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(71) Applicant: **FLUOROK LIMITED** [GB/GB]; 7400 The Quorum, Alec Issigonis Way, Oxford OX4 2JZ (GB).

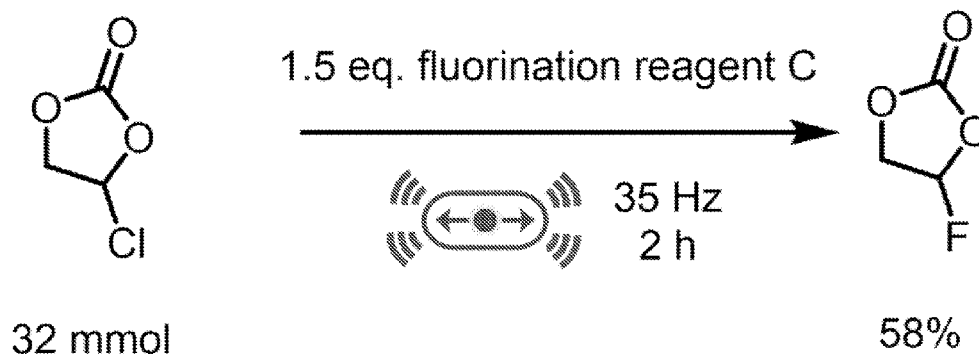
(72) Inventors: **PUPO, Gabriele**; c/o Fluorok Limited, 7400 The Quorum, Alec Issigonis Way, Oxford OX4 2JZ (GB). **IBBA, Francesco**; c/o Fluorok Limited, 7400 The Quorum, Alec Issigonis Way, Oxford OX4 2JZ (GB). **FERGUSON-LEITCH, Jamie**; c/o Fluorok Limited, 7400 The Quorum, Alec Issigonis Way, Oxford OX4 2JZ (GB). **BABRA, Jasraj Singh**; c/o Fluorok Limited, 7400 The Quorum, Alec Issigonis Way, Oxford OX4 2JZ (GB).

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(54) Title: ELECTROLYTES AND ELECTROLYTE COMPONENTS, ADDITIVES, PRECURSORS THEREOF, AND METHODS OF MANUFACTURE

FIG. 4



(57) Abstract: Provided herein are compositions and methods of manufacturing compositions useful in producing battery electrolyte components or additives and battery electrolytes.

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## **ELECTROLYTES AND ELECTROLYTE COMPONENTS, ADDITIVES, PRECURSORS THEREOF, AND METHODS OF MANUFACTURE**

### **CROSS-REFERENCE**

[0001] This application claims the benefit of priority to U.S. Provisional Application No. 63/521,150, filed June 15, 2023, which is incorporated herein by reference.

### **BACKGROUND OF THE INVENTION**

[0002] Use of hazardous and toxic reagents, such as HF, to manufacture and produce battery electrolyte additives and battery electrolyte components is dangerous and harmful to the environment. Provided herein are processes for manufacturing battery electrolyte components and battery electrolyte additives reducing and/or eliminating use of dangerous reagents.

### **SUMMARY OF THE INVENTION**

[0003] In one aspect provided herein are methods for manufacturing battery electrolyte component or additives. In some embodiments, methods provided herein comprise providing a fluorination reagent. In some embodiments, fluorination reagents are crude fluorination reagents that can be further purified to provide a purified fluorination reagent. In some embodiments, fluorination reagents are purified fluorination reagents. In some embodiments, the fluorination reagent comprises a first salt and a second salt. In some embodiments, the first salt comprises calcium and fluorine. In some embodiments, methods provided herein comprise contacting a fluorination reagent with a starting reagent to provide a battery electrolyte component or additive.

[0004] In some embodiments, methods for manufacturing battery electrolyte component or additives can comprise the second salt comprising an anion. In some embodiments, the anion of the second salt, when combined with  $\text{Ca}^{2+}$  to form a third salt, has a lattice energy greater than 2450 KJ/mol. In some embodiments, a powder x-ray diffraction spectrum of the fluorination reagent comprises characteristic  $2\theta$  reflections at about  $21.9^\circ$ ,  $30.3^\circ$ ,  $31.6^\circ$ ,  $43.4^\circ$  and/or combinations thereof. In some embodiments, a powder x-ray diffraction spectrum of the fluorination reagent comprises characteristic  $2\theta$  reflections at about  $28.1^\circ$ ,  $49.0^\circ$ ,  $52.3^\circ$ ,  $54.1^\circ$ ,  $60.0^\circ$ ,  $69.7^\circ$  and/or combinations thereof.

[0005] In one aspect, provided herein are methods for manufacturing fluorination reagents for providing battery electrolyte component or additives. In some embodiments, fluorination reagents are crude fluorination reagents that can be further purified to provide a purified fluorination reagent. In some embodiments, fluorination reagents are purified fluorination reagents. In some embodiments, methods provided herein comprise combining a first salt with a second salt to form a mixed composition. In some embodiments, the first salt can comprise calcium and fluorine. In some embodiments, methods provided herein comprise applying mechanical force to a

combination of a first salt and a second salt to form a mixed composition. In some embodiments, methods provided herein comprise subjecting the mixed composition to a fluid composition and collecting a resultant fluid thereof. In some embodiments, subjecting the mixed composition to a fluid composition produces a solid component and a resultant fluid.

**[0006]** In some embodiments, methods provided herein comprise concentrating the resultant fluid. In some embodiments, concentrating the resultant fluid forms a crude fluorination reagent that can be further purified to provide a purified fluorination reagent. In some embodiments, concentrating the resultant fluid produces a reagent concentrate or precipitate. In some embodiments, methods provided herein comprise washing the fluorination reagent with a solvent to produce a reagent wash. In some embodiments, washing the fluorination reagent provides a second solid component and fluid reagent wash. In some embodiments, the reagent wash comprises a fluorination reagent. In some embodiments, the reagent wash comprises a purified fluorination reagent.

**[0007]** In some embodiments, methods provided herein comprise concentrating the reagent wash to form a fluorination reagent. In some embodiments, concentrating the reagent wash provides a purified fluorination reagent. In some embodiments, the purified fluorination reagent has a higher concentration of fluorine compared to the crude fluorination reagent. In some embodiments, methods provided herein comprise contacting fluorination reagents with starting reagents to provide fluorinated products. In some embodiments, fluorination reagents are purified fluorination reagents. In some embodiments, contacting fluorination reagents with starting reagents provides a battery electrolyte components or additives.

**[0008]** In some embodiments, methods for manufacturing battery electrolyte components or additives, and methods for manufacturing fluorination reagents for providing battery electrolyte components or additives can comprise contacting fluorination reagents with starting reagents in an alkyl carbonate solvent (e.g., dimethyl carbonate). In some embodiments, fluorination reagents are crude fluorination reagents that can be further purified to provide a purified fluorination reagent. In some embodiments, fluorination reagents are purified fluorination reagents. In some embodiments, alkyl carbonate solvent is dimethyl carbonate, diethyl carbonate, dipropyl carbonate, methyl ethyl carbonate, methyl propyl carbonate, ethyl propyl carbonate, and/or combinations thereof. In some embodiments, the alkyl carbonate solvent is a fluoroalkyl carbonate solvent (e.g., trifluoroethyl carbonate, bis(trifluoroethyl) carbonate, trifluoroethyl methyl carbonate, and/or combinations thereof). In some embodiments, a combination of the fluorination reagent, the alkyl carbonate solvent, and the starting reagent is at any suitable temperature. In some embodiments, a combination of the fluorination reagent, the alkyl carbonate solvent, and starting reagent is at a temperature of about 50 to about 150 °C. In some embodiments, a combination of the fluorination

reagent, the alkyl carbonate solvent, and starting reagent is at a temperature of about 80 °C about or more (e.g., about 100 °C or more).

**[0009]** In one aspect, provided herein are methods for manufacturing battery electrolyte component or additives. In some embodiments, methods provided herein comprise providing a fluorination reagent. In some embodiments, fluorination reagents are crude fluorination reagents that can be further purified to provide a purified fluorination reagent. In some embodiments, fluorination reagents are purified fluorination reagents. In some embodiments, the fluorination reagent comprises an alkali metal, fluoride, and at least one additional ion. In some embodiments, the alkali metal is lithium, potassium, or sodium. In some embodiments, methods provided herein comprise contacting the starting reagent with the fluorination reagent to provide a battery electrolyte component or additive.

**[0010]** In one aspect, provided herein are methods for manufacturing battery electrolyte component or additives. In some embodiments, methods provided herein comprise providing a fluorination reagent. In some embodiments, the fluorination reagent comprises calcium and fluorine. In some embodiments, methods provided herein comprise contacting the starting reagent with the fluorination reagent to provide a battery electrolyte component or additive.

**[0011]** In some embodiments, methods for manufacturing fluorination reagents and methods for manufacturing fluorination reagents for providing battery electrolyte component or additives provided herein can comprise adjusting the pH of the resultant fluid prior to concentrating the resultant fluid. In some embodiments, the resultant fluid can be adjusted to a pH of about 6 to about 8. In some embodiments, fluorination reagents are crude fluorination reagents that can be further purified to provide a purified fluorination reagent. In some embodiments, fluorination reagents are purified fluorination reagents.

**[0012]** In some embodiments, pH of the resultant fluid is adjusted with an acid. In some embodiments, the acid can comprise a strong acid, a weak acid, a polyprotic acid, and/or combinations thereof. In some embodiments, the acid can comprise phosphoric acid, hydrochloric acid, formic acid, acetic acid, benzoic acid, boric acid, silicic acid, oxalic acid, sulfuric acid, sulfurous acid, carbonic acid, and/or combinations thereof. In some embodiments, the acid can comprise hydrochloric acid, phosphoric acid, sulfuric acid, and/or combinations thereof.

**[0013]** In some embodiments, the resultant fluid can be adjusted to a pH of about 5 to about 10 (e.g., about 6 to about 9). In some embodiments, the fluid composition has a pH of about 7 or more (e.g., about 10 or more). In some embodiments, the fluid composition has a pH of about 12 to about 13. In some embodiments, a combination of the fluid composition and the mixed composition is at any suitable temperature. In some embodiments, a combination of the fluid composition and the mixed composition is at a temperature of about 0 to about 120 °C. In some embodiments, a

combination of the fluid composition and the mixed composition is at a temperature of 80 °C or more.

**[0014]** In some embodiments, a combination of the fluid composition and the mixed composition is at a temperature of 110 °C or less. In some embodiments, the mixed composition is subjected to the fluid composition for any suitable time. In some embodiments, the mixed composition is subjected to the fluid composition for about 0 hours to about 8 hours. In some embodiments, the mixed composition is subjected to the fluid composition for about 1 hour or more. In some embodiments, the mixed composition is subjected to the fluid composition for about 6 hours or less. In some embodiments, the mixed composition is subjected to the fluid composition for about 2 hours.

**[0015]** In some embodiments, the fluid composition has a boiling point of about 30 °C or more (e.g., about 70 °C or more, about 120 °C or more). In some embodiments, the fluid composition has a boiling point of about 240 °C or less. In some embodiments, a combination of the solvent and fluorination reagent is at any suitable temperature. In some embodiments, fluorination reagents are crude fluorination reagents that can be further purified to provide a purified fluorination reagent. In some embodiments, fluorination reagents are purified fluorination reagents. In some embodiments, a combination of the solvent and fluorination reagent is at a temperature of about -20 to about 240 °C. In some embodiments, a combination of the solvent and fluorination reagent is at a temperature of about 80 °C or more. In some embodiments, a combination of the solvent and the fluorination reagent is at a temperature of about 60 °C. In some embodiments, a combination of the solvent and fluorination reagent is at a temperature of about 235 °C or less.

**[0016]** In some embodiments, fluorination reagents are washed with a solvent for about 4 hours to about 48 hours (e.g., about 8 hours to about 36 hours, about 10 hours to about 28 hours). In some embodiments, fluorination reagents are washed with a solvent for about 8 hours or more. In some embodiments, fluorination reagents are washed with a solvent for about 36 hours or less. In some embodiments, fluorination reagents are washed with a solvent for about 18 hours. In some embodiments, a solvent has a boiling point of about 30 °C or more (e.g., about 70 °C or more, about 120 °C or more). In some embodiments, a solvent has a boiling point of about 240 °C or less. In some embodiments, a solvent is an organic solvent, water, an alcohol, a polar aprotic solvent, a halocarbon, and/or combinations thereof. In some embodiments, a fluid composition is an organic solvent, water, an alcohol, a polar aprotic solvent, a halocarbon, and/or combinations thereof.

**[0017]** In some embodiments, a solvent is acetonitrile, propionitrile, butyronitrile, toluene, 1,2-dichlorobenzene, chlorobenzene, fluorobenzene, 1,2-difluorobenzene, dichloroethane, trifluorotoluene, chloroform, sulfolane, DMF, DMSO, an alcohol (e.g., tert-butanol, tert-amyl alcohol), water, and/or combinations thereof. In some embodiments, a fluid composition is

acetonitrile, propionitrile, butyronitrile, toluene, 1,2-dichlorobenzene, chlorobenzene, fluorobenzene, 1,2-difluorobenzene, dichloroethane, trifluorotoluene, chloroform, sulfolane, DMF, DMSO, an alcohol (e.g., tert-butanol, tert-amyl alcohol), water, and/or combinations thereof. In some embodiments, a solvent is acetonitrile, propionitrile, butyronitrile, and/or combinations thereof.

**[0018]** In some embodiments, a fluid composition is acetonitrile, propionitrile, butyronitrile, and/or combinations thereof. In some embodiments, the mixed composition subjected to the fluid composition is provided as the first salt. In some embodiments, the first salt is a recovered waste material. In some embodiments, the first salt comprises low purity calcium and fluoride. In some embodiments, the first salt can comprise calcium and fluorine in less than 80 weight percent in total. In some embodiments, the first salt is  $\text{CaF}_2$  or  $\text{Ca}_5(\text{PO}_4)_3\text{F}$ . In some embodiments, the second salt is a metal hydroxide, a metal sulphite, a metal sulphate, a carbonate, or an inorganic phosphate (e.g., a pyrophosphate).

**[0019]** In some embodiments, the second salt comprises  $\text{NaOH}$ ,  $\text{KOH}$ ,  $\text{Na}_2\text{SO}_3$ ,  $\text{K}_2\text{SO}_3$ ,  $\text{KHSO}_4$ ,  $\text{CaCO}_3$ ,  $\text{H}_2\text{CO}_3$ ,  $\text{K}_2\text{CO}_3$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{K}_4\text{P}_2\text{O}_7$ ,  $\text{Na}_4\text{P}_2\text{O}_7$ ,  $\text{Na}_3\text{PO}_4$ ,  $\text{Li}_3\text{PO}_4$ ,  $\text{KHCO}_3$ ,  $\text{K}_2\text{CO}_3$ ,  $\text{NaHCO}_3$ ,  $\text{Cs}_2\text{CO}_3$ ,  $\text{K}_2\text{HPO}_4$ ,  $\text{KH}_2\text{PO}_4$ ,  $\text{K}_3\text{PO}_4$ ,  $\text{KPO}_3$ ,  $\text{K}_5\text{P}_3\text{O}_{10}$ ,  $\text{K}_2\text{SO}_4$ , titanium phosphate, aluminum phosphate, uranium phosphate, and/or combinations thereof.

