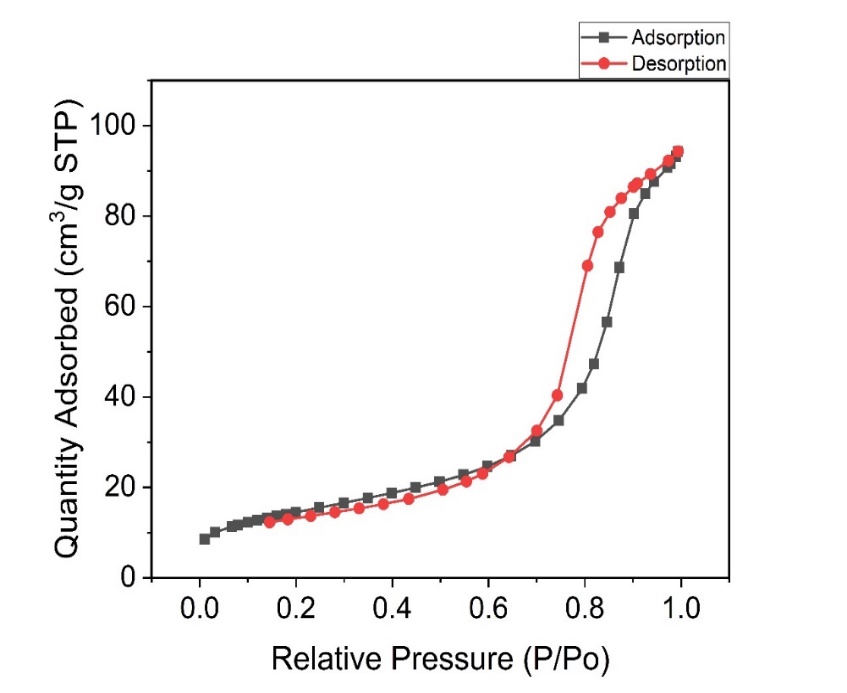
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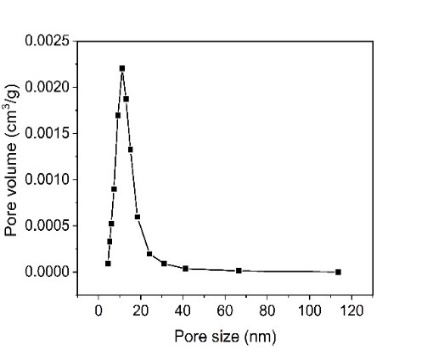
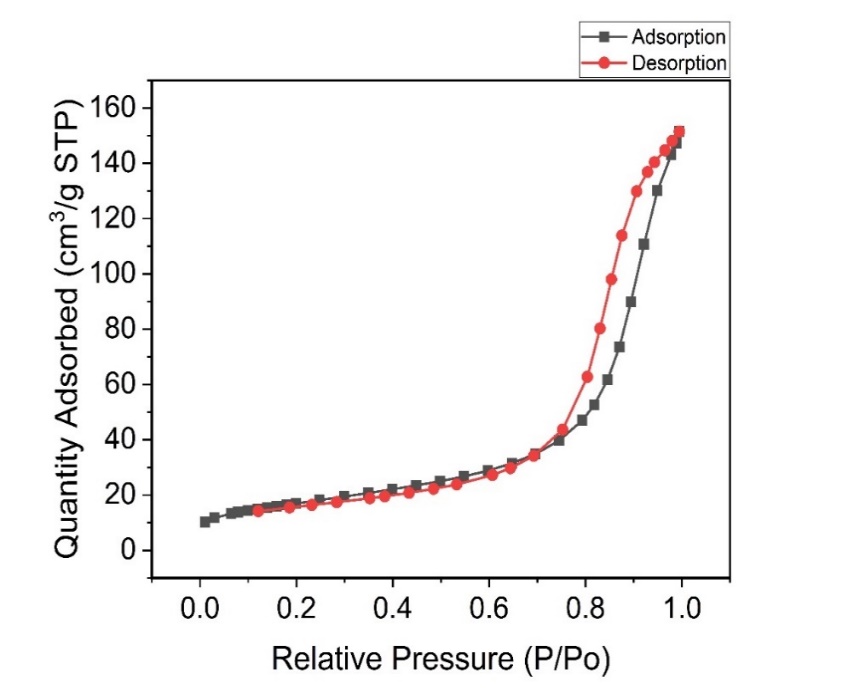
**(a)**



**(b)**

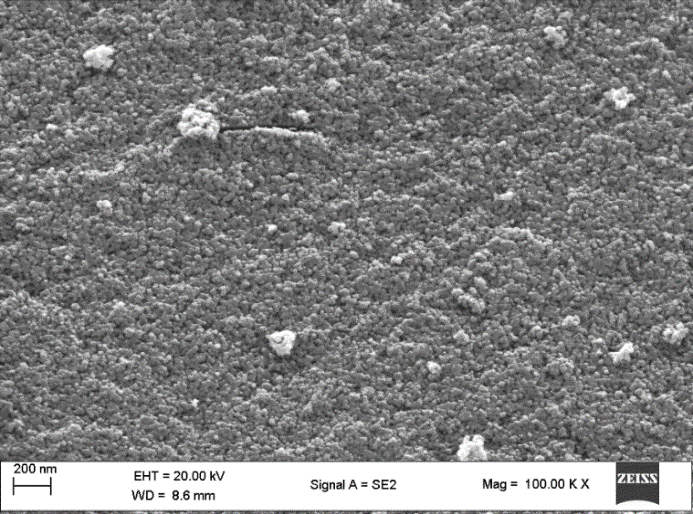


**(c)**



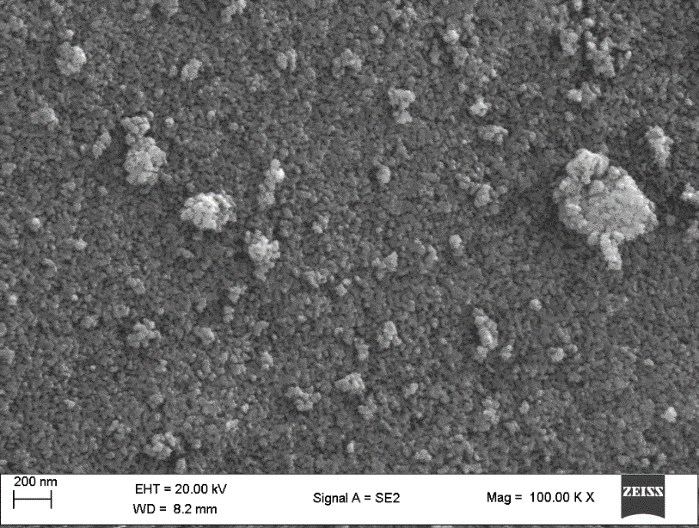
**(d)**

**Figure S1**. Nitrogen adsorption-desorption isotherms of Co1-2xNixMnxFe2-yCeyO4 samples with (a) x = y = 0: dried with infrared lamp, (b) x = y = 0: dried naturally, (c) x = y = 0.2 and (d) x = y = 0.3. **Insets**: The corresponding pore size distribution.



