Supporting Information

Facile Synthesis of C-FeF$_2$ Nanocomposites from CF$_X$: Influence of Carbon Precursor on Reversible Lithium Storage

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Table S1 Physical and chemical properties of various CF$_X$ samples studied

| Product Grade | ARC1000 | ARC2065 | ARC3000 | ARC4000 |
|---------------|---------|---------|---------|---------|
| Carbon source | Petro-coke | Carbon-black | Graphite | Carbon-fiber |
| Precursor code | FPC | FCB | FG | FCF |
| Composition | CF$_{1.05}$ | CF$_{1.12}$ | CF$_{0.95}$ | CF$_{1.1}$ |
| Particle size range, μm | 1-45 | N/A | <1 to 10 | 1-30 |
| Median particle size, μm | ~ 8 | <1 | ~ 2 | ~ 6 |
| Surface Area, m$^2$/g | 130 | 340 | N/A | 344 |
| Decomposition Temperature, °C | ~ 630 | ~ 500 | >550 | N/A |

Sources: Advanced Research Chemicals

Table S2. Rietveld refinement parameters of C-FeF$_2$ nanocomposites

| Sample | Composition | a (Å) | b (Å) | c (Å) | θ (°) | Crystallite Size (nm) | Strain (%) | $R_w$ (%) |
|--------|-------------|-------|-------|-------|-------|-----------------------|------------|----------|
| PC-FeF$_2$ | 93.2 wt% FeF$_2$ | 4.697 | 4.697 | 3.293 | 90 | 11 | 0.07 | 5.6 |
| | 6.8 wt% Fe$_5$C$_2$ | 11.895 | 4.552 | 5.052 | 97.15 | 93 | 1.43 |
| CB-FeF$_2$ | 100 wt% FeF$_2$ | 4.696 | 4.696 | 3.303 | 90 | 17 | 0 | 5.4 |
| G-FeF$_2$ | 89.8 wt% FeF$_2$ | 4.701 | 4.701 | 3.297 | 90 | 12 | 0.24 | 5.6 |
| | 10.2 wt% Fe$_5$C$_2$ | 11.821 | 4.564 | 5.039 | 98.28 | 73 | 1.33 |
| *CF-FeF$_2$ | 77.5 wt% FeF$_2$ | 4.699 | 4.699 | 3.299 | 90 | 16 | 0.13 | 6.6 |
| | 22.5 wt% Fe$_5$C$_2$ | 11.839 | 4.594 | 5.036 | 98.65 | 16 | 0.04 |
Table S3 Summary of hyperfine parameters obtained from fitting the $^{57}$Fe Mössbauer spectra.

|            | FeF$_2$ | Fe$^{3+}$ Content | Fe Carbide |
|------------|---------|-------------------|-----------|
|            | IS      | QS    | %     | IS   | QS   | %     | IS   | IS   | IS   | IS   | IS   | %       |
| PC-FeF$_2$ | 1.33(1) | 2.76(1)| 72    | 0.47* | 0.65(1)| 15    | 0.25(1)| 22.1(1)| 0.31(1)**| 19.2(1)| 0.31(1)**| 11.3(1) | 13    |
| CB-FeF$_2$ | 1.33(1) | 2.77(1)| 79    | 0.47* | 0.77(1)| 21    | -     | -     | -     | -     | -     | -       |
| Q-FeF$_2$  | 1.33(1) | 2.77(1)| 80    | 0.47* | 0.70(1)| 10    | 0.26(1)| 22.0(1)| 0.25(1)**| 18.7(1)| 0.25(1)**| 10.7(1) | 30    |
| CF-FeF$_2$ | 1.33(1) | 2.78(1)| 47    | 0.47(1)| 0.68(1)| 15    | 0.27(1)| 22.2(1)| 0.21** | 18.0(1)| 0.21** | 10.1(1) | 38    |

IS and QS are given in [mm/s], B$_{hf}$ in [T].

"% Carbide" is the sum of the spectral fractions of the FeII, III sub-spectra.

* Parameter is fixed to the value obtained from sample CF-FeF$_2$.

** IS of FeII and FeIII site are constrained to be identical, as the IS of these Fe sites are known to be very similar.

Figure S1 XRD patterns of various CFx samples
Figure S2 SEM Images of (a) FPC (ARC 1000) (b) FCB (ARC 2065) (c) FG (ARC 3000) and (d) FCF (ARC 4000).

Figure S3 SEM images of (a) PC-FeF$_2$ (b) CB-FeF$_2$ (c) G-FeF$_2$ and (d) CF-FeF$_2$
Figure S4 High resolution TEM image of G-FeF$_2$ nanocomposites
Figure S5 Electrochemical impedance spectra of C-FeF$_2$ nanocomposites obtained at OCV.