**[0020]** In some embodiments, crude fluorination reagents are purified at least in part using a filtration process. In some embodiments, a filtrate is concentrated and/or dried during any step or process of any method described herein. In some embodiments, the filtration process comprises passing any solution described herein through the same or a plurality of filtration modules a plurality of times (e.g., by making three or more consecutive passes through the same module and/or by passing once each through three consecutively coupled modules). In some embodiments, a fluorine recovery of a filtration process employed herein is greater than 90% (e.g., greater than 95% or greater than 99%). In some embodiments, a rejection of one or more contaminants by a filtration process employed in any method described herein is greater than 90% (e.g., greater than 95% or greater than 99%).

**[0021]** In some embodiments, an amount of phosphorous in the fluorination reagent is about 1 ppm to about 25 ppm (e.g., about 1 ppm, about 10 ppm, about 20 ppm, or about 25 ppm). In some embodiments, an amount of phosphorous in the fluorination reagent is about 0.015 % to about 12.5 % by weight (wt %). In some embodiments, an amount of calcium in the fluorination reagent is about 0.01 % to about 15 % by weight (wt %). In some embodiments, an amount of phosphorous in the fluorination reagent is about about 0.02 % to about 10 % by weight (wt %) (e.g., about 0.05 wt % to about 8 wt %, about 0.1 wt % to about 6 wt %, about 0.5 wt % to about 5 wt %, about 1 wt % to about 4 wt %). In some embodiments, an amount of phosphorous in the fluorination reagent

is about 0.015 % by weight (wt %) or more (e.g., about 0.05 wt % or more, about 0.1 wt % or more, about 0.5 wt % or more). In some embodiments, an amount of phosphorous in the fluorination reagent is about 5 % by weight (wt %) or less (e.g., about 3 wt % or less, about 2 wt % or less, about 1 wt % or less, about 0.5 wt % or less, about 0.1 wt % or less, about 0.05 wt % or less). In some embodiments, a powder x-ray diffraction spectrum of the fluorination reagent comprises characteristic 2 $\theta$  reflections at about 5.2°, 31.5°, 36.8° and/or combinations thereof.

**[0022]** In some embodiments, methods for manufacturing battery electrolyte component or additives and methods for manufacturing fluorination reagents for providing battery electrolyte component or additives provided herein can comprise fluorination reagents. In some embodiments, fluorination reagents are crude fluorination reagents that can be further purified to provide a purified fluorination reagent. In some embodiments, fluorination reagents are purified fluorination reagents. In some embodiments a combination of the fluorination reagent and the starting reagent comprises a reaction mixture. In some embodiments, the reaction mixture is at any suitable temperature. In some embodiments, the reaction mixture is at a temperature of about 55 to about 150 °C. In some embodiments, the reaction mixture is at a temperature of about 100 °C or less. In some embodiments, the reaction mixture is refluxed at a reaction temperature. In some embodiments, the reaction temperature and/or a reflux temperature is about 100 to about 175 °C. In some embodiments, the reaction mixture is stirred in a pressure vessel. In some embodiments, the reaction is performed in a heated twin-screw extruder. In some embodiments, the fluorination reagent is contacted with the starting reagent for any suitable time. In some embodiments, the fluorination reagent is contacted with the starting reagent for about 12 hours or more. In some embodiments, the fluorination reagent is contacted with the starting reagent for about 14 hours to about 22 hours. In some embodiments, the fluorination reagent is contacted with the starting reagent for about 84 hours or less. In some embodiments, the fluorination reagent is contacted with the starting reagent for about 60 hours to about 80 hours.

**[0023]** In some embodiments, the reaction mixture further comprises a phase transfer agent, a base, and/or combinations thereof. In some embodiments, the phase transfer agent is a crown ether (e.g., 18 crown 6), a cryptand, an ionic transfer agent (e.g., tetramethylammonium chloride), and/or a hydrogen-bonding phase transfer agent. In some embodiments, the phase transfer agent is a crown ether (e.g., 18 crown 6). In some embodiments, the base is a pyridine or a derivative thereof (e.g., DMAP).

**[0024]** In some embodiments, the reaction mixture further comprises a reaction solvent. In some embodiments, the reaction solvent is an organic solvent, water, an alcohol, a polar aprotic solvent, a halocarbon, and/or combinations thereof. In some embodiments, the reaction solvent is acetonitrile, propionitrile, pyridine, butyronitrile, toluene, 1,2-dichlorobenzene, chlorobenzene,

fluorobenzene, 1,2-difluorobenzene, dichloroethane, trifluorotoluene, chloroform, DMF, DMSO, an alcohol (e.g., tert-butanol, tert-amyl alcohol), water, and/or combinations thereof. In some embodiments, the reaction solvent is acetonitrile, propionitrile, pyridine, butyronitrile, and/or combinations thereof.

[0025] In some embodiments, the starting reagent comprises a leaving group. In some embodiments, the leaving group is chlorine, iodine, or bromine. In some embodiments, the battery electrolyte component or additive comprises at least one additional fluorine (e.g., at least two additional fluorine) compared to the starting reagent. In some embodiments, the starting reagent is 4-chloroethylene carbonate. In some embodiments, the starting reagent is dichloroethylene carbonate. In some embodiments, the battery electrolyte component or additive is 4-fluoroethylene carbonate. In some embodiments, the battery electrolyte component or additive is difluoroethylene carbonate.

[0026] In some embodiments, the at least one additional ion of the fluorination reagent comprises (i) at least one cation and at least one anion; or (ii) at least one zwitterion (e.g., psilocybin). In some embodiments, the at least one cation comprises  $K^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $Li^+$ , or  $Cs^+$ . In some embodiments, the at least one anion comprises a hydroxide, a sulphate, a carbonate, a phosphate, a pyrophosphate. In some embodiments, a molar ratio of the phase transfer agent to the starting reagent is about 0 to about 4. In some embodiments, a molar ratio of the base to the starting reagent is about 0 to about 2. In some embodiments, a molar ratio of a fluorine equivalent content in the fluorination reagent to the starting reagent is about 0.1 or more.

[0027] In some embodiments, a yield of the battery electrolyte component or additive is about 10% or more. In some embodiments, a yield of the battery electrolyte component or additive is about 20% to about 80%. In some embodiments, a concentration of the starting reagent in the reaction solvent and/or alkyl carbonate solvent is about 0.01 M to about 3 M. In some embodiments, a concentration of the starting reagent in the reaction solvent is about 1 M or less. In some embodiments, a concentration of the starting reagent in the alkyl carbonate solvent is about 1 M or less. In some embodiments, the fluorination reagent is contacted with the starting reagent under mechanochemical conditions (e.g., ball mill).

## BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings (also “Figure” and “FIG.” herein), of which:

[0029] **FIG. 1** illustrates an exemplary schematic of a mechanochemical method for combining one or more salts provided herein.

[0030] **FIG. 2** illustrates an exemplary schematic of a process for manufacturing a fluorinating reagent provided herein.

[0031] **FIG. 3** illustrates an exemplary schematic of using a fluorination reagent (e.g., a purified fluorination reagent) provided herein to synthesize 4-fluoroethylene carbonate.

[0032] **FIG. 4** illustrates an exemplary schematic of a method of using a fluorination reagent provided herein to synthesize 4-fluoroethylene carbonate.

[0033] **FIG. 5** illustrates an exemplary schematic of a process for manufacturing a fluorination reagent useful in synthesis of 4-fluoroethylene carbonate by methods provided herein.

## **DETAILED DESCRIPTION OF THE INVENTION**

### **Certain Definitions**

[0034] As used herein and in the appended claims, the singular forms "a," "and," and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "an agent" includes a plurality of such agents, and reference to "the cell" includes reference to one or more cells (or to a plurality of cells) and equivalents thereof known to those skilled in the art, and so forth. When ranges are used herein for physical properties, such as molecular weight, or chemical properties, such as chemical formulae, all combinations and subcombinations of ranges and specific embodiments therein are intended to be included. The term "about" when referring to a number or a numerical range means that the number or numerical range referred to is an approximation within experimental variability (or within statistical experimental error), and thus the number or numerical range may vary between 1% and 15% of the stated number or numerical range. The term "comprising" (and related terms such as "comprise" or "comprises" or "having" or "including") is not intended to exclude that in other certain embodiments, for example, an embodiment of any composition of matter, composition, method, or process, or the like, described herein, may "consist of" or "consist essentially of" the described features.

[0035] Provided herein are fluorination reagents and compositions useful for synthesizing battery electrolytes. In some instances, such reagents and compositions are useful in producing battery electrolytes in high-yields and/or without using toxic reagents, such as HF.

[0036] Provided herein are fluorination reagents and compositions useful for synthesizing battery electrolyte components or additives. In some instances, such reagents and compositions are useful in producing battery electrolyte components or additives in high-yields and/or without using toxic reagents, such as HF.

[0037] In some embodiments, provided herein is a method of manufacturing a battery electrolyte component or additive (e.g., 4-fluoroethylene carbonate). In specific embodiments, any of the

methods provided herein can comprise contacting a fluorination reagent with a starting reagent (e.g., a starting reagent provided herein) to provide a battery electrolyte component or additive (e.g., 4-fluoroethylene carbonate).

**[0038]** In some embodiments, provided herein is a method of manufacturing a battery electrolyte. In specific embodiments, any of the methods provided herein can comprise contacting a fluorination reagent with a starting reagent (e.g., a starting reagent provided herein) to provide a battery electrolyte.

**[0039]** Provided herein are fluorination reagents and compositions, as well as methods of making and using such fluorination reagents and compositions. In some instances, such reagents and compositions are useful in producing fluorinated products in high yield and/or without the need for use of toxic reagents, such as HF.

**[0040]** In some embodiments, provided herein is a method of manufacturing a fluorination reagent. In specific embodiments, the method comprises (1) combining (e.g., in the solid state) a first salt with a second salt, the first salt comprising fluoride (e.g., and calcium); and (2) subjecting a combination of the first salt and the second salt to a (e.g., aqueous) fluid composition. In some embodiments, the resultant fluid composition is subsequently concentrated (e.g., by evaporation or other suitable method) to produce a fluorination reagent composition.

**[0041]** In certain embodiments, the fluorination reagent composition is further washed with a (e.g., organic) solvent (e.g., an alcohol, such as methanol) to produce a reagent wash. In specific embodiments a (e.g., purified) fluorination reagent composition is recovered from the reagent wash (e.g., after filtering residual solids from the reagent wash). In some embodiments, separating a purified fluorination reagent from residual solids and/or separating solid contaminants from a resultant solution can independently comprise: centrifugation (e.g., using a decanter centrifuge and/or a disk stack centrifuge), press filtration, microfiltration, nanofiltration, ultrafiltration, cross-flow membrane filtration and/or combinations thereof.

**[0042]** In some embodiments, crude fluorination reagents are purified at least in part using a filtration process. In some embodiments, a filtrate is concentrated and/or dried during any step or process of any method described herein. In some embodiments, the filtration process comprises passing any solution described herein through the same or a plurality of filtration modules a plurality of times (e.g., by making three or more consecutive passes through the same module and/or by passing once each through three consecutively coupled modules). In some embodiments, a fluorine recovery of a filtration process employed herein is greater than 90% (e.g., greater than 95% or greater than 99%). In some embodiments, a rejection of one or more contaminants by a filtration process employed in any method described herein is greater than 90% (e.g., greater than 95% or greater than 99%).

**[0043]** In some embodiments, provided herein is a method of manufacturing a purified fluorination reagent, the method comprising:

- a. combining a first salt with a second salt to form a mixed composition, the first salt comprising calcium and fluoride;
- b. subjecting the mixed composition to a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
- c. concentrating the resultant fluid to produce a crude fluorination reagent (e.g., a reagent concentrate or precipitate);
- d. washing the crude fluorination reagent with a solvent (e.g., an alcohol) to produce a reagent wash (a second solid component and fluid reagent wash); and
- e. concentrating the reagent wash to form a purified fluorination reagent (e.g., the purified fluorination reagent having a higher concentration of fluorine compared to the crude fluorination reagent).

**[0044]** In specific embodiments, provided herein is a method of manufacturing a purified fluorination reagent, the method comprising:

- a. combining a first salt with a second salt to form a mixed composition, the first salt comprising calcium and fluoride;
- b. applying mechanical force to the mixed composition;
- c. subjecting the mixed composition to a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
- d. concentrating the resultant fluid to produce a crude fluorination reagent (e.g., a reagent concentrate or precipitate);
- e. washing the crude fluorination reagent with a solvent (e.g., an alcohol) to produce a reagent wash (a second solid component and fluid reagent wash); and
- f. concentrating the reagent wash to form a purified fluorination reagent (e.g., the purified fluorination reagent having a higher concentration of fluorine compared to the crude fluorination reagent).

**[0045]** In certain embodiments, provided herein are compositions or methods of providing (e.g., making, manufacturing, or the like) compositions comprising battery electrolytes or battery electrolyte components or additives. In specific embodiments, a battery electrolyte or a battery electrolyte component or additive provided herein comprises 4-fluoroethylene carbonate (e.g., the product of any of the reactions illustrated in FIGs. 3 or 4). In certain embodiments, battery electrolytes or battery electrolyte components or additives (e.g., 4-fluoroethylene carbonate) provided herein are useful for producing battery electrolytes without the use of toxic reagents such as HF.

**[0046]** In certain embodiments, provided herein are compositions or methods of providing (e.g., making, manufacturing, or the like) compositions comprising reagents or reagent compositions. In some embodiments, reagents or reagent compositions provided herein are high purity and/or low-phosphorous reagents or reagent compositions. In some embodiments, presence of high purity and/or low phosphorous (e.g., a purified fluorination reagent provided herein) allows for the use of a reagent or reagent composition that produces high yield fluorination (e.g., relative to otherwise similar reagents/compositions having lower purity and/or higher phosphorous content). In certain embodiments, reagent or reagent compositions provided herein provide an improved rate of fluorination (e.g., at least about 10% improved). In certain embodiments (e.g., purified) reagents or reagent compositions provided herein have a higher fluorine content compared to (e.g., crude) reagents or reagent compositions provided herein. In some embodiments (e.g., purified) reagents or reagent compositions provide a rate of fluorination of a starting reagent (e.g., aromatic compound) that is higher when compared to a rate of fluorination provided by a (e.g., crude) reagent or reagent composition provided herein.

**[0047]** In some embodiments, any reagent (e.g., fluorination reagent, such as a purified fluorination reagent, or crude fluorination reagent) or (e.g., reagent) composition (e.g., any reagent or mixed composition, such as used in making of a reagent) provided herein comprises a first salt (e.g., calcium fluoride) provided herein. In certain embodiments, a reagent or reagent composition provided herein comprises a first salt and a second salt (e.g.,  $K_2HPO_4$ ) provided herein. In specific embodiments, a reagent or reagent composition provided herein comprises a first salt provided herein.

**[0048]** In some embodiments, any reagent or reagent composition provided herein comprises a metal (e.g., alkali metal, alkaline earth metal). In certain embodiments, a reagent or reagent composition comprises an alkali metal. In specific embodiments, a reagent or reagent composition provided herein comprises an alkali metal (such as lithium, potassium, or sodium), fluoride, and (e.g., at least one additional) ion.