**200 nm**

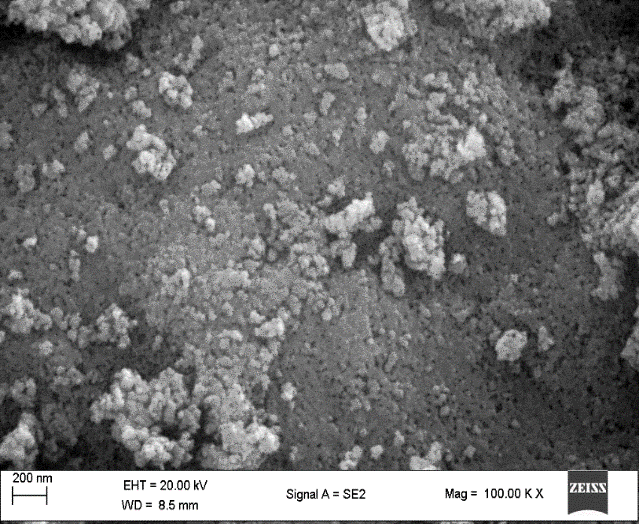
**(a)**



**(b)**

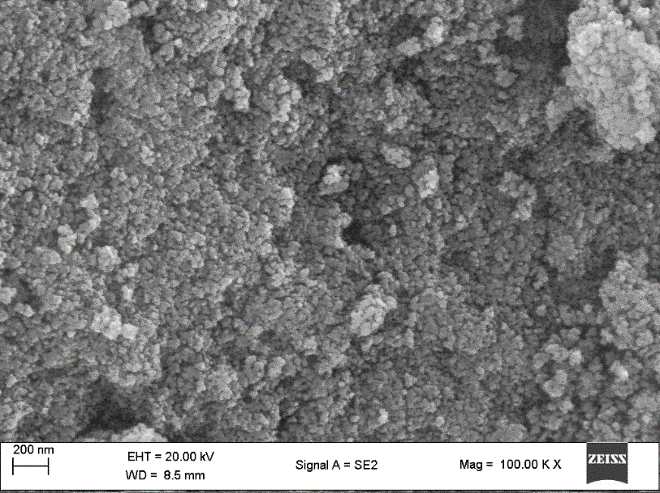
**200 nm**

200 nm



**(c)**

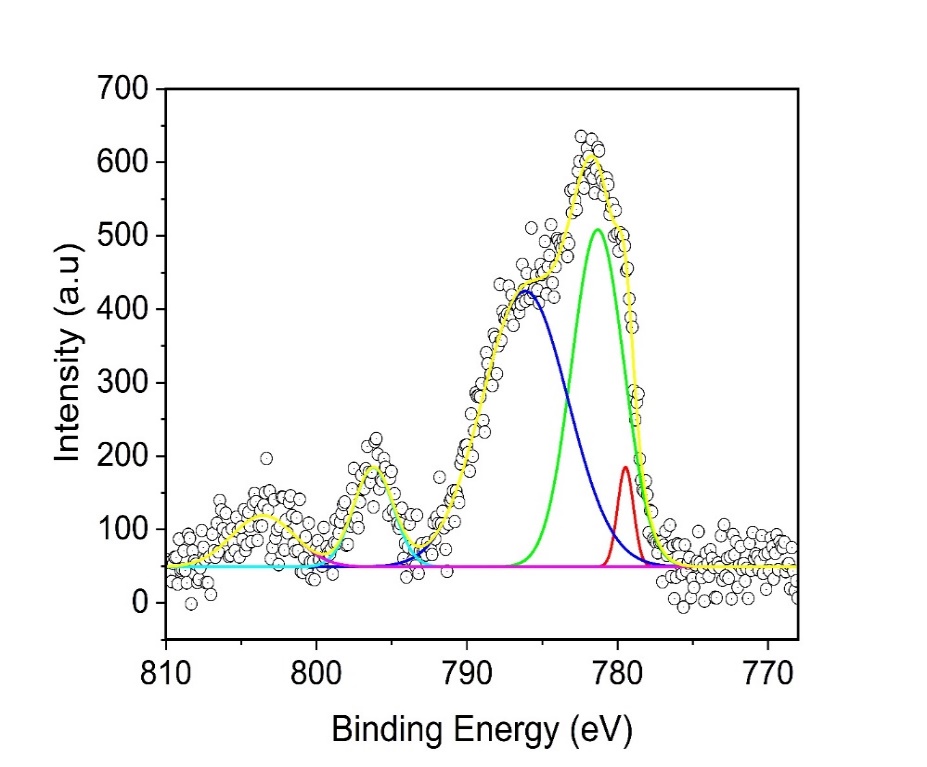
**200 nm**



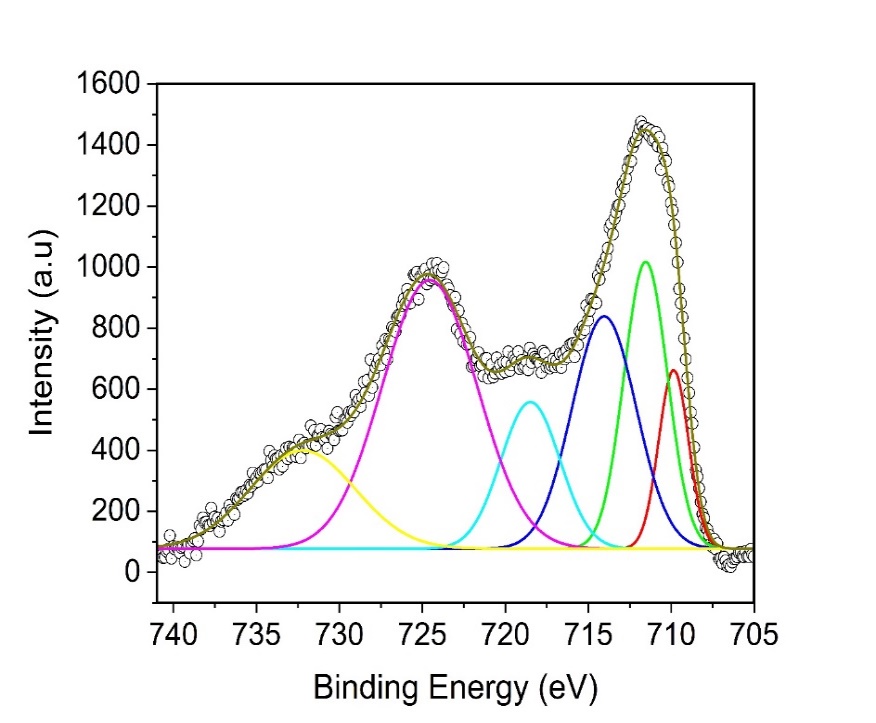
**(d)**

**200 nm**

**Figure S2**. SEM images of the Co1-2xNixMnxFe2-yCeyO4 samples with (a) x = y = 0: dried with infrared lamp, (b) x = y = 0: dried naturally, (c) x = y = 0.2 and (d) x = y = 0.3.



Co 2p scan



Fe 2p scan

B-site Co2+

A-site Co2+

Co 2p1/2

satellite

Co 2p1/2

Co 2p3/2

B-site Fe3+

A-site Fe3+

B-site Fe3+

satellite

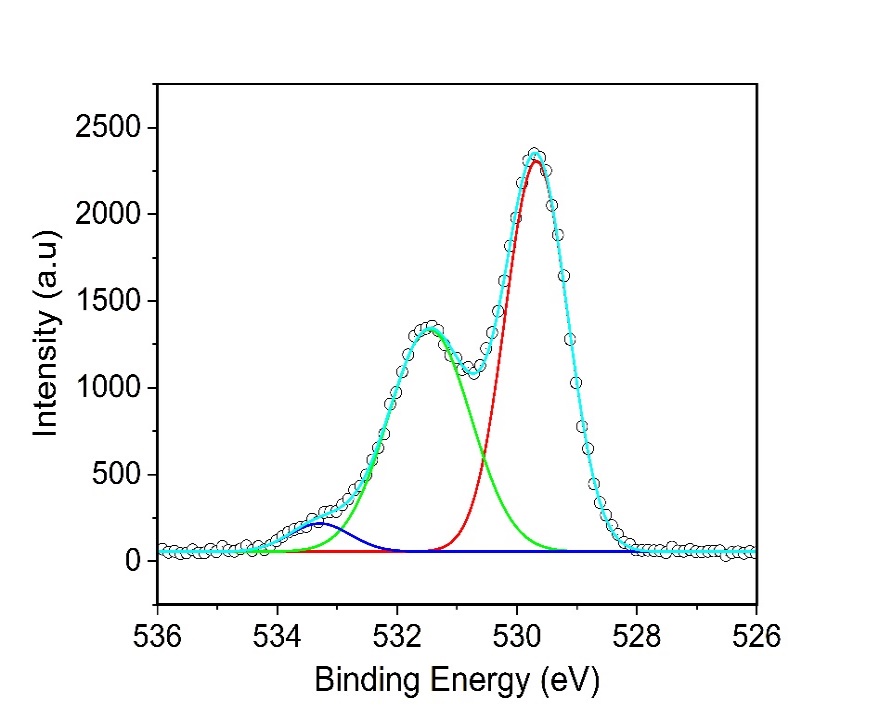
A-site Fe3+

satellite

Fe 2p3/2

Fe 2p1/2

Fe 2p1/2 satellite



O1s scan

529.68 eV

531.46 eV

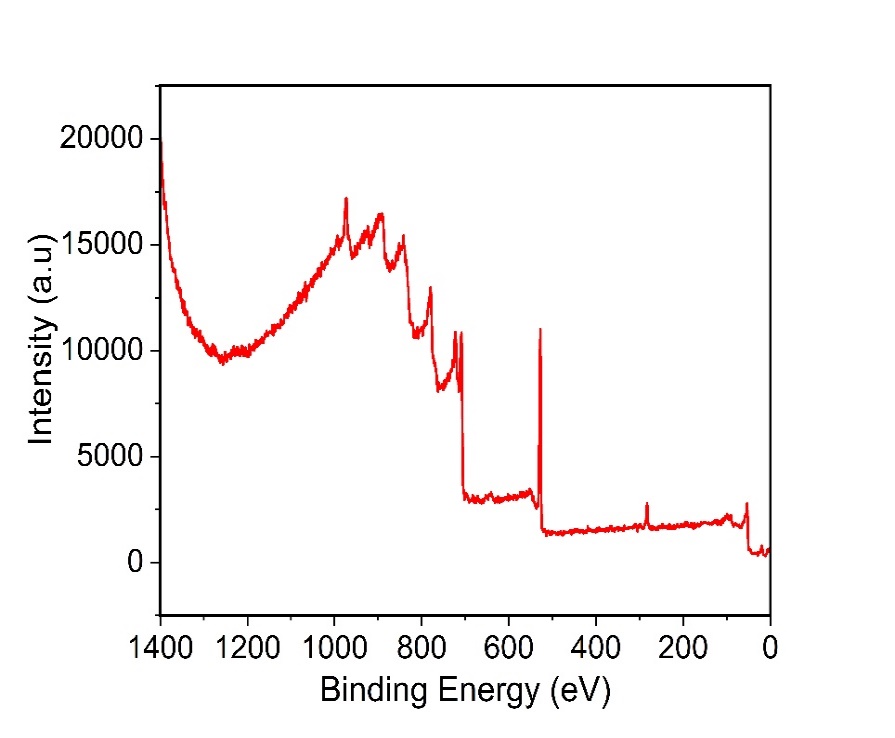
533.24 eV

B-site Co2+

satellite

**(b)**

**(c)**



Fe3p

Co3s

C1s