**[0049]** In certain embodiments, any composition provided herein comprises an ion (e.g., at least one additional ion herein). In some embodiments, a reagent (e.g., fluorination reagent, such as a purified fluorination reagent, or crude fluorination reagent) or (e.g., reagent) composition (e.g., any reagent or mixed composition, such as used in making of a reagent) provided herein comprises (e.g., at least one additional) ion. In specific embodiments, a reagent or reagent composition provided herein comprises at least one additional ion. In certain embodiments, a (e.g., salt or salt comprising a) composition provided herein comprises (e.g., at least one additional) ion. In specific embodiments, a (e.g., salt or salt comprising a) composition provided herein comprises at least one additional ion.

**[0050]** In some embodiments, an (e.g., at least one additional) ion provided herein comprises a cation, anion, and/or zwitterion. In some embodiments, an (e.g., at least one) cation provided herein comprises an alkali metal, alkaline earth metal, transition metal, other metal, cationic complex or ligand, or the like. In specific embodiments, an (e.g., at least one) cation provided herein is  $K^+$ ,  $Na^+$ ,  $Rb^+$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Fe^{2+}$ ,  $Fe^{3+}$ ,  $Cu^+$ ,  $Cu^{2+}$ ,  $Ag^+$ ,  $Li^+$ ,  $NH_4^+$ ,  $Sr^+$ ,  $Ba^{2+}$ ,  $Zn^{2+}$ ,  $Cd^{2+}$ ,  $Al^{3+}$ ,  $[Co(NH_3)_6]^{3+}$ ,  $Co^{3+}$ ,  $Co^{2+}$ ,  $U^{2+}$ ,  $U^{4+}$ ,  $U^{6+}$ ,  $Ni^{2+}$ , or  $Cs^+$ . In still more specific embodiments, (e.g., at least one) cation is  $K^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $Li^+$ , and/or  $Cs^+$ .

**[0051]** In certain embodiments, an (e.g., at least one) anion provided herein comprises a hydroxide, a sulphate, a carbonate, a phosphate, a pyrophosphate, a halide, a chlorate, a nitrate, a carbonate, a hydride, a sulfite, or the like. In specific embodiments, an (e.g., at least one) anion provided herein is a hydroxide, a sulphate, a carbonate, a phosphate, and/or a pyrophosphate.

**[0052]** In certain embodiments, an (e.g., at least one) zwitterion provided herein comprises an amino acid, a betaine, sulfamic acid, an acid, an aromatic compound, and/or a phospholipid. In specific embodiments, an (e.g., at least one) zwitterion provided herein is an amino acid, trimethylglycine, cocamidopropyl betaine, sulfamic acid, anthranilic acid, psilocybin, and/or phosphatidylcholine. In still more specific embodiments, an (e.g., at least one) zwitterion provided herein is psilocybin.

**[0053]** In certain embodiments, provided herein are reagents and reagent compositions with high purity and/or low levels of impurities (e.g., phosphorous, calcium, or the like). In some embodiments, high purity and low-content phosphorous allows for the use of a reagent or reagent composition that produces high-yield fluorination relative to other reagent or reagent compositions having low purity and/or higher phosphorous content. In certain embodiments, high purity and low-content calcium allows for the use of a reagent or reagent composition that produces high-yield fluorination relative to other reagent or reagent compositions having low purity and/or higher calcium content. In some instances, low-content calcium and/or phosphorous and high purity reagent or reagent compositions allow substantially improved fluorination capabilities.

**[0054]** In some embodiments, crude fluorination reagents are purified at least in part using a filtration process. In some embodiments, a filtrate is concentrated and/or dried during any step or process of any method described herein. In some embodiments, the filtration process comprises passing any solution described herein through the same or a plurality of filtration modules a plurality of times (e.g., by making three or more consecutive passes through the same module and/or by passing once each through three consecutively coupled modules). In some embodiments, a fluorine recovery of a filtration process employed herein is greater than 90% (e.g., greater than 95% or greater than 99%). In some embodiments, a rejection of one or more contaminants by a

filtration process employed in any method described herein is greater than 90% (e.g., greater than 95% or greater than 99%).

**[0055]** In some embodiments, an amount of phosphorous in the fluorination reagent is about 1 ppm to about 25 ppm (e.g., about 1 ppm, about 10 ppm, about 20 ppm, or about 25 ppm).

**[0056]** In some embodiments, any reagent or reagent composition provided herein (and/or produced or used herein) comprises low-content phosphorus. In certain embodiments, any reagent or reagent composition provided herein (and/or produced or used herein) comprises phosphorous in an amount of about 0.015 % to about 12.5 % by weight (wt %) (w/w). In some embodiments, a reagent or reagent composition provided herein comprises phosphorous in an amount of about 0.015 % by weight (wt %) or more (e.g., about 0.05 wt % or more, about 0.1 wt % or more, about 0.5 wt % or more). In certain embodiments, a reagent or reagent composition provided herein comprises phosphorous in an amount of about 1 % by weight or less (e.g., about 1 wt % or less, about 0.5 wt% or less, about 0.1 wt% or less, about 0.05 wt % or less).

**[0057]** In some embodiments, a reagent or reagent composition provided herein comprises phosphorous in an amount of about 0.05 % to about 10 wt % (e.g., about 0.1 wt % to about 6 wt %, about 0.5 wt% to about 5 wt %, about 1 wt% to about 4 wt %). In certain embodiments, a reagent or reagent composition provided herein comprises phosphorous in an amount of about 5 wt % or less (e.g., about 3 wt % or less, about 2 wt % or less, about 1 wt % or less, about 0.5 wt % or less, about 0.1 wt % or less).

**[0058]** In specific embodiments, a reagent or reagent composition provided herein comprises phosphorous in an amount of about 0.05 wt % to about 0.2 wt %.

**[0059]** In some embodiments, any reagent or reagent composition provided herein (and/or produced or used herein) comprises low-content calcium. In certain embodiments, any reagent or reagent composition provided herein (and/or produced or used herein) comprises calcium in an amount of about 0.01 % to about 15 % by weight (wt %) (w/w). In some embodiments, a reagent or reagent composition provided herein comprises calcium in an amount of about 0.01 % by weight (wt %) or more (e.g., about 0.05 wt % or more, about 0.1 wt% or more, about 0.5 wt % or more, about 1 wt % or more). In certain embodiments, a reagent or reagent composition provided herein comprises calcium in an amount of about 2 % by weight or less (e.g., about 1 wt% or less, about 0.5 wt% or less, about 0.1 wt % or less, about 0.05 wt% or less).

**[0060]** In some embodiments, a reagent or reagent composition provided herein comprises calcium in an amount of about 0.05 wt % to about 12 wt % (e.g., about 0.1 wt % to about 8 wt %, about 0.5 wt % to about 4 wt %). In certain embodiments, a reagent or reagent composition provided herein comprises calcium in an amount of about 6 wt % or less (e.g., about 4 wt % or less, about 2 wt %

or less, about 1 wt % or less, about 0.5 wt % or less, about 0.1 wt % or less, about 0.05 wt % or less).

**[0061]** In specific embodiments, a reagent or reagent composition provided herein comprises calcium in an amount of about 0.01 % to about 0.05 wt %.

**[0062]** In certain embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at about 28.1°. In some embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 28.1°, 49.0°, and/or 52.3°. In some embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 28.1°, 49.0°, 52.3°, 54.1°, 60.0°, and/or 69.7°. In specific embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 28.1°, 49.0°, 52.3°, 54.1°, 60.0°, and 69.7°.

**[0063]** In certain embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at about 21.9°. In some embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 21.9°, 30.3°, and/or 31.6°. In certain embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 21.9°, 30.3°, 31.6°, and/or 43.4°. In specific embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 21.9°, 30.3°, 31.6°, and 43.4°.

**[0064]** In certain embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at about 5.2°. In some embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 5.2°, 31.5°, and/or 36.8°. In certain embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein may further comprise peaks corresponding  $\pm 0.2^\circ 2\theta$  to one or more 2-theta values from Table 2. In specific embodiments, a powder x-ray diffraction spectrum of a reagent or reagent composition provided herein comprises characteristic 2 $\theta$  reflections at 5.2°, 31.5°, and 36.8°.

**[0065]** In certain embodiments, any reagent or reagent composition provided herein comprises high-content fluorine. In some embodiments, fluorine conversion (or F conversion) refers to a relative proportion or percentage (%) of fluorine from a (e.g., first) salt or salt composition provided herein that is converted to a reagent or reagent composition provided herein. In some embodiments, about 10 % to about 80 % of fluorine from a (e.g., first) salt or salt composition provided herein is converted into a (e.g., fluorination) reagent or reagent composition provided herein. In specific embodiments, about 30% to about 60% of fluorine from a (e.g., first) salt or salt

composition provided herein is converted into a (e.g., fluorination) reagent or reagent composition provided herein.

**[0066]** In certain embodiments, Fluorine wt% or F wt% refers to fluorine content by weight in a reagent or reagent composition provided herein. In certain embodiments, Fluorine wt% or F wt% is measured by any suitable method (e.g., quantitative  $^{19}\text{F}$  NMR). In some embodiments, a weight % of fluorine (F wt%) in a (e.g., fluorination) reagent or reagent composition provided herein is about 8% to about 75% (e.g., about 10% to about 70%, about 20% to about 60%, about 30% to about 50%, about 45% to about 55%). In specific embodiments, a weight % of fluorine (F wt%) in a (e.g., fluorination) reagent or reagent composition provided herein is about 20% or more (e.g., about 30% or more, about 40% or more, about 50% or more, about 60% or more, about 70% or more). In still more specific embodiments, a weight % of fluorine (F wt%) in a (e.g., fluorination) reagent or reagent composition provided herein is about 75% or less.

**[0067]** In certain embodiments, a (e.g., fluorination) reagent or reagent composition provided herein can be characterized by X-ray powder diffraction (XRPD) using Cu K $\alpha$ 1 ( $\lambda = 1.5406 \text{ \AA}$ ) and/or Cu K $\alpha$ 2 ( $\lambda = 1.5444 \text{ \AA}$ ). Due to differences in instruments, samples, and sample preparation, peak values are often reported with the modifier " $\pm 0.2^\circ 2\theta$ ". This is common practice in the solid-state chemical arts because of the variation inherent in peak values.

**[0068]** In certain embodiments, a (e.g., fluorination) reagent or reagent composition provided herein can have an XRPD pattern comprising peaks corresponding  $\pm 0.2^\circ 2\theta$  to at least 1, at least 2, at least 3, at least 5, at least 10, at least 20, at least 50, and/or at least 70 of the 2-theta values reported in Table 2 provided herein. In some embodiments, a (e.g., fluorination) reagent or reagent composition provided herein can have an XRPD pattern comprising peaks corresponding  $\pm 0.2^\circ 2\theta$  to at least 10%, at least 30%, at least 50%, at least 70%, at least 90%, and/or 100% of the 2-theta values reported in Table 2 provided herein. In specific embodiments, a (e.g., fluorination) reagent or reagent composition provided herein can have an XRPD pattern comprising peaks corresponding  $\pm 0.2^\circ 2\theta$  to at least 30% of the 50 2-theta values reported in Table 2 provided herein (the (e.g., fluorination) reagent or reagent composition may have an XRPD pattern comprising peaks corresponding to at least 15 of the 2-theta values, modified  $\pm 0.2^\circ 2\theta$ , in Table 2).

**[0069]** Table 2 illustrates X-ray powder diffraction using Cu K $\alpha$ 1 ( $\lambda = 1.5406 \text{ \AA}$ ) and/or Cu K $\alpha$ 2 ( $\lambda = 1.5444 \text{ \AA}$ ) for a (e.g., fluorination) reagent or reagent composition provided herein (e.g., fluorination reagent C as provided herein in Example 2).

**[0070]** In certain embodiments a method provided herein comprises combining a first salt and a second salt.

**[0071]** In certain embodiments, any of the methods or compositions provided herein comprise a first salt. In some embodiments, a first salt provided herein comprises fluoride. In specific

embodiments, the first salt comprises calcium and fluoride. In some embodiments, the first salt further comprises additional ions, such as cations and/or anions provided herein. In specific embodiments, the first salt comprises  $\text{CaF}_2$ ,  $\text{Ca}_5(\text{PO}_4)_3\text{F}$ , and/or combinations thereof.

**[0072]** In some embodiments, the first salt or composition comprising the first salt comprises fluoride. In specific embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride. In some embodiments, the first salt or composition comprising the first salt further comprises additional ions, such as cations and/or anions provided herein. In specific embodiments, the first salt or composition comprising the first salt comprises  $\text{CaF}_2$ ,  $\text{Ca}_5(\text{PO}_4)_3\text{F}$ , and/or combinations thereof.

**[0073]** In some embodiments, a first salt (e.g., a first salt provided herein) or a composition comprising a first salt provided herein is sourced from a material with low-value, low-purity, such as a waste material. In specific embodiments, the first salt provided herein is sourced from a waste material (e.g., calcium fluoride). In yet more specific embodiments, a composition comprising the first salt provided herein is sourced from a waste material. In certain embodiments, provided herein are methods for manufacturing reagents or reagent composition with waste materials. In some embodiments, a waste material (e.g., a waste material provided herein) comprises a raw, processed, and/or treated waste material. In certain embodiments, a waste material provided herein is a (e.g., recovered) waste product (e.g., sourced from an industrial process). In some embodiments, a waste material herein is a (e.g., recovered) waste product from an industrial process such as semiconductor manufacturing, fluorochemical manufacturing, pharmaceutical manufacturing, or the like. In certain embodiments, a waste material provided herein comprises fluorine (or a fluorinated salt), fluorapatite, calcium fluoride (e.g., in low purity), CFC-12, per- and polyfluoroalkyl substances (PFAs), or the like. In specific embodiments, a waste material provided herein comprises fluorine, or a fluorinated salt (e.g., in low purity). In yet more specific embodiments, a waste material provided herein comprises fluorine and calcium (e.g., in low purity). In certain instances, a waste material provided herein may be used as a raw, processed, or treated waste material to provide reagent or reagent compositions provided herein.

**[0074]** In certain embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride in a collective amount of about 20% or less. In some embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride in a collective amount of about 30% or less. In certain embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride in a collective amount of about 40% or less. In certain embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride in a collective amount of about 50% or less. In some embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride in a collective amount of about 60% or

less. In some embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride in a collective amount of about 70% or less. In some embodiments, the first salt or composition comprising the first salt comprises calcium and fluoride in a collective amount of about 80% or less.

**[0075]** In certain embodiments, the first salt comprises calcium and fluoride in a collective amount of about 20% or less. In some embodiments, the first salt comprises calcium and fluoride in a collective amount of about 30% or less. In certain embodiments, the first salt comprises calcium and fluoride in a collective amount of about 40% or less. In certain embodiments, the first salt comprises calcium and fluoride in a collective amount of about 50% or less. In some embodiments, the first salt comprises calcium and fluoride in a collective amount of about 60% or less. In some embodiments, the first salt comprises calcium and fluoride in a collective amount of about 70% or less. In some embodiments, the first salt comprises calcium and fluoride in a collective amount of about 80% or less.