O1s

Co2p

Fe2p

Co2s

Co LMM

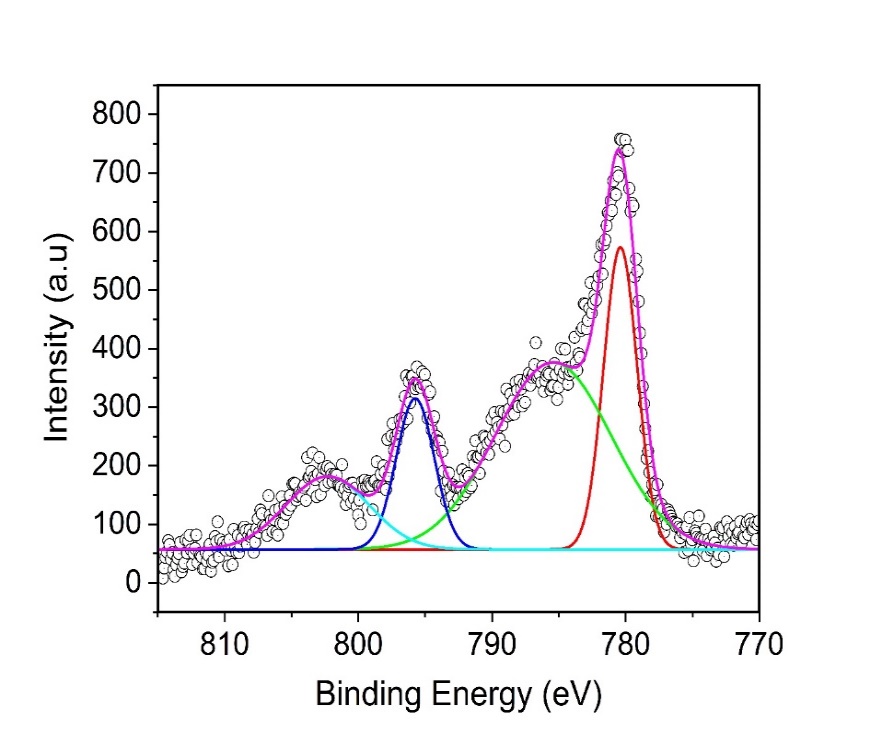
O KLL

**(a)**

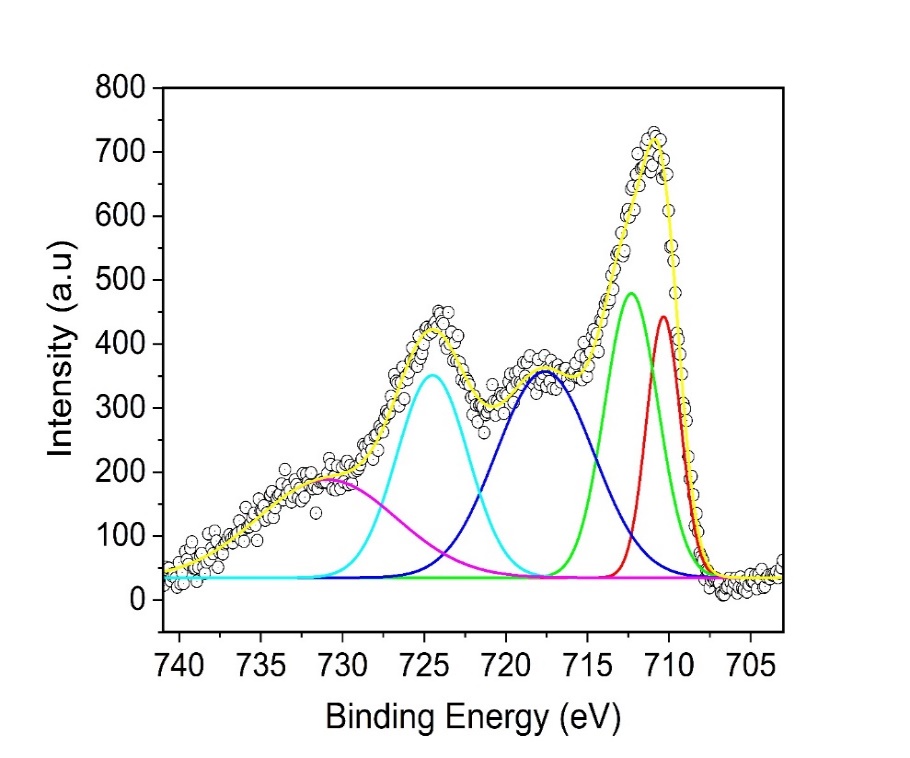
Survey scan

**(d)**

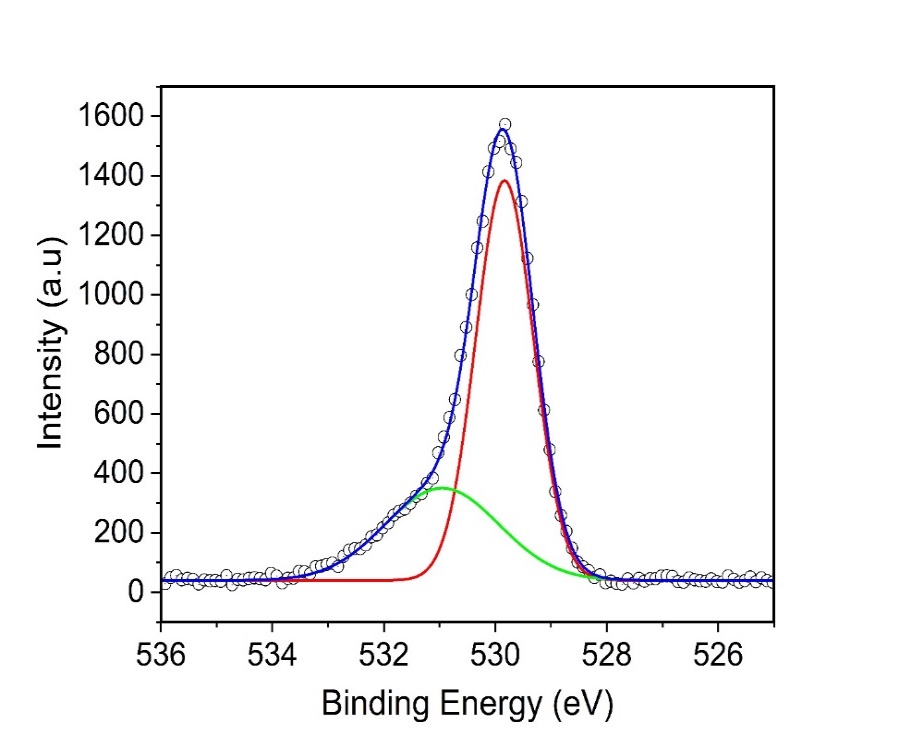
**Figure S3**.(a) Survey spectrum, before sputtering, of CoFe2O4 samples. XPS spectra of Co1-2xNixMnxFe2-yCeyO4 sample for which x = y = 0 (lamp-dried): (b) Co 2p scan, (c) Fe 2p scan, and (d) O 1s scan.



Co 2p scan



Fe 2p scan



O 1s scan

529.84 eV

530.93 eV

B-site Fe3+

A-site Fe3+

A-site Fe3+

satellite

Fe 2p1/2

Fe 2p1/2 satellite

Fe 2p3/2

Co 2p1/2

satellite

Co 2p1/2

B-site Co2+

Co 2p3/2

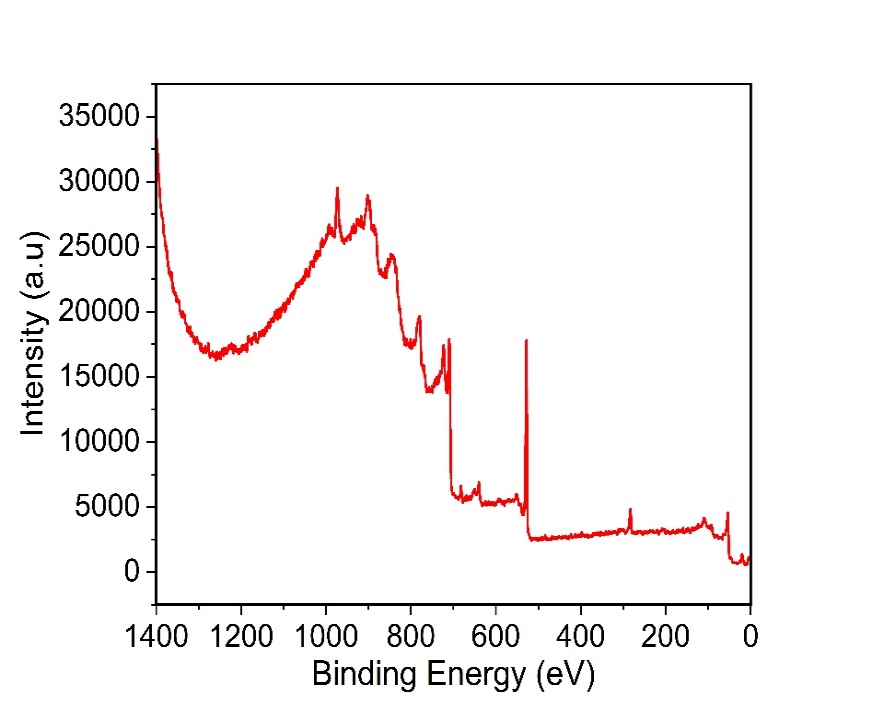
B-site Co2+

satellite

**(b)**

**(c)**

**(d)**



Survey scan

**(a)**

Fe3p

Co3s

C1s

O1s

Mn2p

Fe2p

Co2p

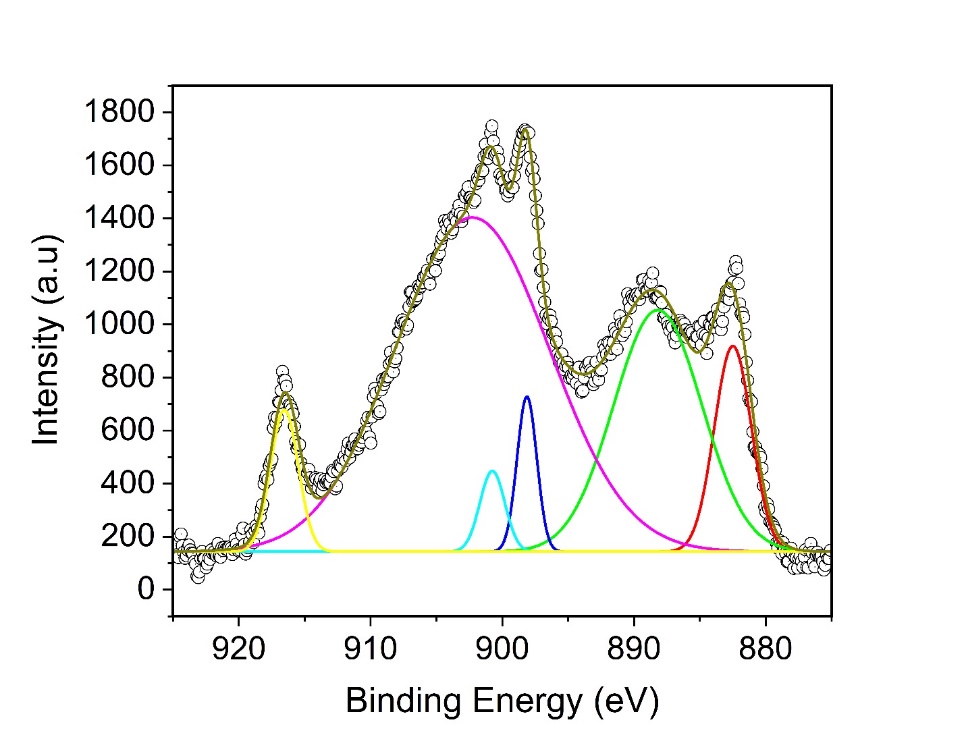
Ni2p

Ce3d

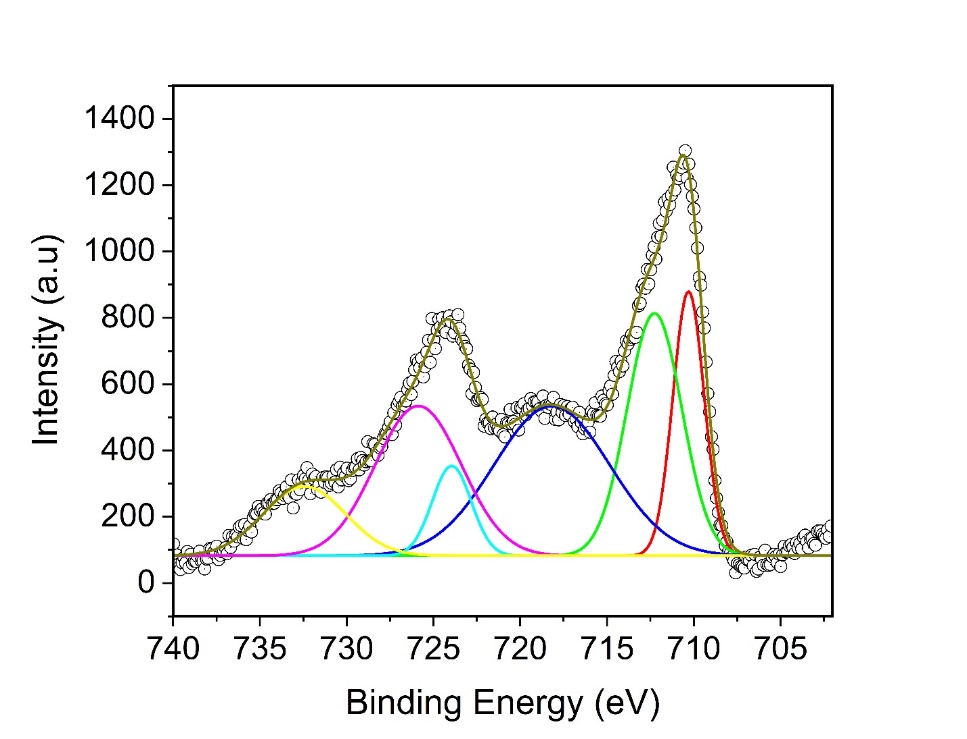
Co2s

Ni2s

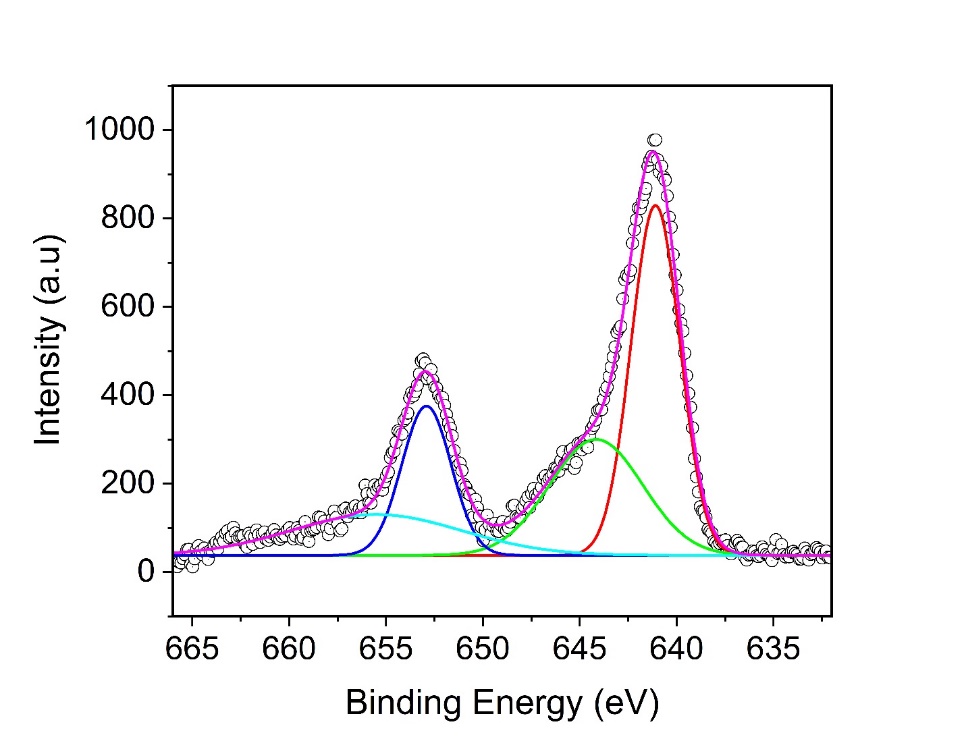
**Figure S4**.(a) Survey spectrum, before sputtering, of Co1-2xNixMnxFe2-yCeyO4 samples. XPS spectra of Co1-2xNixMnxFe2-yCeyO4 sample for which x = y = 0 (natural-dried): (b) Co 2p scan, (c) Fe 2p scan, and (d) O 1s scan.