**[0076]** In certain embodiments, any of the methods or compositions provided herein comprise a second salt. In some embodiments, a second salt provided herein comprises a metal, such as an alkali metal or an alkaline earth metal. In certain embodiments, the second salt comprises a metal (e.g., an alkali metal or an alkaline earth metal) and an anion (e.g., a phosphate, hydroxide, sulphate, carbonate, and/or sulphite). In some embodiments, the second salt comprises sodium, lithium, cesium, potassium, and/or combinations thereof. In certain embodiments, the second salt further comprises phosphate (e.g., such as an inorganic phosphate or a pyrophosphate), hydroxide, carbonate, sulphite, and/or a sulphate. In specific embodiments, the second salt is NaOH, Na<sub>2</sub>SO<sub>3</sub>, K<sub>2</sub>SO<sub>3</sub>, KOH, KHSO<sub>4</sub>, K<sub>2</sub>HPO<sub>4</sub>, KH<sub>2</sub>PO<sub>4</sub>, K<sub>3</sub>PO<sub>4</sub>, Na<sub>3</sub>PO<sub>4</sub>, Li<sub>3</sub>PO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, Na<sub>2</sub>CO<sub>3</sub>, NaHCO<sub>3</sub>, Cs<sub>2</sub>CO<sub>3</sub>, K<sub>2</sub>SO<sub>4</sub>, KPO<sub>3</sub>, K<sub>5</sub>P<sub>3</sub>O<sub>10</sub>, K<sub>4</sub>P<sub>2</sub>O<sub>7</sub>, Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> titanium phosphate, aluminum phosphate, uranium phosphate, and/or combinations of one or more thereof. In some embodiments, the second salt further comprises additional ions, such as cations and/or anions provided herein.

**[0077]** In some embodiments, the second salt or composition comprising the second salt comprises a metal, such as an alkali metal or an alkaline earth metal. In certain embodiments, the second salt or composition comprising the second salt comprises a metal (e.g., an alkali metal or an alkaline earth metal) and an anion (e.g., such as a phosphate, hydroxide, sulphate, carbonate, and/or sulphite). In some embodiments, the second salt or composition comprising the second salt comprises sodium, lithium, cesium, potassium, and/or combinations thereof. In certain embodiments, the second salt further comprises phosphate (e.g., such as an inorganic phosphate or a pyrophosphate), hydroxide, carbonate, sulphite, and/or a sulphate. In specific embodiments, the second salt or composition comprising the second salt is NaOH, Na<sub>2</sub>SO<sub>3</sub>, K<sub>2</sub>SO<sub>3</sub>, KOH, KHSO<sub>4</sub>, K<sub>2</sub>HPO<sub>4</sub>, KH<sub>2</sub>PO<sub>4</sub>, K<sub>3</sub>PO<sub>4</sub>, Na<sub>3</sub>PO<sub>4</sub>, Li<sub>3</sub>PO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, Na<sub>2</sub>CO<sub>3</sub>, NaHCO<sub>3</sub>, Cs<sub>2</sub>CO<sub>3</sub>, K<sub>2</sub>SO<sub>4</sub>, KPO<sub>3</sub>,

$K_5P_3O_{10}$ ,  $K_4P_2O_7$ ,  $Na_4P_2O_7$  titanium phosphate, aluminum phosphate, uranium phosphate, and/or combinations of one or more thereof. In some embodiments, the second salt or composition comprising the second salt further comprises additional ions, such as cations and/or anions provided herein.

**[0078]** In certain embodiments, any of the methods or compositions provided herein comprise a third salt. In some embodiments, a third salt provided herein comprises calcium. In certain embodiments, a third salt provided herein further comprises an anion provided herein. In specific embodiments, a third salt provided herein comprises calcium and an anion provided herein (e.g., a phosphate, hydroxide, sulphate, carbonate, and/or sulphite).

**[0079]** In some embodiments, a combination of a first salt (or a composition comprising the first salt) and a second salt (or a composition comprising the second salt) of any method provided herein provides a third salt. In some embodiments, a third salt provided herein comprises any cation (e.g.,  $Ca^{2+}$ ) of a first salt or composition comprising a first salt provided herein and any anion of a second salt or composition comprising a second salt provided herein.

**[0080]** In certain embodiments, the third salt provided herein or a composition comprising the third salt comprises calcium. In certain embodiments, the third salt or composition comprising the third salt further comprises an anion provided herein. In specific embodiments, the third salt or a composition comprising the third salt comprises calcium and an anion provided herein (e.g., a phosphate, hydroxide, sulphate, carbonate, and/or sulphite).

**[0081]** In some embodiments, a combination of a first salt (or a composition comprising the first salt) and a second salt (or a composition comprising the second salt) of any method provided herein provides a third salt or composition comprising a third salt. In some embodiments, a third salt or a composition comprising the third salt comprises any cation (e.g.,  $Ca^{2+}$ ) of a first salt or composition comprising a first salt provided herein and any anion of a second salt or composition comprising a second salt provided herein.

**[0082]** In certain embodiments, a third salt or composition comprising a third salt provided herein has a lattice energy of about 2400 kJ/mol or more (e.g., about 2600 kJ/mol or more, about 3000 kJ/mol or more). In specific embodiments, the third salt or composition comprising the third salt has a lattice energy of about 2450 kJ or more. In still more specific embodiments, the third salt or composition comprising the third salt has a lattice energy of about 2630 kJ/mol or more. In some embodiments, a lattice energy of a third salt or composition comprising the third salt provided herein is greater than a lattice energy of a first salt or composition comprising the first salt provided herein and/or a lattice energy of a second salt or composition comprising the second salt provided herein.

**[0083]** In certain instances, reactivity of a third salt or composition comprising the third salt provided herein with a high lattice energy (e.g., about 2500 kJ/mol or more) is low.

**[0084]** In some embodiments, provided herein is a composition or a method comprising combining a first salt (or a composition comprising the first salt) and a second salt (or a composition comprising the second salt) provided herein. In certain embodiments, a ratio of a first ion in a first salt (or a composition comprising the first salt) provided herein to a second ion in a second salt (or a composition comprising the second salt) provided herein is about 0.1:5 to about 5:0.1. In specific embodiments, a ratio of the first ion in the first salt (or a composition comprising the first salt) to the second ion in the second salt (or a composition comprising the second salt) is about 1:1. In yet more specific embodiments, a ratio of the first ion in the first salt (or a composition comprising the first salt) to the second ion in the second salt (or a composition comprising the second salt) is about 1:2.

**[0085]** In certain embodiments, the first salt (or a composition comprising the first salt) and the second salt (or a composition comprising the second salt) of any method provided herein are combined in any suitable manner (e.g., thereby providing a mixed composition described herein). In some embodiments, both the first salt (or a composition comprising the first salt) and the second salt (or a composition comprising the second salt) are combined as solids. In specific embodiments, the first salt (or a composition comprising the first salt) and the second salt (or a composition comprising the second salt) are combined to form a solid salt combination. In some embodiments, a method provided herein comprises applying a mechanical force to a mixed composition provided herein (e.g., comprising the first salt or a composition comprising the first salt and the second salt or a composition comprising the second salt). In specific embodiments, any suitable mechanical force provided herein is used.

**[0086]** In certain embodiments, the first salt (or a composition comprising the first salt) and the second salt (or a composition comprising the second salt) of any method provided herein are combined in any suitable manner to provide a third salt provided herein or a composition comprising the third salt.

**[0087]** In certain embodiments, a (e.g., mixed) composition provided herein comprises a first salt. In specific embodiments, the first salt comprises fluoride. In specific embodiments, the first salt comprises calcium and fluoride. In certain embodiments, a (e.g., mixed) composition provided herein comprises a second salt.

**[0088]** In some embodiments, a (e.g., mixed) composition provided herein comprises a reagent or reagent composition provided herein. In specific embodiments, a mixed composition provided herein is useful for directly fluorinating a compound (such as a starting reagent provided herein).

**[0089]** In certain embodiments, a mechanical force (e.g., a mechanical force provided herein) comprises any suitable mechanical force, such as by using a ball mill, a planetary mill, a mortar and pestle, a twin-screw-extruder, an attritor, a drum mill, an ultrasonic bath, a mechanical press, and/or combinations of one or more thereof. In certain embodiments, a mechanical force is applied using a high-shear mixer, an in-line homogenizer, one or more bead mills, and/or combinations thereof. In certain embodiments, mechanical force provided herein is provided with a ball mill. In some embodiments, a ball mill provided herein comprises a jar and balls (e.g., with a weight of about 1 g to about 20 g). In certain embodiments, a first (e.g., salt) composition provided herein and a second (e.g., salt) composition provided herein are combined in a jar and balls are added. In some embodiments, mechanical force provided herein is provided with a twin screw-extruder, such as by extruding a combination of (e.g., salt) compositions provided herein at varying screw speeds, screw temperatures, residence times, or the like. A twin screw-extruder provided herein is fixed with a gravimetric single screw feeder (e.g., hopper) for programmed addition of (e.g., salt) compositions provided herein.

**[0090]** In specific embodiments, mechanical force is applied under any suitable condition, such as at a selected or varying frequency, time, temperature, cycles, or the like. In some embodiments, a mechanical force provided herein is applied at a frequency of about 0.5 Hz to about 60 kHz (e.g., about 10 Hz to about 20 kHz). In certain embodiments, a mechanical force provided herein is applied at a frequency of about 5 Hz or more (e.g., about 10 Hz or more, about 20 Hz or more, about 30 Hz or more). In specific embodiments, a mechanical force provided herein is applied at about 35 Hz. In certain embodiments, a mechanical force provided herein is applied for about 1 cycle to about 50 cycles (e.g., about 5 to about 40 cycles, about 10 to about 30 cycles). In some embodiments, a mechanical force provided herein is applied for 1 cycle or more. In specific embodiments, a mechanical force provided herein is applied for 10 cycles. In some embodiments, mechanical force is applied to one or more compositions in solution-phase. In some embodiments, mechanical force is applied to one or more compositions in solid-phase.

**[0091]** In certain embodiments, mechanical force provided herein is applied at a temperature of about 20 to about 300 ° C (e.g., about 50 to about 250 ° C, about 100 to about 200 ° C). In some embodiments, mechanical force provided herein is applied at a temperature of about 20 ° C or more (e.g., about 50 ° C or more, about 100 ° C or more, about 150 ° C or more). In some embodiments, the reaction mixture is refluxed at a reaction temperature. In some embodiments, the reaction temperature and/or a reflux temperature is about 100 to about 175 °C. In some embodiments, the reaction mixture is stirred in a pressure vessel. In some embodiments, the reaction is performed in a heated twin-screw extruder. In specific embodiments, mechanical force provided herein is applied at a temperature of about 25 ° C (e.g., at room temperature).

**[0092]** In certain embodiments, a mechanical force provided herein is applied for about 5 minutes to about 3 hours (e.g., about 10 minutes to about 2.5 hours, about 20 minutes to about 2 hours, about 30 minutes to about 1.5 hours). In some embodiments, a mechanical force provided herein is applied for about 5 minutes or more (e.g., about 15 minutes or more, about 30 minutes or more, about 45 minutes or more, about 1 hour or more, about 2 hours or more). In specific embodiments, mechanical force provided herein is applied for about 45 minutes.

**[0093]** In some instances, varying time, frequency, temperature, and/or the like provides high yields of a reagent (e.g., fluorination reagent, such as a purified fluorination reagent, or crude fluorination reagent) or composition (e.g., any reagent or mixed composition, such as used in making of a reagent) provided herein.

**[0094]** In certain embodiments, a method provided herein comprises combining a first composition and a second composition, the first composition comprising a first salt and the second composition comprising a second salt. In more specific embodiments, the first and/or the second composition is a waste material provided herein (e.g., raw, processed, or treated waste material).

**[0095]** In some embodiments, provided herein is a composition or a method comprising subjecting a (e.g., mixed) composition to a (e.g., fluid) composition. In certain embodiments, the (e.g., mixed) composition of any method provided herein is subjected to a (e.g., fluid) composition (e.g., thereby forming a reagent or reagent composition, such as described herein). In some embodiments, the (e.g., mixed) composition is subjected to a (e.g., fluid) composition under any suitable conditions, such as at any selected temperature, with any selected volume of fluid composition, with stirring or other agitation, at any selected pH (e.g., using a buffer), for any selected period of time, or the like.

**[0096]** In certain embodiments, an (e.g., fluid) composition provided herein comprises any suitable solvent. In specific embodiments, a fluid composition provided herein comprises a solvent (e.g., a solvent provided herein). In certain embodiments, a fluid composition provided herein comprises any suitable solvent (e.g., water or an organic solvent). In specific embodiments, a fluid composition provided herein comprises a solvent (e.g., water).

**[0097]** In some embodiments, a solvent provided herein is any suitable solvent, such as a polar aprotic solvent, water, an alcohol, an alkyl carbonate solvent, a halocarbon and/or a combination thereof. In certain embodiments, a solvent provided herein is acetonitrile, propionitrile, butyronitrile, toluene, 1,2-dichlorobenzene, chlorobenzene, fluorobenzene, 1,2-difluorobenzene, dichloroethane, trifluorotoluene, chloroform, sulfolane, DMF, DMSO, tert-butanol, dichloromethane (DCM), tert-amyl alcohol, water, dimethyl carbonate, diethyl carbonate, dipropyl carbonate, methyl ethyl carbonate, methyl propyl carbonate, ethyl propyl carbonate, trifluoroethyl

carbonate, bis(trifluoroethyl) carbonate, trifluoroethyl methyl carbonate, THF, MeTHF, NMP, butyl acetate, dioxane, and/or combinations thereof.

**[0098]** In some embodiments, a solvent provided herein is selected according to its characteristics, such as boiling point, ability to solubilize a composition provided herein, polarity, pH, or the like.

**[0099]** In certain embodiments, a solvent (e.g., a solvent provided herein) has a boiling point of about 30 °C or more. In some embodiments, a solvent provided herein has a boiling point of about 70 °C or more. In certain embodiments, a solvent or (e.g., fluid) composition provided herein has a boiling point of about 120 °C or more. In some embodiments, a solvent or (e.g., fluid) composition provided herein has a boiling point of about 240 °C or less.

**[0100]** In some embodiments, a (e.g., mixed) composition provided herein is subjected to a (e.g., fluid) composition provided herein for about 0 to about 8 hours. In certain embodiments, a (e.g., mixed) composition is subjected to a (e.g., fluid) composition for about 1 hour or more. In some embodiments, a (e.g., mixed) composition is subjected to a (e.g., fluid) composition for about 6 hours or less. In specific embodiments, a (e.g., mixed) composition is subjected to a (e.g., fluid) composition for about 2 hours.

**[0101]** In certain embodiments, a combination of a (e.g., mixed) composition provided herein and a (e.g., fluid) composition provided herein is at a temperature of about 0 to about 120 °C. In some embodiments, a combination of a (e.g., mixed) composition and a (e.g., fluid) composition is at a temperature of about 80 °C or more. In certain embodiments, a combination of a (e.g., mixed) composition and a (e.g., fluid) composition is at a temperature of about 110 °C or less. In certain instances, the selected temperature of a combination of a (e.g., mixed) composition and (e.g., fluid) composition provided herein increases a yield of a reagent or reagent composition provided herein.

**[0102]** In certain embodiments, a (e.g., mixed) composition provided herein is subjected to a (e.g., fluid) composition at a selected pH of about 3 to about 12. In some embodiments, pH of a (e.g., fluid) composition provided herein can be modified in any suitable manner (e.g., by using a buffer). In certain embodiments, the selected pH is about 4 or more. In some embodiments, the selected pH is about 7 or more. In certain embodiments, the selected pH is about 10 or more.