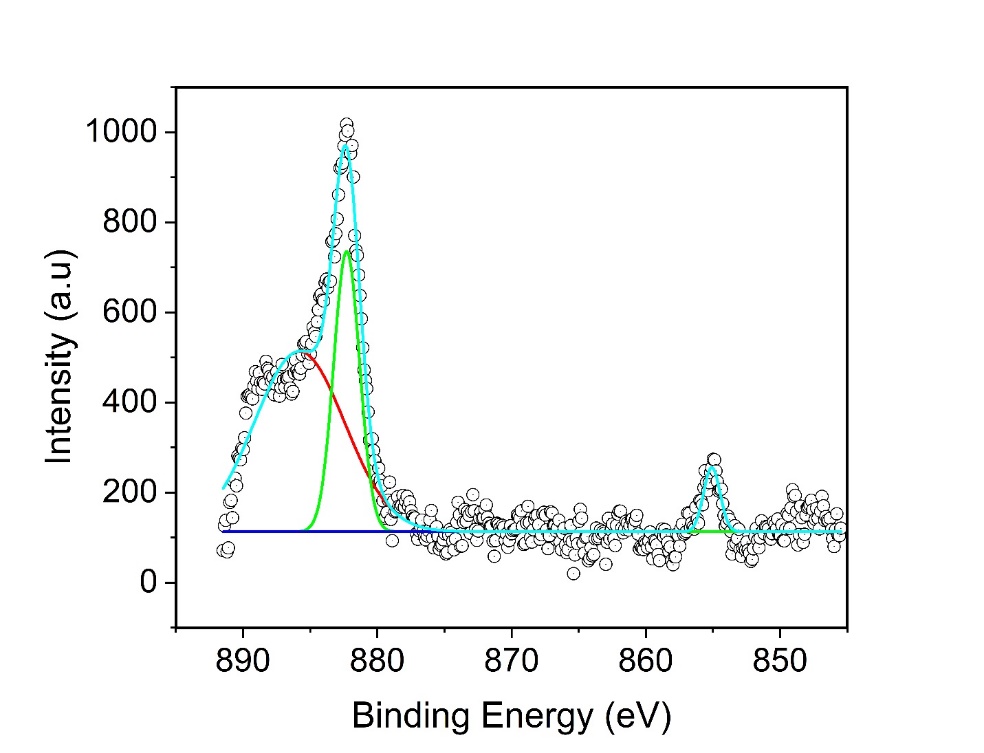
Ce 3d scan



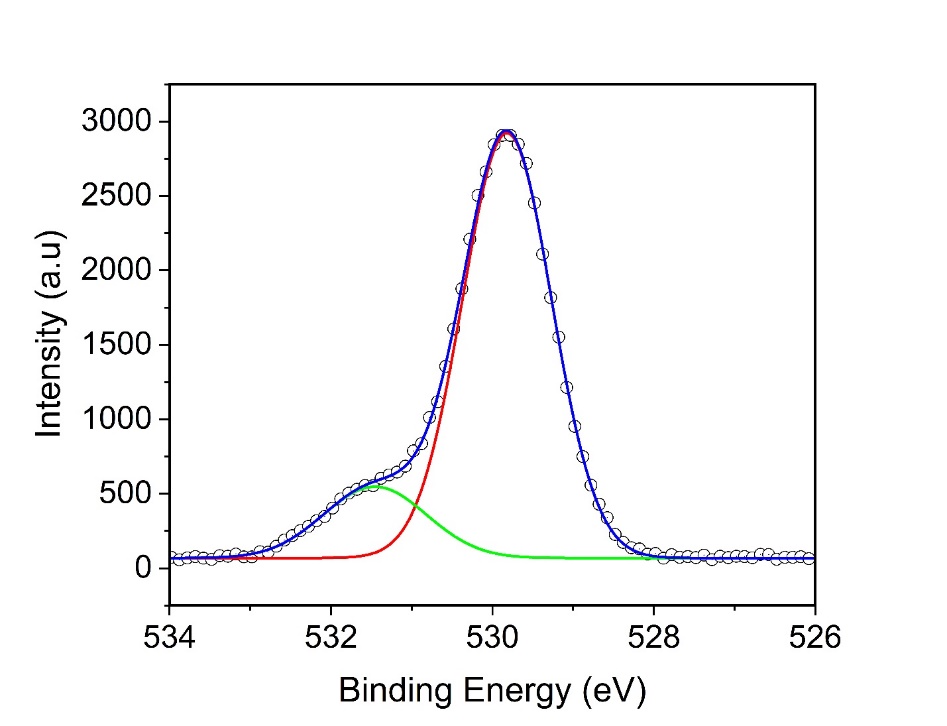
Fe 2p scan



Mn 2p scan



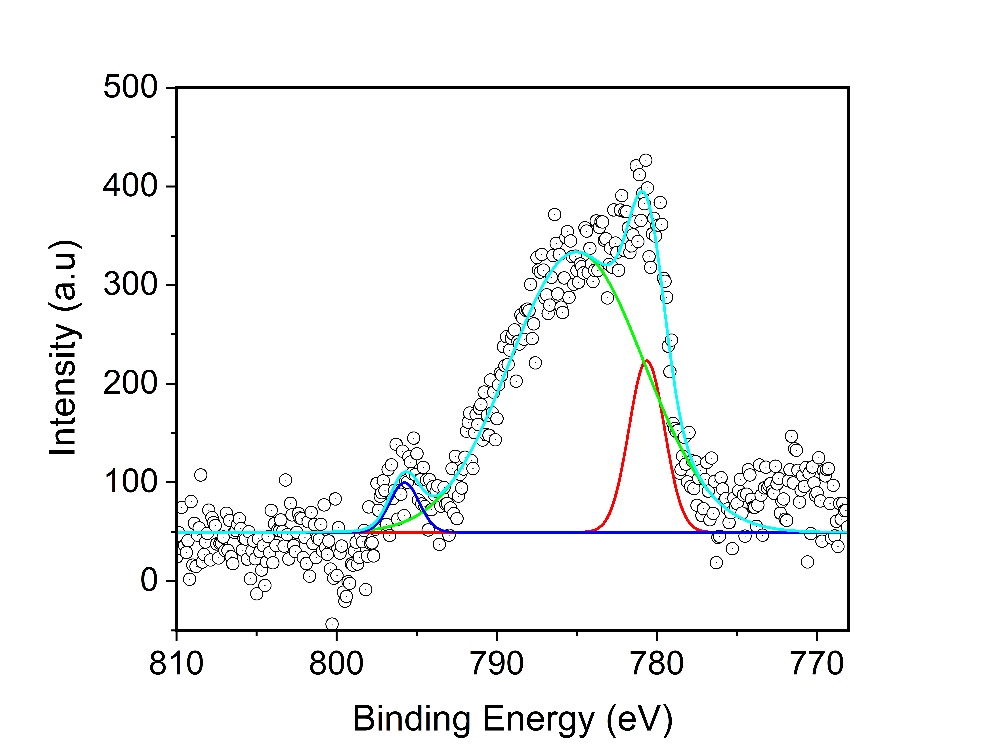
Ni 2p scan



O 1s scan

529.81 eV

531.39 eV



Co 2p scan

B-site Co2+

B-site Co2+

satellite

Co 2p1/2

Co 2p3/2

Ni 2p1/2

Ni 2p3/2

B-site Fe3+

A-site

Fe3+

A-site Fe3+

satellite

B-site Fe3+

A-site

Fe 3+

Fe 2p1/2 satellites

Fe 2p3/2

Fe 2p1/2

Mn 2p1/2

Mn 2p1/2 satellite

Mn 2p3/2 satellite

Mn 2p3/2

*v*

*vʹ*

*vʹʹ*

*vʹʹʹ*

*u*

*vʹʹʹʹ*

**(a)**

**(b)**

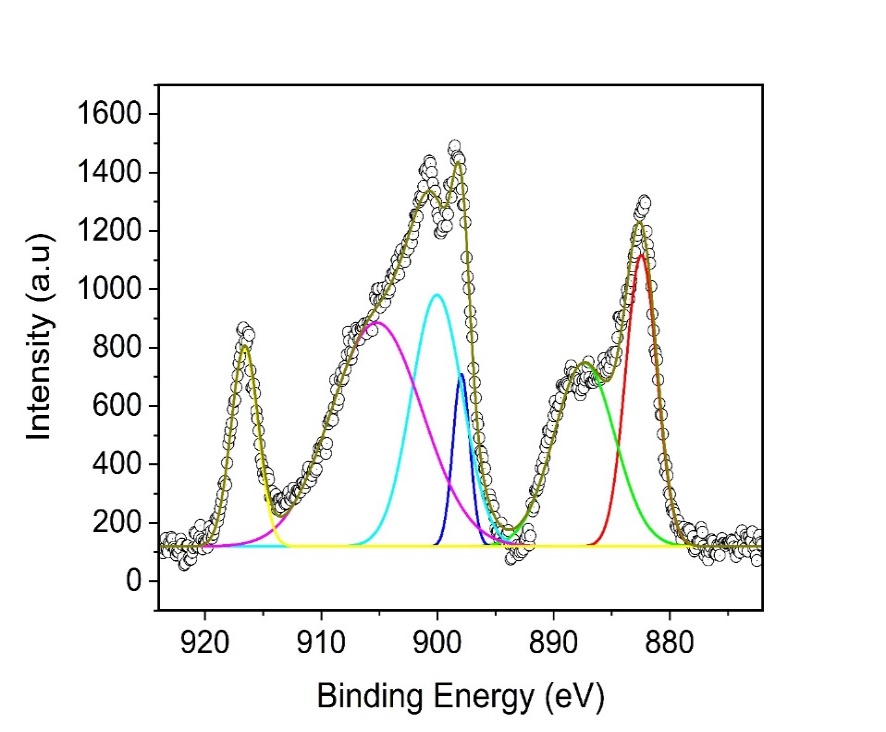
**(c)**

**(d)**

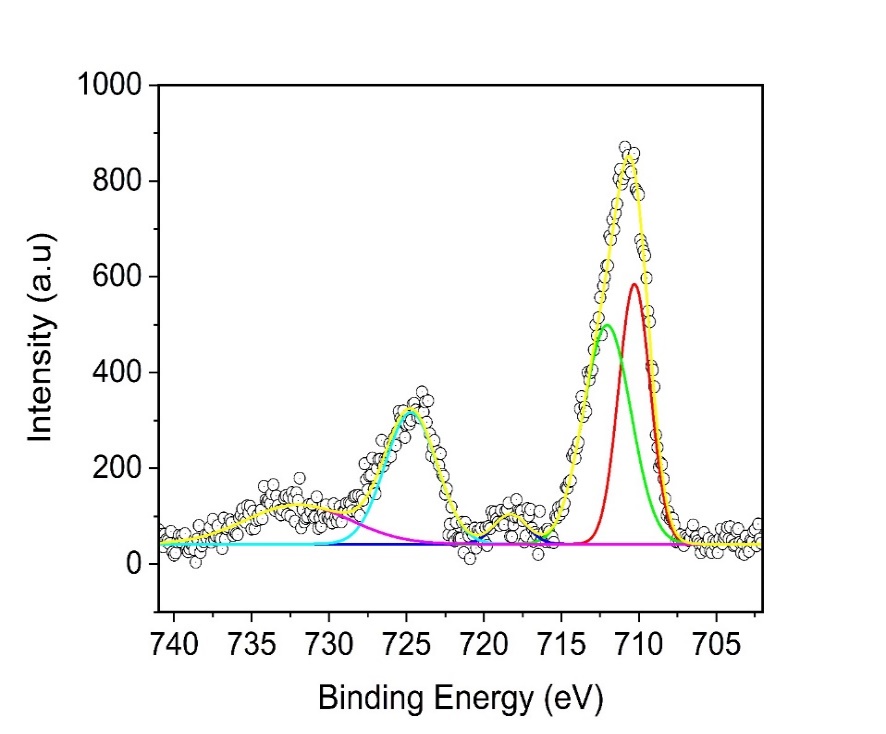
**(e)**

**(f)**

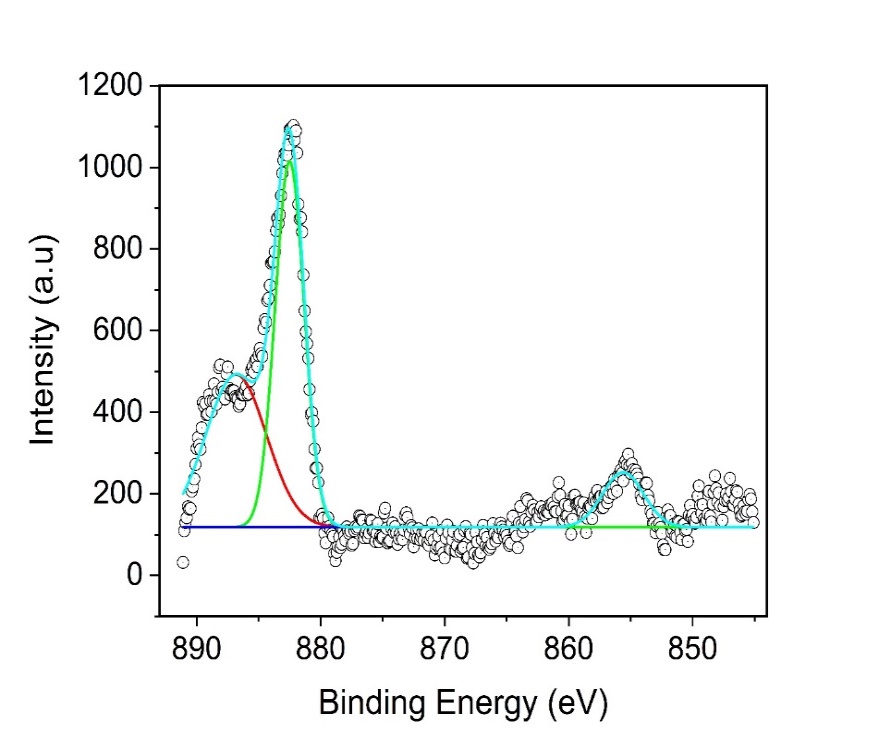
**Figure S5**:XPS spectra of Co1-2xNixMnxFe2-yCeyO4 sample for which x = y = 0.2: (a) Co 2p scan, (b) Ni 2p scan, (c) Mn 2p scan (d) Ce 3d scan, (e) Fe 2p scan, and (f) O 1s scan.