**[0103]** In certain embodiments, a (e.g., mixed) composition of any method provided herein is subjected to a (e.g., fluid) composition provided herein, thereby forming a resultant fluid (e.g., comprising a (e.g., crude) reagent or reagent composition that can be further purified to provide a (e.g., purified reagent or reagent composition) and a washed (e.g., mixed) composition. In some embodiments, the washed (e.g., mixed) composition is a solid. In certain embodiments, the resultant fluid comprises a reagent or reagent composition, such as described herein. In specific embodiments, the resultant fluid comprises a crude reagent or reagent composition provided herein.

**[0104]** In certain embodiments, a method provided herein comprises adjusting pH (e.g., by any suitable means) of a (e.g., resultant) fluid described herein. In some embodiments, the pH of a resultant fluid of any method provided herein is adjusted (e.g., using an acid, base, and/or buffer).

**[0105]** In certain embodiments, pH of a resultant fluid provided herein is adjusted to a pH of about 5 to about 10. In some embodiments, pH of a resultant fluid is adjusted to a pH of about 6 to about 9. In certain embodiments, pH of a resultant fluid is adjusted to a pH of about 6 to about 8 (e.g., thereby neutralizing the resultant fluid). In certain embodiments, a pH of a resultant fluid is adjusted based on a presence of an alkaline impurity in the first salt (e.g., to a pH of about 6). In certain embodiments, a pH of the resultant fluid is adjusted to a pH compatible with one or more downstream processes of a method described herein (e.g., a pH may be adjusted to about 7, about 8, or about 9 for a process requiring neutral or mildly basic solutions, such as when using a pH sensitive filtration media). In some cases, the pH of the resultant fluid is adjusted for compatibility with and/or separation on one or more ion exchange columns.

**[0106]** In some embodiments, pH of a resultant fluid provided herein is adjusted to a pH of about 8 to about 14. In certain embodiments, pH of a resultant fluid is adjusted to a pH of about 12 to about 13.

**[0107]** In certain embodiments, pH of a (e.g., resultant) fluid provided herein is adjusted with any suitable acid or base. In some embodiments, pH of a resultant fluid is adjusted (e.g., neutralized) with a (e.g., polyprotic) acid. In specific embodiments, a resultant fluid described herein is neutralized.

**[0108]** In certain embodiments, an acid (e.g., an acid provided herein) is any suitable acid, such as a strong acid, a weak acid, a polyprotic acid, and/or a combination thereof. In some embodiments, an acid provided herein is phosphoric acid, hydrochloric acid, formic acid, acetic acid, sulfuric acid, sulfurous acid, carbonic acid, benzoic acid, boric acid, silicic acid, oxalic acid, and/or a combination thereof. In certain embodiments, use of polyprotic acids (e.g., phosphoric acid) provided herein avoids releasing additional anions.

**[0109]** In certain embodiments, a base (e.g., a base provided herein) is any suitable base, such as a strong base, a weak base, an organic base, or the like. In some embodiments, a base provided herein comprises a hydroxide, an amine, ammonia, a pyridine, and/or a combination thereof. In certain embodiments, a base provided herein is NaOH, KOH, or LiOH. In specific embodiments, a base provided herein is KOH.

**[0110]** In certain embodiments, the washed (e.g., mixed) composition comprises a salt (e.g., a first salt as described herein). In some embodiments, a method provided herein comprises combining the washed (e.g., mixed) composition and a second salt as provided herein (e.g., thereby forming a mixed composition described herein). In specific embodiments, a mixed composition provided

herein comprises the washed (e.g., mixed) composition. In certain embodiments, a washed (e.g., mixed) composition described herein is provided as a first salt provided herein (e.g., thereby providing for sustainable manufacturing of a reagent or reagent composition described herein). In some instances, providing a washed (e.g., mixed) composition described herein as the first salt in methods and compositions described herein provides for sustainable manufacturing of reagents or reagent compositions. In certain instances, providing a washed (e.g., mixed) composition described herein as the first salt in methods and compositions described herein reduces the cost of waste disposal and/or the cost manufacturing a reagent or reagent composition provided herein.

**[0111]** In certain embodiments, provided herein is a composition or a method comprising concentrating a resultant fluid described herein (e.g., thereby forming a reagent or reagent composition, such as described herein). In some embodiments, a resultant fluid provided herein is concentrated by any suitable method and/or to any suitable endpoint provided herein. In certain embodiments, concentrating a resultant fluid described herein provides a (e.g., crude) reagent or reagent composition (e.g., a reagent concentrate or precipitate). In specific embodiments, concentrating a resultant fluid described herein provides a crude reagent or reagent composition (e.g., a reagent concentrate or precipitate). In yet more specific embodiments, the (e.g., crude) reagent or reagent composition is useful for directly fluorinating an organic compound provided herein (e.g., a starting reagent).

**[0112]** In certain embodiments, any suitable concentration method is used, such as by drying, lyophilizing, evaporating (e.g., using a rotary evaporator), distilling, or the like. In some embodiments, any fluid or wash provided herein is concentrated to any suitable endpoint (e.g., by about 10% or more). In specific embodiments, a resultant fluid described herein is concentrated by drying, evaporation, and/or a combination thereof. In still more specific embodiments, a resultant fluid described herein is concentrated under reduced pressure. In yet more specific embodiments, a resultant fluid described herein is concentrated under reduced pressure thereby providing a (e.g., crude) reagent or reagent composition provided herein.

**[0113]** In some embodiments, alternate concentration methods may be performed prior to, during, after, or in place of drying, lyophilizing, evaporating, distilling or the like. In some embodiments, alternate concentration methods comprise reverse osmosis, ultra-high pressure reverse osmosis, falling film evaporation, agitated thin film evaporation, spray-drying, and/or any combination of two or more thereof (e.g., up to, and including, a combination of all methods thereof).

**[0114]** In some embodiments, provided herein is a composition or a method comprising washing a (e.g., crude) reagent or reagent composition with a (e.g., solvent) composition. In certain embodiments, a (e.g., solvent) composition is any suitable solvent. In some embodiments, a (e.g., solvent) composition is any (e.g., organic) solvent (e.g., a solvent provided herein). In certain

embodiments, the (e.g., crude) reagent or reagent composition of any method provided herein is washed with a (e.g., organic) solvent (e.g., thereby forming a reagent or reagent composition, such as described herein). In some embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with a (e.g., organic) solvent under any suitable conditions, such as at a targeted temperature, with any selected volume of fluid composition, with stirring or other agitation, at any selected pH (e.g., using a buffer), at any selected temperature, for any selected period of time, or the like. In specific embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with an organic solvent (e.g., an alcohol).

**[0115]** In some embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with a (e.g., organic) solvent for about 4 hours to about 48 hours. In certain embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with a (e.g., organic) solvent for about 8 hours to about 36 hours. In some embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with a (e.g., organic) solvent for about 10 hours to about 28 hours. In certain embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with a (e.g., organic) solvent for 8 hours or more. In some embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with a (e.g., organic) solvent for 36 hours or less. In specific embodiments, a (e.g., crude) reagent or reagent composition provided herein is washed with a (e.g., organic) solvent for about 18 hours.

**[0116]** In certain embodiments, a combination of a (e.g., crude) reagent or reagent composition provided and a (e.g., organic) solvent is at a temperature of about -20 to about 240 °C. In some embodiments, a combination of the (e.g., crude) reagent or reagent composition and the (e.g., organic) solvent is at a temperature of about 80 °C or more. In certain embodiments, a combination of the (e.g., crude) reagent or reagent composition and the (e.g., organic) solvent is at a temperature of about 235 °C or less.

**[0117]** In some embodiments, a (e.g., crude) reagent or reagent composition of any method provided herein is washed with a (e.g., organic) solvent described herein, thereby providing a reagent wash (e.g., a fluid reagent wash) and a washed (e.g., reagent) composition. In certain embodiments, a (e.g., crude) reagent or reagent composition of any method provided herein is washed with a (e.g., organic) solvent, thereby providing a reagent wash (e.g., comprising a (e.g., purified) reagent or reagent composition). In some embodiments, the (e.g., fluid) reagent wash comprises a reagent or reagent composition, such as described herein. In specific embodiments, the (e.g., fluid) reagent wash comprises a purified reagent or reagent composition provided herein.

**[0118]** In certain embodiments, provided herein is a composition or a method comprising concentrating a (e.g., fluid) reagent wash described herein (e.g., thereby forming a reagent or reagent composition, such as described herein). In some embodiments, a (e.g., fluid) reagent wash

provided herein is concentrated by any suitable method and/or to any suitable endpoint provided herein. In certain embodiments, concentrating (e.g., fluid) reagent wash provided herein provides and/or produces a (e.g., purified) reagent or reagent composition (e.g., a reagent wash concentrate or reagent precipitate). In specific embodiments, the (e.g., purified) reagent or reagent composition is useful for directly fluorinating an organic compound provided herein (e.g., a starting reagent).

**[0119]** In certain embodiments, a reagent or reagent composition provided herein is activated, whereby the reagent or reagent composition comprises an (e.g., fluorination) reagent or reagent composition that can be used to fluorinate a starting reagent (e.g., organic compound) in that form. In some embodiments, any reagent or reagent composition provided herein comprises a fluorination reagent or reagent composition. In specific embodiments, an (e.g., crude) reagent or reagent composition provided herein comprises a fluorination reagent or reagent composition provided herein. In yet more specific embodiments, a (e.g., purified) reagent or reagent composition provided herein comprises a fluorination reagent or reagent composition provided herein. In still more specific embodiments, a reagent or reagent composition provided herein comprises a fluorination reagent or reagent composition provided herein (e.g., a mixed composition provided herein and/or a first salt provided herein).

**[0120]** In some embodiments, provided herein is a method for fluorinating a starting reagent (e.g., haloalkyl carbonate). In certain embodiments, a starting reagent (e.g., a starting reagent provided herein) is a haloalkyl compound and/or a haloalkane. In some embodiments, a starting reagent comprises an aliphatic organic compound substituted with one or more halogens selected from the group of Cl, Br, and I, a heterocyclic compound substituted with one or more halogens selected from the group of Cl, Br, and I, a haloalkyl compound, a dihaloalkyl compound, a trihaloalkyl compound, or the like. In certain embodiments, a starting reagent provided herein is 4-chloroethylene carbonate. In certain embodiments, a starting reagent provided herein is 4-chloroethylene carbonate, 4-bromoethylene carbonate, dibromoethylene carbonate, or dichloroethylene carbonate. In some embodiments, provided herein is a method for fluorinating a starting reagent comprising 4-chloroethylene carbonate (e.g., the starting reagent illustrated in FIG. 3). In certain embodiments, starting reagents provided herein comprise a leaving group (e.g., chlorine, iodine, bromine). In specific embodiments, a leaving group of a starting reagent provided herein is chlorine. In some embodiments, 4-chloroethylene carbonate provided herein is referred to by alternate names herein such as 4-chloro-1,3-Dioxolan-2-one, carbonic acid, cyclic chloroethylene ester, 1,2-ethanediol, 1-chloro- cyclic carbonate, chloroethylene carbonate, cyclic chloroethylene carbonate, carbonic acid cyclic 1-chloroethylene ester, salts thereof, or the like. In certain embodiments, dichloroethylene carbonate is referred to by alternate names herein such as 4,5-Dichloro-1,3-dioxolan-2-one, Cyclic 1,2-dichloroethylene carbonate, 1,2-Dichloroethylene

carbonate, 4,5-Dichloro-1,3-dioxolane-2-one, 1,3-Dioxolan-2-one, 4,5-dichloro-, Carbonic acid, cyclic 1,2-dichloroethylene ester, 1,3-DIOXOLANE, 4,5-DICHLORO-2-OXO-, 1,2-Dichloroethylene carbonate 4,3-dioxolane-2-one, Carbonic acid, 1,2-dichloroethylene ester, 1, 4,5-dichloro-2-oxo-, Carbonic acid, 2-dichloroethylene ester, 3,4-dichloroethylene carbonate, 4,5-dichloroethylene carbonate, salts thereof, or the like. In some embodiments, 4-bromoethylene carbonate provided herein is referred to by an alternate name herein such as 4-bromo-1,3-dioxolan-2-one. In certain embodiments, dibromoethylene carbonate provided herein is referred to by an alternate name herein such as 4,5-dibromo-1,3-dioxolan-2-one and 1,3-Dioxolan-2-one,4,5-dibromo. In certain embodiments, provided herein are methods for fluorinating 4-chloroethylene carbonate to provide a battery electrolyte component or additive comprising 4-fluoroethylene carbonate (e.g., the product of any of the reactions illustrated in FIGs. 2 or 3). In some embodiments, provided herein are methods for fluorinating 4-chloroethylene carbonate to provide a battery electrolyte component or additive comprising difluoroethylene carbonate. In certain embodiments, provided herein are methods for fluorinating dichloroethylene carbonate to provide a battery electrolyte component or additive comprising difluoroethylene carbonate. In some embodiments, provided herein are methods for fluorinating 4-bromoethylene carbonate to provide a battery electrolyte component or additive comprising 4-fluoroethylene carbonate. In certain embodiments, provided herein are methods for fluorinating 4-bromoethylene carbonate to provide a battery electrolyte component or additive comprising difluoroethylene carbonate. In some embodiments, provided herein are methods for fluorinating dibromoethylene carbonate to provide a battery electrolyte component or additive comprising difluoroethylene carbonate. In specific embodiments, provided herein are methods for fluorinating 4-chloroethylene carbonate. In yet specific embodiments, provided herein are methods for fluorinating 4-fluoroethylene carbonate.

**[0121]** In some instances, a reagent or reagent composition provided herein is used to fluorinate 4-chloroethylene carbonate provided herein to provide a high value, high yield battery electrolyte component or additive without the use of toxic chemicals such as HF.

**[0122]** In certain embodiments, provided herein is a composition or a method comprising contacting a starting reagent provided herein with a reagent or reagent composition described herein (e.g., thereby fluorinating the starting reagent and providing a fluorinated product). In some embodiments, the starting reagent comprises a leaving group. In some embodiments, the leaving group is chlorine, iodine, or bromine. In some embodiments, the battery electrolyte component or additive comprises at least one additional fluorine (e.g., at least two additional fluorine) compared to the starting reagent. In specific embodiments, the battery electrolyte component or additive comprises one additional fluorine (e.g., 4-fluoroethylene carbonate compared to 4-chloroethylene carbonate). In yet more specific embodiments, the battery electrolyte component or additive

comprises two additional fluorines (e.g., difluoroethylene carbonate compared to 4-chloroethylene carbonate). In still more specific embodiments, the starting reagent is 4-chloroethylene carbonate. In yet more specific embodiments, the starting reagent is dichloroethylene carbonate.

**[0123]** In yet more specific embodiments, the battery electrolyte component or additive is 4-fluoroethylene carbonate. In still more specific embodiments, the battery electrolyte component or additive is difluoroethylene carbonate. In some embodiments, a starting reagent provided herein contacted with a reagent or reagent composition provided herein provides a battery electrolyte component or additive provided herein. In some embodiments, the starting reagent is contacted with the reagent or reagent composition under any suitable conditions, such as at any selected temperature, with stirring or other agitation, at any selected pH, for any selected period of time, or the like.

**[0124]** In certain embodiments, a combination of a (e.g., fluorination) reagent or reagent composition provided herein and a starting reagent provided herein is at a temperature of about 20 to about 200 °C (e.g., about 60 to about 160 °C, about 70 to about 120 °C). In some embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 20 °C or more. In certain embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 40 °C or more. In some embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 60 °C or more. In certain embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 80 °C or more. In some embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 100 °C or more. In certain embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 120 °C or more. In some embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 140 °C or more. In specific embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 75 °C. In still more specific embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 80 °C. In yet more specific embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 90 °C. In still more specific embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 110 °C. In yet more specific embodiments, a combination of the (e.g., fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 115 °C. In still more specific embodiments, a combination of the (e.g.,

fluorination) reagent or reagent composition and the starting reagent is at a temperature of about 150 °C.