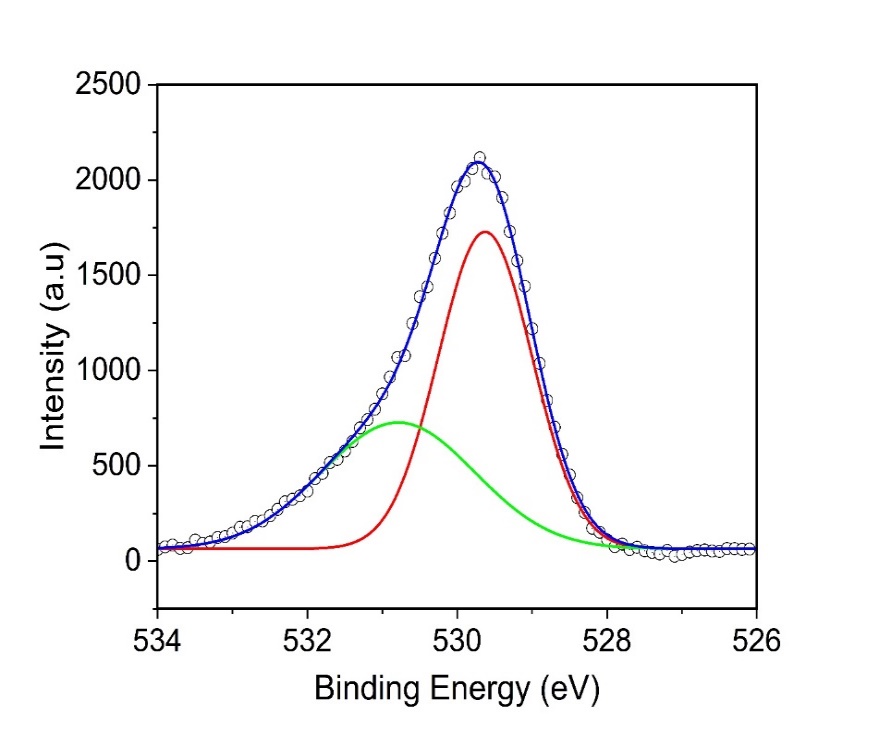
Ce 3d scan



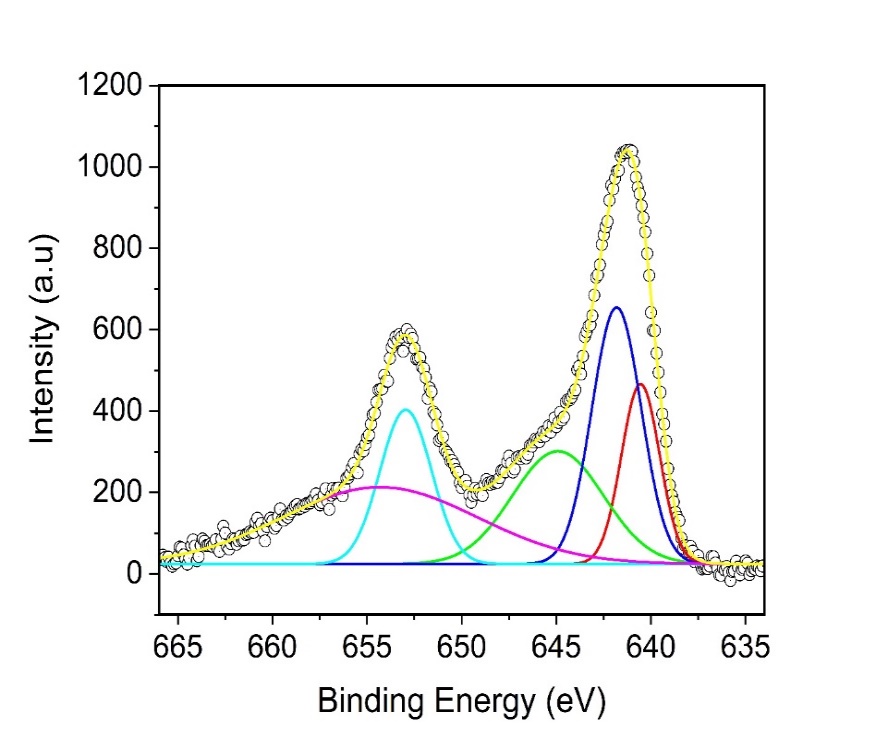
Fe 2p scan



Ni 2p scan



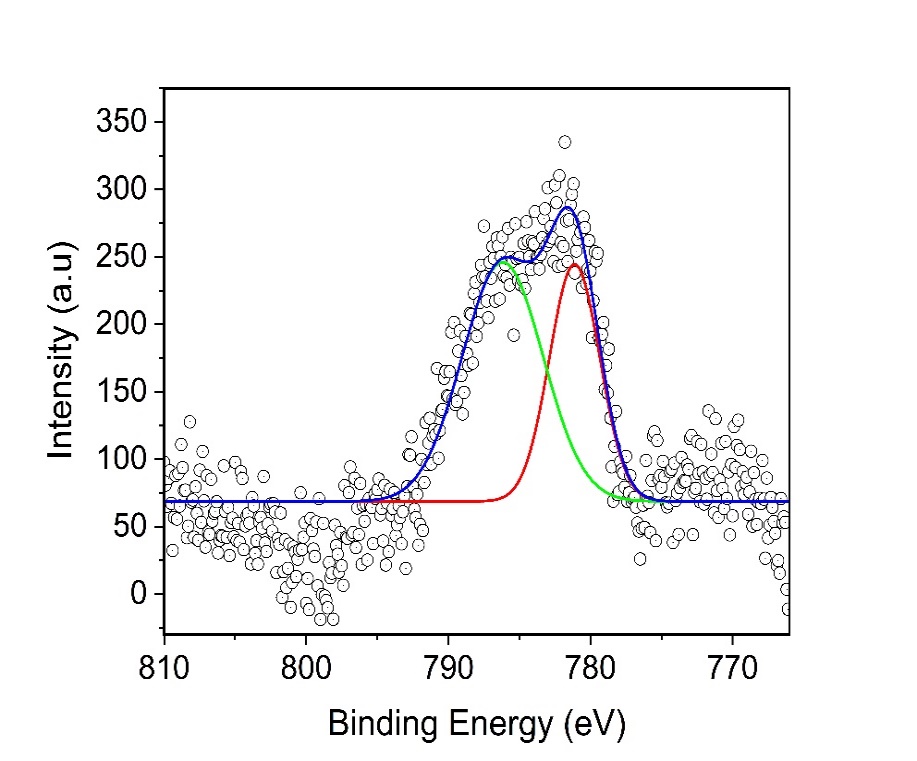
O 1s scan



Mn 2p scan

529.62 eV

530.77 eV



Co 2p scan

Co 2p3/2

B-site Co2+

B-site Co2+

satellite

Ni 2p3/2

Ni 2p1/2

B-site Fe3+

A-site

Fe3+

A-site Fe3+

satellite

Fe 2p1/2

Fe 2p1/2 satellite

Fe 2p3/2

Mn2+

Mn3+

Mn 2p3/2

Mn 2p3/2 satellite

Mn 2p1/2

Mn 2p1/2 satellite

*v*

*vʹ*

*vʹʹ*

*vʹʹʹ vʹʹʹʹ*

*u*

*vʹʹʹʹ*

*ʹ*

**(a)**

**(b)**

**(c)**

**(d)**

**(e)**

**(f)**

**Figure S6**.XPS spectra of Co1-2xNixMnxFe2-yCeyO4 sample for which x = y = 0.3: (a) Co 2p scan, (b) Ni 2p scan, (c) Mn 2p scan (d) Ce 3d scan, (e) Fe 2p scan, and (f) O 1s scan

**Table S1**: Fitting peaks in Figures S5(d) and S6(d) and the responsible cations

|  |  |
| --- | --- |
| Peak | cation |
| V | Ce4+ |
| V’ | Ce4+ |
| V’’ | Ce4+ |
| V’’’ | Ce4+ |
| V’’’’ | Ce4+ |
| U | Ce3+ |

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