**[0125]** In certain embodiments, a starting reagent provided herein is contacted with a (e.g., fluorination) reagent or reagent composition provided herein for about 1 hour to about 84 hours (e.g., about 2 hours to about 76 hours, about 3 hours to about 24 hours, about 4 hours to about 12 hours, about 5 hours to about 10 hours). In some embodiments, the starting reagent is contacted with the (e.g., fluorination) reagent or reagent composition for about 30 hours or less (e.g., about 24 hours or less, about 18 hours or less, about 12 hours or less, about 8 hours or less). In certain embodiments, the starting reagent is contacted with the (e.g., fluorination) reagent or reagent composition for about 84 hours or less (e.g., about 72 hours or less). In some certain embodiments, the starting reagent is contacted with the (e.g., fluorination) reagent or reagent composition for about 1 hour or more (e.g., about 4 hours or more, about 16 hours or more, about 56 hours or more). In specific embodiments, the starting reagent is contacted with the (e.g., fluorination) reagent or reagent composition for about 6 hours. In yet more specific embodiments, the starting reagent is contacted with the (e.g., fluorination) reagent or reagent composition for about 8 hours. In still more specific embodiments, the starting reagent is contacted with the (e.g., fluorination) reagent or reagent composition for about 18 hours. In yet more specific embodiments, the starting reagent is contacted with the (e.g., fluorination) reagent or reagent composition for about 66 hours.

**[0126]** In certain embodiments, an amount of a (e.g., fluorination) reagent or reagent composition provided herein is about 0.1 equivalents to about 10 equivalents of a starting reagent provided herein. In some embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 1 or more (e.g., about 2 or more, about 3 or more, about 4 or more, about 5 or more, about 6 or more, about 7 or more, about 8 or more, about 9 or more) equivalents of the starting reagent. In certain embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 10 or less (e.g., about 8 or less, about 6 or less, about 4 or less, about 2 or less) equivalents of the starting reagent. In specific embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 1 equivalent of the starting reagent. In still more specific embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 2 equivalents of the starting reagent. In yet more specific embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 3 equivalents of the starting reagent. In still more specific embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 4 equivalents of the starting reagent. In yet more specific embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 5 equivalents of the starting reagent. In still more specific embodiments, the amount of the (e.g., fluorination) reagent or reagent composition is about 6 equivalents of the starting reagent.

[0127] In some instances, contacting greater equivalents of an (e.g., fluorination) reagent or reagent composition relative to the starting reagent results in high yields of a battery electrolyte component or additive provided herein.

[0128] In some embodiments, a starting reagent provided herein is contacted with a (e.g., fluorination) reagent or reagent composition provided herein under mechanochemical conditions to provide a battery electrolyte component or additive provided herein. In specific embodiments, any suitable mechanical force is used as provided herein and under any suitable conditions (e.g., as provided herein). In still more specific embodiments, a starting reagent provided herein is combined with a (e.g., fluorination) reagent or reagent composition provided herein in a laboratory mixer mill (e.g., and milled for 2 hours at 35 Hz) thereby providing a battery electrolyte component or additive provided herein.

[0129] In certain embodiments, a starting reagent provided herein is contacted with a (e.g., fluorination) reagent or reagent composition provided herein in a reaction mixture. In some embodiments, a reaction mixture provided herein comprises a starting reagent, a (e.g., fluorination) reagent or reagent composition, and a (e.g., reaction) solvent. In certain embodiments, a reaction mixture provided herein comprises a starting reagent, a (e.g., fluorination) reagent or reagent composition, and a reaction solvent. In some embodiments, an (e.g., reaction) solvent is any suitable solvent (e.g., as provided herein). In certain embodiments, a reaction solvent is any suitable solvent (e.g., organic solvent) provided herein. In specific embodiments, the reaction solvent is acetonitrile, propionitrile, dimethyl carbonate (DMC), sulfolane, MeTHF, butyl acetate, dioxane, pyridine, butyronitrile, diethyl carbonate, NMP, and/or DMSO, and/or combinations of one or more thereof. In yet more specific, embodiments, the reaction solvent is acetonitrile, propionitrile, pyridine, and/or dimethylcarbonate, and/or combinations of one or more thereof. In still more specific embodiments, the (e.g., reaction) solvent is an alkyl carbonate solvent provided herein.

[0130] In certain embodiments, a reaction mixture provided herein comprises a starting reagent provided herein, a (e.g., fluorination) reagent or reagent composition provided herein, a reaction solvent (e.g., a reaction solvent provided herein), a reaction base (e.g., a reaction base provided herein), water (e.g., deionized water), and/or an alcohol (e.g., an alcohol provided herein), and/or combinations of two or more thereof.

[0131] In certain embodiments, a reaction mixture provided herein further comprises a phase transfer agent. In specific embodiments, a reaction mixture provided herein comprises a starting reagent provided herein, a (e.g., fluorination) reagent or reagent composition provided herein, a reaction solvent (e.g., a reaction solvent provided herein), and a phase transfer reagent (e.g., a phase transfer agent provided herein). In certain embodiments, a phase transfer agent (e.g., a phase transfer agent provided herein) is any suitable phase transfer agent, such as a crown ether, a

cryptand, an ionic transfer agent (e.g., an ammonium salt), a hydrogen-bonding phase transfer agent, and/or a combination thereof. In some embodiments, a phase transfer agent provided herein is Kryptofix 221, Kryptofix 222, 18-crown-6, (Dibenzo)18-crown-6, (dicyclo)18-crown-6, 12-crown-4, 15-crown-5, 21-crown-7, cryptand-222, 30-crown-10, (dibenzo)30-crown-10, Schreiner's urea, ammonium sulfate, ammonium bicarbonate, ammonium chloride (e.g., tetramethyl ammonium chloride (TMAC)), ammonium iodide, ammonium benzoate, benzyltrimethyl, ammonium hydroxide, ammonium carbonate, ammonium dichromate, ammonium acetate, ammonium bromide, sodium tetradecyl sulfate, ammonium iodate and/or combinations thereof. In specific embodiments, a phase transfer agent provided herein is 18-crown-6, ammonium chloride, TMAC, and/or combinations thereof.

**[0132]** In some instances, addition of a phase transfer agent (e.g., a phase transfer agent provided herein) to a reaction mixture provided herein results in high yields of a battery electrolyte component or additive provided herein.

**[0133]** In certain embodiments, an amount of a phase transfer agent (e.g., a phase transfer agent provided herein) is about 0 equivalents to about 8 equivalents of a starting reagent provided herein (e.g., about 0.05 to about 5 equivalents, about 0.1 to about 4 equivalents, about 0.5 to about 3 equivalents). In some embodiments, the amount of the phase transfer agent is about 0.05 or more (e.g., about 0.1 or more, about 0.5 or more, about 1 or more, about 2 or more) equivalents of the starting reagent. In certain embodiments, the amount of phase transfer agent is about 5 or less (e.g., about 3 or less, about 2 or less, about 1 or less, about 0.5 or less, about 0.1 or less) equivalents of the starting reagent. In specific embodiments, the amount of the phase transfer agent is about 1 equivalent of the starting reagent. In still more specific embodiments, the amount of the phase transfer agent is about 2 equivalents of the starting reagent. In yet more specific embodiments, the amount of the phase transfer agent is about 0.2 equivalents of the starting reagent. In still more specific embodiments, the amount of the phase transfer agent is about 0.5 equivalents of the starting reagent. In yet more specific embodiments, the amount of the phase transfer agent is about 0.1 equivalents of the starting reagent. In still more specific embodiments, the amount of the phase transfer agent is about 0.08 equivalents of the starting reagent.

**[0134]** In certain embodiments, a reaction mixture provided herein further comprises a reaction base (e.g., a reaction base provided herein). In specific embodiments, a reaction mixture provided herein comprises a starting reagent provided herein, a (e.g., fluorination) reagent or reagent composition provided herein, a reaction solvent (e.g., a reaction solvent provided herein), and a reaction base (e.g., a reaction base provided herein). In yet more specific embodiments, a reaction mixture provided herein comprises a starting reagent provided herein, a (e.g., fluorination) reagent or reagent composition provided herein, a reaction solvent (e.g., a reaction solvent provided

herein), a phase transfer agent (e.g., a phase transfer agent provided herein), and a reaction base (e.g., a reaction base provided herein). In still more specific embodiments, a reaction mixture provided herein comprises a starting reagent provided herein, a (e.g., fluorination) reagent or reagent composition provided herein, a reaction solvent (e.g., a reaction solvent provided herein), a phase transfer agent (e.g., a phase transfer agent provided herein), and one or more reaction bases (e.g., a reaction base provided herein). In certain embodiments, a reaction base (e.g., a reaction base provided herein) is any suitable base, such as an organic base, an amine, a pyridine, and/or a pyridine derivative. In some embodiments, a reaction base provided herein is 4-dimethylaminopyridine (DMAP), diisopropylethylamine (DIPEA), and/or pyridine. In specific embodiments, a reaction base provided herein is DMAP. In yet more specific embodiments, a reaction base provided herein is DIPEA. In still more specific embodiments, a reaction base provided herein is pyridine.

**[0135]** In some instances, addition of a reaction base provided herein to a reaction mixture provided herein results in high yields of a battery electrolyte component or additive provided herein.

**[0136]** In certain embodiments, an amount of a reaction base (e.g., a reaction base provided herein) is about 0 equivalents to about 5 equivalents of a starting reagent provided herein (e.g., about 0.1 to about 4 equivalents, about 0.2 to about 3 equivalents, about 0.5 to about 2 equivalents). In some embodiments, the amount of the reaction base is about 0.05 or more (e.g., about 0.1 or more, about 0.5 or more, about 1 or more, about 2 or more) equivalents of the starting reagent. In certain embodiments, the amount of the reaction base is about 3 or less (e.g., about 2 or less, about 1.5 or less, about 1 or less, about 0.5 or less) equivalents of the starting reagent. In specific embodiments, the amount of the reaction base is about 0.2 equivalent of the starting reagent. In still more specific embodiments, the amount of the reaction base is about 1.2 equivalents of the starting reagent. In yet more specific embodiments, the amount of the reaction base is about 1 equivalents of the starting reagent. In still more specific embodiments, the amount of the reaction base is about 2 equivalents of the starting reagent. In yet more specific embodiments, the amount of the reaction base is about 0.5 equivalents of the starting reagent.

**[0137]** In certain embodiments, a reaction mixture provided herein further comprises (e.g., deionized) water. In specific embodiments, a reaction mixture provided herein comprises a starting reagent provided herein, a (e.g., fluorination) reagent or reagent composition provided herein, a reaction solvent (e.g., a reaction solvent provided herein), a reaction base (e.g., a reaction base provided herein), and water.

**[0138]** In some instances, addition of water to a reaction mixture provided herein results in high yields of a battery electrolyte component or additive provided herein.

**[0139]** In certain embodiments, an amount of water is about 0 equivalents to about 15 equivalents of a starting reagent provided herein (e.g., about 1 to about 12 equivalents, about 2 to about 9 equivalents, about 3 to about 7 equivalents). In some embodiments, the amount of water is about 1 or more (e.g., about 2 or more, about 4 or more, about 6 or more, about 8 or more) equivalents of the starting reagent. In certain embodiments, the amount of water is about 12 or less (e.g., about 10 or less, about 5 or less, about 2 or less) equivalents of the starting reagent. In specific embodiments, the amount of water is about 10 equivalents of the starting reagent. In still more specific embodiments, the amount of water is about 5 equivalents of the starting reagent. In yet more specific embodiments, the amount of water is about 7.5 equivalents of the starting reagent.

**[0140]** In certain embodiments, a reaction mixture provided herein further comprises an alcohol (e.g., t-amyl alcohol). In specific embodiments, a reaction mixture provided herein comprises a starting reagent provided herein, a (e.g., fluorination) reagent or reagent composition provided herein, a reaction solvent (e.g., a reaction solvent provided herein), a reaction base (e.g., a reaction base provided herein), and an alcohol (e.g., an alcohol provided herein). In certain embodiments, an alcohol (e.g., an alcohol provided herein) is any suitable alcohol, such as an alkyl alcohol, a diol, and/or a combination thereof. In some embodiments, an alcohol provided herein is ethyl alcohol, methanol, isopropyl alcohol, t-amyl alcohol, butanol, ethylene glycol, propylene glycol, and/or a combination thereof. In specific embodiments, an alcohol provided herein is isopropyl alcohol, t-amyl alcohol, and/or ethylene glycol.

**[0141]** In certain embodiments, an amount of alcohol (e.g., an alcohol provided herein) is about 0 equivalents to about 10 equivalents of a starting reagent provided herein (e.g., about 1 to about 9 equivalents, about 2 to about 8 equivalents, about 3 to about 7 equivalents). In some embodiments, the amount of alcohol is about 1 or more (e.g., about 2 or more, about 3 or more, about 4 or more, about 8 or more) equivalents of the starting reagent. In certain embodiments, the amount of alcohol is about 9 or less (e.g., about 8 or less, about 7 or less, about 3 or less) equivalents of the starting reagent. In specific embodiments, the amount of alcohol is about 5 equivalents of the starting reagent.

**[0142]** In some embodiments, a starting reagent provided herein is contacted with a (e.g., fluorination) reagent or reagent composition provided herein with any selected volume of an (e.g., reaction) solvent.

**[0143]** In certain embodiments, a concentration of a starting reagent provided herein in a reaction mixture provided herein is about 0.05 M to about 1 M (e.g., about 0.1 M to about 0.75 M, about 0.2 M to about 0.5 M). In some embodiments, a concentration of the starting reagent in the reaction mixture is about 0.08 M or more (e.g., about 0.1 M or more, about 0.2 M or more, about 0.4 M or more). In certain embodiments, a concentration of the starting reagent in the reaction mixture is

about 0.75 M or less (e.g., about 0.5 M or less, about 0.25 M or less). In specific embodiments, a concentration of the starting reagent in the reaction mixture is about 0.25 M. In yet more specific embodiments, a concentration of the starting reagent in the reaction mixture is about 0.33 M. In still more specific embodiments, a concentration of the starting reagent in the reaction mixture is about 0.5 M. In yet more specific embodiments, a concentration of the starting reagent in the reaction mixture is about 0.125 M.

**[0144]** In some instances, increasing a concentration of a starting reagent provided herein in a reaction mixture provided herein results in high yields of a battery electrolyte component or additive provided herein.

**[0145]** In certain embodiments, a starting reagent provided herein contacted with a (e.g., fluorination) reagent or reagent composition provided herein provides a battery electrolyte component or additive provided herein. In some embodiments, a leaving group (e.g., chlorine, iodine, bromine) of a starting reagent provided herein is replaced with fluorine. In certain embodiments, contacting a starting reagent provided herein with a (e.g., fluorination) reagent or reagent composition provided herein provides a battery electrolyte component or additive provided herein in a yield of about 10% or more (e.g., about 20% or more, about 30% or more, about 40% or more, about 50% or more, about 60% or more, about 70% or more, about 80% or more, about 90% or more). In certain embodiments, a yield of a battery electrolyte component or additive provided herein is about 10% to about 95% (e.g., about 20% to about 80%, about 30% to about 70%, about 40% to about 60%).

**[0146]** In some embodiments, a battery electrolyte component or additive provided herein comprises 4-fluoroethylene carbonate. In certain embodiments, a battery electrolyte component or additive comprises difluoroethylene carbonate. In some embodiments, difluoroethylene carbonate or a salt thereof may be referred to by alternate names herein such as 4,5-difluoro-1,3-dioxolan-2-one, 4,5-difluoroethylene carbonate, or 1,3-Dioxolan-2-one, 4,5-difluoro-.

**[0147]** In certain embodiments, any of the steps provided herein can comprise any of the methods provided herein.

**[0148]** While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

**EXAMPLES****[0149] Example 1: applying mechanical force to a combination of a first and second salt**

**[0150]** To a 50 mL stainless steel milling jar was charged calcium fluoride (1 equiv.), and a second salt (e.g.,  $K_2HPO_4$ ,  $K_3PO_4$ ) (1 or 2 equiv.). The jar was sealed finger tight and fastened to the MM500 Vario before milling for 10 cycles (1 hour at 35 Hz followed by 45 min at 5 Hz). For fluorination reagent B only, additional  $K_2HPO_4$  (1 eq) was added to the mixture in the stainless steel milling jar. The jar was sealed finger tight and fastened to the MM500 Vario a second milling for 10 cycles (1 hour at 35 Hz followed by 45 min at 5 Hz). The jar was removed from the mill and taken to a fume cupboard before opening. The solid residue was removed and collected. An exemplary scheme is provided in FIG. 1.

**Table 1**

| Fluorination Reagent | Fluorine source - equivalents | Activator - equivalents |
|----------------------|-------------------------------|-------------------------|
| A                    | calcium fluoride - 1 equiv.   | $K_2HPO_4$ 1 equiv.     |
| B                    | calcium fluoride - 1 equiv.   | $K_2HPO_4$ 2 equiv.     |

**[0151] Example 2: manufacture and use of a fluorination reagent**

**[0152]** To a 50 mL stainless steel milling jar was charged calcium fluoride (1 equiv), and an activator,  $K_3PO_4$  (1 eq). The jar was sealed finger tight and fastened to the MM500 Vario before milling for 10 cycles (1 hour at 35 Hz followed by 45 min at 5 Hz). The jar was removed from the mill and taken to a fume cupboard before opening. The solid residue, a mixed composition, was removed and collected. An exemplary scheme is provided in FIG. 2.

**[0153]** The mixed composition (49.0 g, 168mmol) was stirred in water (150 mL, pH = 12-13) and heated at 100 °C for 2 h. The mixture was allowed to cool to room temperature before adjusting to pH of 7 by addition of ~ 20 ml of  $H_3PO_4$  20% (aqueous). 300 ml of methanol were added, and the suspension stirred for 30 minutes. The mixture was filtered washing with methanol. The filtrate was concentrated under reduced pressure to a small volume. Methanol (100 mL) was added to the flask and the suspension stirred at 50 °C for 1 h, then cooled down to rt and filtered. The filtrate was collected evaporated under reduced pressure and dried to yield an off-white purified fluorination reagent solid (11.5 g, 56 % fluorine conversion, 32 F wt%), fluorination reagent C. An exemplary reaction scheme is provided in FIG. 2. Powder X-ray diffraction data for fluorination reagent C is found in Table 2 below.

**[0154]** Additional purified reagents were prepared using a scheme similar to that provided in **FIG. 5**. A reactor described herein was charged with tripotassium phosphate, and mechanical force was applied according to methods described herein. The reactor was charged with calcium fluoride, heated to reflux, and aged before cooling to room temperature whilst continuing to apply mechanical force.

[0155] A resultant suspension was charged into a benchtop centrifuge. The solids were then separated and were combined with water to form a slurry which was cycled through the centrifuge. The liquids were charged into a container equipped with an overhead stirrer and stirring commenced. The solution was charged with phosphoric acid until a pH of 6 was obtained and stirring was performed for 1 hour.

[0156] The liquids were charged to and concentrated using a rotary evaporator to yield a white crystalline powder. A reactor as described herein was charged with methanol, mechanical force was applied, and the reactor was charged the white crystalline powder. The stirred suspension was heated, aged, cooled to room temperature, and discharged from the reactor. The resulting suspension was siphoned onto a Buchner funnel and filtered. The filter cake was re-slurried in methanol and then re-filtered.

[0157] The subsequent combined filtrates were then charged to a rotary evaporator and concentrated in vacuo to afford a crystalline solid comprising a purified fluorination reagent.

[0158] Production of a purified fluorination reagent was also achieved using reactions at elevated temperatures (including 150 °C) in a pressure flask, as well as using high shear mixing and/or a homogenizer as a reactor, as described herein.

[0159] For example, production of a purified fluorination reagent using a reactor equipped with an in-line homogeniser comprised charging the reactor, sealing the reactor, and applying mechanical force. The reaction mixture was and then cooled to room temperature. The resulting suspension was purified using similar methods to those described throughout this example. Further, spray-drying was tested for purification and produced similar results.

[0160] Table 2: XRPD of fluorination reagent C

| Angle (°2 $\theta$ ) | Intensity [a.u.] |
|----------------------|------------------|
| 17.1065              | 48.03            |
| 18.1243              | 56.65            |
| 19.8556              | 180.49           |
| 20.1077              | 443.85           |
| 21.7697              | 127.08           |
| 24.6649              | 55.53            |
| 26.0729              | 59.75            |
| 26.5044              | 765.05           |
| 27.8025              | 593.63           |
| 28.8975              | 1146.01          |
| 29.6196              | 1502.66          |

|         |         |
|---------|---------|
| 30.7473 | 181.75  |
| 33.5278 | 3742.12 |
| 34.1891 | 299.51  |
| 34.5311 | 619.91  |
| 34.5606 | 259.81  |
| 35.0389 | 711.86  |
| 36.0813 | 137.03  |
| 36.6838 | 132.76  |
| 40.8449 | 35.02   |
| 41.6134 | 472.23  |
| 42.5274 | 1030.97 |
| 44.3484 | 550.71  |
| 44.5738 | 159.05  |
| 46.2653 | 170.23  |
| 46.7412 | 525.11  |
| 48.0764 | 2597.43 |
| 49.0280 | 84.97   |
| 49.1401 | 118.82  |
| 50.1292 | 60.09   |
| 50.5421 | 71.06   |
| 52.0373 | 83.41   |
| 52.4004 | 213.73  |
| 54.0201 | 207.41  |
| 57.1244 | 590.72  |
| 57.7184 | 226.83  |
| 58.4393 | 49.82   |
| 59.8714 | 1179.03 |
| 61.9070 | 71.87   |
| 63.7016 | 161.22  |
| 64.6762 | 99.11   |
| 66.3163 | 159.72  |
| 66.7518 | 92.20   |
| 67.6036 | 93.35   |
| 70.4056 | 467.93  |

|         |        |
|---------|--------|
| 72.3758 | 149.53 |
| 72.5514 | 50.60  |
| 75.0914 | 61.76  |
| 75.2740 | 47.83  |
| 77.8145 | 372.80 |

[0161] Fluorination reagent C (1.5 eq), an optional additive (1 eq), and 4-chloroethylene carbonate was stirred in acetonitrile (80 °C, 3h) as provided in Table 3 to provide 4-fluoroethylene carbonate. An exemplary reaction scheme is provided in FIG. 3. Exemplary results are provided in Table 3.

**Table 3**

| Additive   | Yield % |
|------------|---------|
| None       | 29      |
| TMAC       | 0       |
| 18-Crown-6 | 48      |

**[0162] Example 3: mechanochemical conditions for providing battery electrolyte component or additive**

[0163] Fluorination reagent C (1.5 eq) and 4-chloroethylene carbonate (32 mmol) were combined under mechanochemical conditions (milled for 2 hours at 35 Hz) to provide 4-fluoroethylene carbonate. The mechanochemical reaction resulted in a yield of 58%. An exemplary reaction scheme is provided in FIG. 4.

## CLAIMS

## WHAT IS CLAIMED IS:

1. A method of manufacturing a battery electrolyte component or additive, the method comprising:
  - (a) providing a fluorination reagent, wherein the fluorination reagent comprises a first salt and a second salt, the first salt comprising calcium and fluorine;
  - (b) contacting a starting reagent with the fluorination reagent to provide a battery electrolyte component or additive.
2. The method of any one of the preceding claims, wherein the second salt comprises an anion, wherein the anion, when combined with  $\text{Ca}^{2+}$  to form a third salt, has a lattice energy greater than 2450 KJ/mol.
3. The method of any one of the preceding claims, wherein a powder x-ray diffraction spectrum of the fluorination reagent comprises characteristic  $2\theta$  reflections at about  $21.9^\circ$ ,  $30.3^\circ$ ,  $31.6^\circ$ ,  $43.4^\circ$  and/or combinations thereof.
4. The method of any one of the preceding claims, wherein a powder x-ray diffraction spectrum of the fluorination reagent comprises characteristic  $2\theta$  reflections at about  $28.1^\circ$ ,  $49.0^\circ$ ,  $52.3^\circ$ ,  $54.1^\circ$ ,  $60.0^\circ$ ,  $69.7^\circ$  and/or combinations thereof.
5. A method of manufacturing a battery electrolyte component or additive, the method comprising:
  - (a) combining a first salt with a second salt to form a mixed composition, the first salt comprising calcium and fluoride;
  - (b) subjecting the mixed composition with a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
  - (c) concentrating the resultant fluid to produce a crude fluorination reagent (e.g., a wash concentrate or precipitate);
  - (d) washing the crude fluorination reagent with a solvent (e.g., an alcohol) to produce a reagent wash (e.g., a second solid component and fluid reagent wash); and
  - (e) concentrating the reagent wash to form a purified fluorination reagent (e.g., the purified fluorination reagent having a higher concentration of fluorine compared to the crude fluorination reagent).
  - (f) contacting a starting reagent with the purified fluorination reagent to provide a battery electrolyte component or additive.
6. A method of manufacturing a battery electrolyte component or additive, the method comprising:
  - (a) combining a first salt with a second salt, the first salt comprising calcium and fluoride;

- (b) applying mechanical force to the combination of the first salt and the second salt to form a mixed composition;
  - (c) subjecting the mixed composition with a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
  - (d) concentrating the resultant fluid to produce a crude fluorination reagent (e.g., a wash concentrate or precipitate);
  - (e) washing the crude fluorination reagent with a solvent (e.g., an alcohol) to produce a reagent wash (a second solid component and fluid reagent wash); and
  - (f) concentrating the reagent wash to form a purified fluorination reagent (e.g., the purified fluorination reagent having a higher concentration of fluorine compared to the crude fluorination reagent).
  - (g) contacting a starting reagent with the purified fluorination reagent to provide a battery electrolyte component or additive.
7. The method of any one of the preceding claims, wherein the fluorination reagent and/or purified fluorination reagent is contacted with the starting reagent in an alkyl carbonate solvent (e.g., dimethyl carbonate).
8. The method of any one of the preceding claims, wherein the alkyl carbonate solvent is dimethyl carbonate, diethyl carbonate, dipropyl carbonate, methyl ethyl carbonate, methyl propyl carbonate, ethyl propyl carbonate, and/or combinations thereof.
9. The method of any one of the preceding claims, wherein the alkyl carbonate solvent is a fluoroalkyl carbonate solvent (e.g., trifluoroethyl carbonate, bis(trifluoroethyl) carbonate, trifluoroethyl methyl carbonate, and/or combinations thereof).
10. The method of any one of the preceding claims, wherein a combination of the fluorination reagent and/or purified fluorination reagent, the alkyl carbonate solvent, and the starting reagent is at a temperature of about 50 to about 150 °C.
11. The method of any one of the preceding claims, wherein a combination of the fluorination reagent and/or purified fluorination reagent, the alkyl carbonate solvent, and the starting reagent is at a temperature of about 80 °C about or more (e.g., about 100 °C or more).
12. A method of manufacturing a battery electrolyte component or additive, the method comprising:
- (a) providing a purified fluorination reagent, wherein the purified fluorination reagent comprises an alkali metal comprising lithium, potassium, or sodium, fluoride, and at least one additional ion;
  - (b) contacting a starting reagent with the purified fluorination reagent to provide a battery electrolyte component or additive.

13. A method of manufacturing a purified fluorination reagent, the method comprising:
  - (a) combining a first salt with a second salt to form a mixed composition, the first salt comprising calcium and fluoride;
  - (b) subjecting the mixed composition with a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
  - (c) concentrating the resultant fluid to produce a crude fluorination reagent (e.g., a wash concentrate or precipitate);
  - (d) washing the crude fluorination reagent with a solvent (e.g., an alcohol) to produce a reagent wash (a second solid component and fluid reagent wash); and
  - (e) concentrating the reagent wash to form a purified fluorination reagent (e.g., the purified fluorination reagent having a higher concentration of fluorine compared to the crude fluorination reagent).
14. A method of manufacturing a purified fluorination reagent, the method comprising:
  - (a) combining a first salt with a second salt, the first salt comprising calcium and fluoride;
  - (b) applying mechanical force to the combination of the first salt and the second salt to form a mixed composition;
  - (c) subjecting the mixed composition with a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
  - (d) concentrating the resultant fluid to produce a crude fluorination reagent (e.g., a wash concentrate or precipitate);
  - (e) washing the crude fluorination reagent with a solvent (e.g., an alcohol) to produce a reagent wash (a second solid component and fluid reagent wash); and
  - (f) concentrating the reagent wash to form a purified fluorination reagent (e.g., the purified fluorination reagent having a higher concentration of fluorine compared to the crude fluorination reagent).
15. A method of manufacturing a purified fluorination reagent, the method comprising:
  - (a) combining a first salt with a second salt to form a mixed composition, the first salt comprising calcium and fluoride;
  - (b) subjecting the mixed composition with a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
  - (c) concentrating the resultant fluid to produce a purified fluorination reagent (e.g., a wash concentrate or precipitate).
16. A method of manufacturing a purified fluorination reagent, the method comprising:
  - (a) combining a first salt with a second salt, the first salt comprising calcium and fluoride;

- (b) applying mechanical force to the combination of the first salt and the second salt to form a mixed composition;
  - (c) subjecting the mixed composition with a fluid composition (to produce a solid component and a resultant fluid) and collecting a resultant fluid thereof;
  - (d) concentrating the resultant fluid to produce a purified fluorination reagent (e.g., a wash concentrate or precipitate).
17. A method of manufacturing a battery electrolyte component or additive, the method comprising:
- (a) providing a fluorination reagent, wherein the fluorination reagent comprises calcium and fluorine;
  - (b) contacting a starting reagent with the fluorination reagent to provide a battery electrolyte component or additive.
18. The method of any one of the preceding claims, further comprising adjusting the pH of the resultant fluid (e.g., to a pH of about 6 to about 8) prior to concentrating the resultant fluid.
19. The method of any one of the preceding claims, wherein the pH of the resultant fluid is adjusted with an acid (e.g., strong acid, weak acid, polyprotic acid, and/or combinations thereof).
20. The method of any one of the preceding claims wherein the acid comprises phosphoric acid, hydrochloric acid, formic acid, acetic acid, benzoic acid, boric acid, silicic acid, oxalic acid, sulfuric acid, sulfurous acid, carbonic acid, and/or combinations thereof.
21. The method of any one of the preceding claims, wherein the acid comprises hydrochloric acid, phosphoric acid, sulfuric acid, and/or combinations thereof.
22. The method of any one of the preceding claims, wherein the pH of the resultant fluid is adjusted to a pH of about 5 to about 10 (e.g., about 6 to about 9).
23. The method of any one of the preceding claims, wherein the fluid composition has a pH of about 7 or more (e.g., about 10 or more).
24. The method of any one of the preceding claims, wherein the fluid composition has a pH of about 12 to about 13.
25. The method of any one of the preceding claims, wherein a combination of the fluid composition and the mixed composition is at a temperature of about 0 to about 120 °C.
26. The method of any one of the preceding claims, wherein a combination of the fluid composition and the mixed composition is at a temperature of 80 °C or more.
27. The method of any one of the preceding claims, wherein a combination of the fluid composition and the mixed composition is at a temperature of 110 °C or less.

28. The method of any one of the preceding claims, wherein the mixed composition is subjected to the fluid composition for about 0 hours to about 8 hours.
29. The method of any one of the preceding claims, wherein the mixed composition is subjected to the fluid composition for about 1 hour or more.
30. The method of any one of the preceding claims, wherein the mixed composition is subjected to the fluid composition for about 6 hours or less.
31. The method of any one of the preceding claims, wherein the mixed composition is subjected to the fluid composition for about 2 hours.
32. The method of any one of the preceding claims, wherein the fluid composition has a boiling point of about 30 °C or more (e.g., about 70 °C or more, about 120 °C or more).
33. The method of any one of the preceding claims, wherein the fluid composition has a boiling point of about 240 °C or less.
34. The method of any one of the preceding claims, wherein a combination of the solvent and the crude fluorination reagent is at a temperature of about -20 to about 240 °C.
35. The method of any one of the preceding claims, wherein a combination of the solvent and the crude fluorination reagent is at a temperature of about 80 °C or more.
36. The method of any one of the preceding claims, wherein a combination of the solvent and the crude fluorination reagent is at a temperature of about 60 °C.
37. The method of any one of the preceding claims, wherein a combination of the solvent and the crude fluorination reagent is at a temperature of about 235 °C or less.
38. The method of any one of the preceding claims, wherein the crude fluorination reagent is washed with the solvent for about 4 hours to about 48 hours (e.g., about 8 hours to about 36 hours, about 10 hours to about 28 hours).
39. The method of any one of the preceding claims, wherein the crude fluorination reagent is washed with the solvent for about 8 hours or more.
40. The method of any one of the preceding claims, wherein the crude fluorination reagent is washed with the solvent for about 36 hours or less.
41. The method of any one of the preceding claims, wherein the crude fluorination reagent is washed with the solvent for about 18 hours.
42. The method of any one of the preceding claims, wherein the solvent has a boiling point of about 30 °C or more (e.g., about 70 °C or more, about 120 °C or more).
43. The method of any one of the preceding claims, wherein the solvent has a boiling point of about 240 °C or less.

44. The method of any one of the preceding claims, wherein the solvent and/or the fluid composition is an organic solvent, water, an alcohol, a polar aprotic solvent, a halocarbon, and/or combinations thereof.
45. The method of any one of the preceding claims, wherein the solvent and/or the fluid composition is acetonitrile, propionitrile, butyronitrile, toluene, 1,2-dichlorobenzene, chlorobenzene, fluorobenzene, 1,2-difluorobenzene, dichloroethane, trifluorotoluene, chloroform, DMF, DMSO, sulfolane, MeTHF, THF, NMP, pyridine, butyl acetate, dioxane, an alcohol (e.g., tert-butanol, tert-amyl alcohol), water, and/or combinations thereof.
46. The method of any one of the preceding claims, wherein the solvent and/or the fluid composition is acetonitrile, propionitrile, butyronitrile, and/or combinations thereof.
47. The method of any one of the preceding claims, further comprising providing the mixed composition subjected to the fluid composition as the first salt.
48. The method of any one of the preceding claims, wherein the first salt is a recovered waste material.
49. The method of any one of the preceding claims wherein the first salt comprises low purity calcium and fluoride (e.g., less than 80 weight percent in total is calcium and fluorine).
50. The method of any one of the preceding claims, wherein the first salt is  $\text{CaF}_2$  or  $\text{Ca}_5(\text{PO}_4)_3\text{F}$ .
51. The method of any one of the preceding claims, wherein the second salt is a metal hydroxide, a metal sulphite, a metal sulphate, a carbonate, or an inorganic phosphate (e.g., a pyrophosphate).
52. The method of any one of the preceding claims, wherein the second salt comprises  $\text{NaOH}$ ,  $\text{KOH}$ ,  $\text{Na}_2\text{SO}_3$ ,  $\text{K}_2\text{SO}_3$ ,  $\text{KHSO}_4$ ,  $\text{CaCO}_3$ ,  $\text{H}_2\text{CO}_3$ ,  $\text{K}_2\text{CO}_3$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{K}_4\text{P}_2\text{O}_7$ ,  $\text{Na}_4\text{P}_2\text{O}_7$ ,  $\text{Na}_3\text{PO}_4$ ,  $\text{Li}_3\text{PO}_4$ ,  $\text{KHCO}_3$ ,  $\text{K}_2\text{CO}_3$ ,  $\text{NaHCO}_3$ ,  $\text{Cs}_2\text{CO}_3$ ,  $\text{K}_2\text{HPO}_4$ ,  $\text{KH}_2\text{PO}_4$ ,  $\text{K}_3\text{PO}_4$ ,  $\text{KPO}_3$ ,  $\text{K}_5\text{P}_3\text{O}_{10}$ ,  $\text{K}_2\text{SO}_4$ , titanium phosphate, aluminum phosphate, uranium phosphate, and/or combinations thereof.
53. The method of any one of the preceding claims, wherein a combination of the fluorination reagent and/or purified fluorination reagent and the starting reagent comprises a reaction mixture.
54. The method of any one of the preceding claims, wherein the reaction mixture is at a temperature of about 55 to about 150 °C.
55. The method of any one of the preceding claims, wherein the reaction mixture is at a temperature of about 100 °C or less.

56. The method of any one of the preceding claims, wherein the fluorination reagent and/or the purified fluorination reagent is contacted with the starting reagent for about 12 hours or more.
57. The method of any one of the preceding claims, wherein the fluorination reagent and/or the purified fluorination reagent is contacted with the starting reagent for about 14 hours to about 22 hours.
58. The method of any one of the preceding claims, wherein the fluorination reagent and/or the purified fluorination reagent is contacted with the starting reagent for about 84 hours or less.
59. The method of any one of the preceding claims, wherein the fluorination reagent and/or the purified fluorination reagent is contacted with the starting reagent for about 60 hours to about 80 hours.
60. The method of any one of the preceding claims, wherein the reaction mixture further comprises a phase transfer agent, a base, and/or combinations thereof.
61. The method of any one of the preceding claims, wherein the phase transfer agent is a crown ether (e.g., 18 crown 6), a cryptand, an ionic transfer agent (e.g., tetramethylammonium chloride), and/or a hydrogen-bonding phase transfer agent.
62. The method of any one of the preceding claims, wherein the phase transfer agent is a crown ether (e.g., 18 crown 6).
63. The method of any one of the preceding claims, wherein the base is a pyridine derivative (e.g., DMAP).
64. The method of any one of the preceding claims, wherein the reaction mixture further comprises a reaction solvent.
65. The method of any one of the preceding claims, wherein the reaction solvent is an organic solvent, water, an alcohol, a polar aprotic solvent, a halocarbon, and/or combinations thereof.
66. The method of any one of the preceding claims, wherein the reaction solvent is acetonitrile, propionitrile, pyridine, butyronitrile, toluene, 1,2-dichlorobenzene, chlorobenzene, fluorobenzene, 1,2-difluorobenzene, dichloroethane, trifluorotoluene, chloroform, DMF, DMSO, an alcohol (e.g., tert-butanol, tert-amyl alcohol), water, and/or combinations thereof.
67. The method of any one of the preceding claims, wherein the reaction solvent is acetonitrile, propionitrile, pyridine, butyronitrile, and/or combinations thereof.
68. The method of any one of the preceding claims, wherein the starting reagent comprises a leaving group.

69. The method of any one of the preceding claims, wherein the leaving group is chlorine, iodine, or bromine.
70. The method of any one of the preceding claims, wherein the battery electrolyte component or additive comprises at least one additional fluorine (e.g., at least two additional fluorine) compared to the starting reagent.
71. The method of any one of the preceding claims, wherein the starting reagent is 4-chloroethylene carbonate.
72. The method of any one of the preceding claims, wherein the starting reagent is dichloroethylene carbonate.
73. The method of any one of the preceding claims, wherein the battery electrolyte component or additive is 4-fluoroethylene carbonate.
74. The method of any one of the preceding claims, wherein the battery electrolyte component or additive is difluoroethylene carbonate.
75. The method of any one of the preceding claims, wherein an amount of phosphorous in the purified fluorination reagent is about 0.015 % to about 12.5 % by weight (wt %).
76. The method of any one of the preceding claims, wherein an amount of calcium in the purified fluorination reagent is about 0.01 % to about 15 % by weight (wt %).
77. The method of any one of the preceding claims, wherein an amount of phosphorous in the purified fluorination reagent is about 0.02 % to about 10 % by weight (wt %) (e.g., about 0.05 wt % to about 8 wt %, about 0.1 wt % to about 6 wt %, about 0.5 wt % to about 5 wt %, about 1 wt % to about 4 wt %), or wherein an amount phosphorous in the purified fluorination reagent is about 1 ppm to about 25 ppm (e.g., about 1 ppm, about 10 ppm, about 20 ppm, or about 25 ppm).
78. The method of any one of the preceding claims, wherein an amount of phosphorous in the purified fluorination reagent is about 0.015 % by weight (wt %) or more (e.g., about 0.05 wt % or more, about 0.1 wt % or more, about 0.5 wt % or more).
79. The method of any one of the preceding claims, wherein an amount of phosphorous in the purified fluorination reagent is about 5 % by weight (wt %) or less (e.g., about 3 wt % or less, about 2 wt % or less, about 1 wt % or less, about 0.5 wt % or less, about 0.1 wt % or less, about 0.05 wt % or less).
80. The method of any one of the preceding claims, wherein a powder x-ray diffraction spectrum of the crude fluorination reagent comprises characteristic  $2\theta$  reflections at about  $5.2^\circ$ ,  $31.5^\circ$ ,  $36.8^\circ$  and/or combinations thereof.

81. The method of any one of the preceding claims, wherein the at least one additional ion of the purified fluorination reagent comprises (i) at least one cation and at least one anion; or (ii) at least one zwitterion (e.g., psilocybin).
82. The method of any one of the preceding claims, wherein the at least one cation comprises  $K^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $Li^+$ , or  $Cs^+$ .
83. The method of any one of the preceding claims, wherein the at least one anion comprises a hydroxide, a sulphate, a carbonate, a phosphate, a pyrophosphate.
84. The method of any one of the preceding claims, wherein a molar ratio of the phase transfer agent to the starting reagent is about 0 to about 4.
85. The method of any one of the preceding claims, wherein a molar ratio of the base to the starting reagent is about 0 to about 2.
86. The method of any one of the preceding claims, wherein a molar ratio of a fluorine equivalent content in the fluorination reagent and/or purified fluorination reagent to the starting reagent is about 0.1 or more.
87. The method of any one of the preceding claims, wherein a yield of the battery electrolyte component or additive is about 10% or more.
88. The method of any one of the preceding claims, wherein a yield of the battery electrolyte component or additive is about 20% to about 80%.
89. The method of any one of the preceding claims, wherein a concentration of the starting reagent in the reaction solvent and/or alkyl carbonate solvent is about 0.01 M to about 3 M.
90. The method of any one of the preceding claims, wherein a concentration of the starting reagent in the reaction solvent and/or alkyl carbonate solvent is about 1 M or less.
91. The method of any one of the preceding claims, wherein the fluorination reagent and/or purified fluorination reagent is contacted with the starting reagent under mechanochemical conditions (e.g., ball mill).

FIG. 1

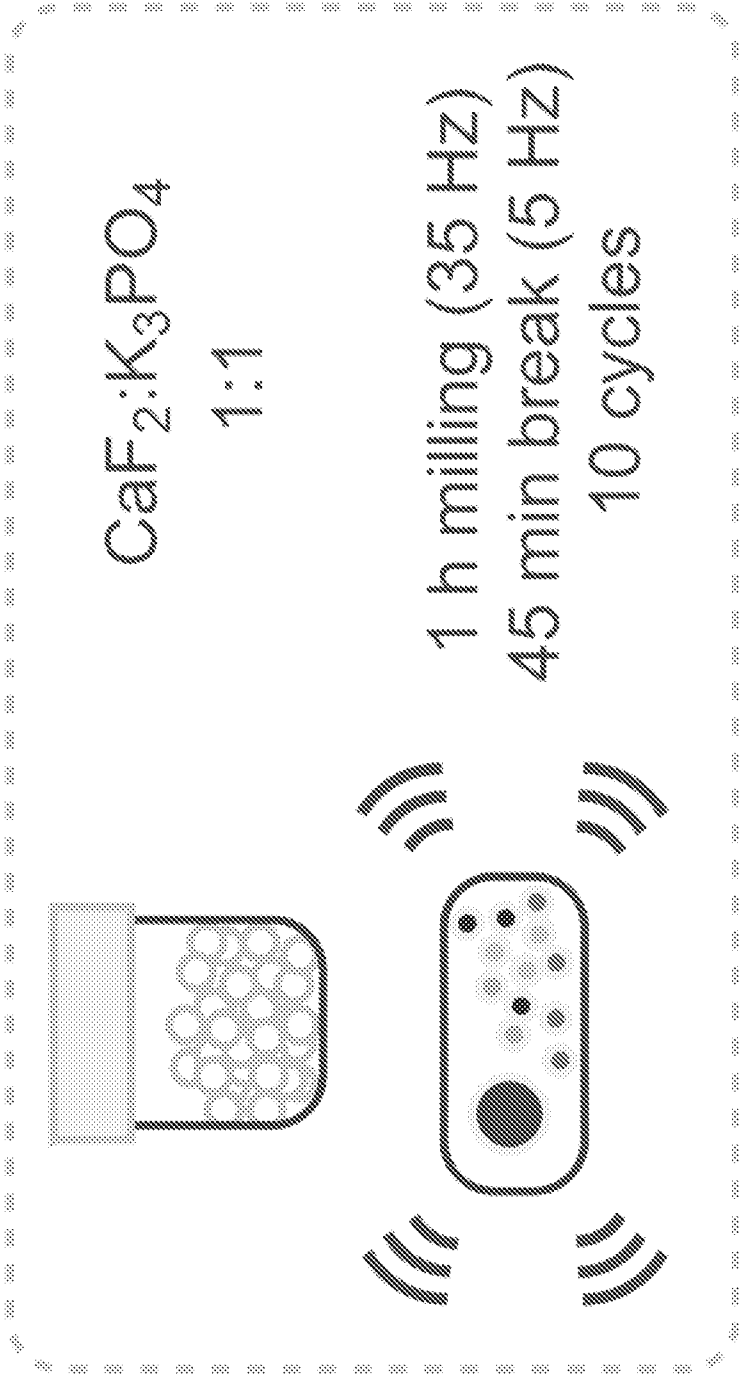


FIG. 2

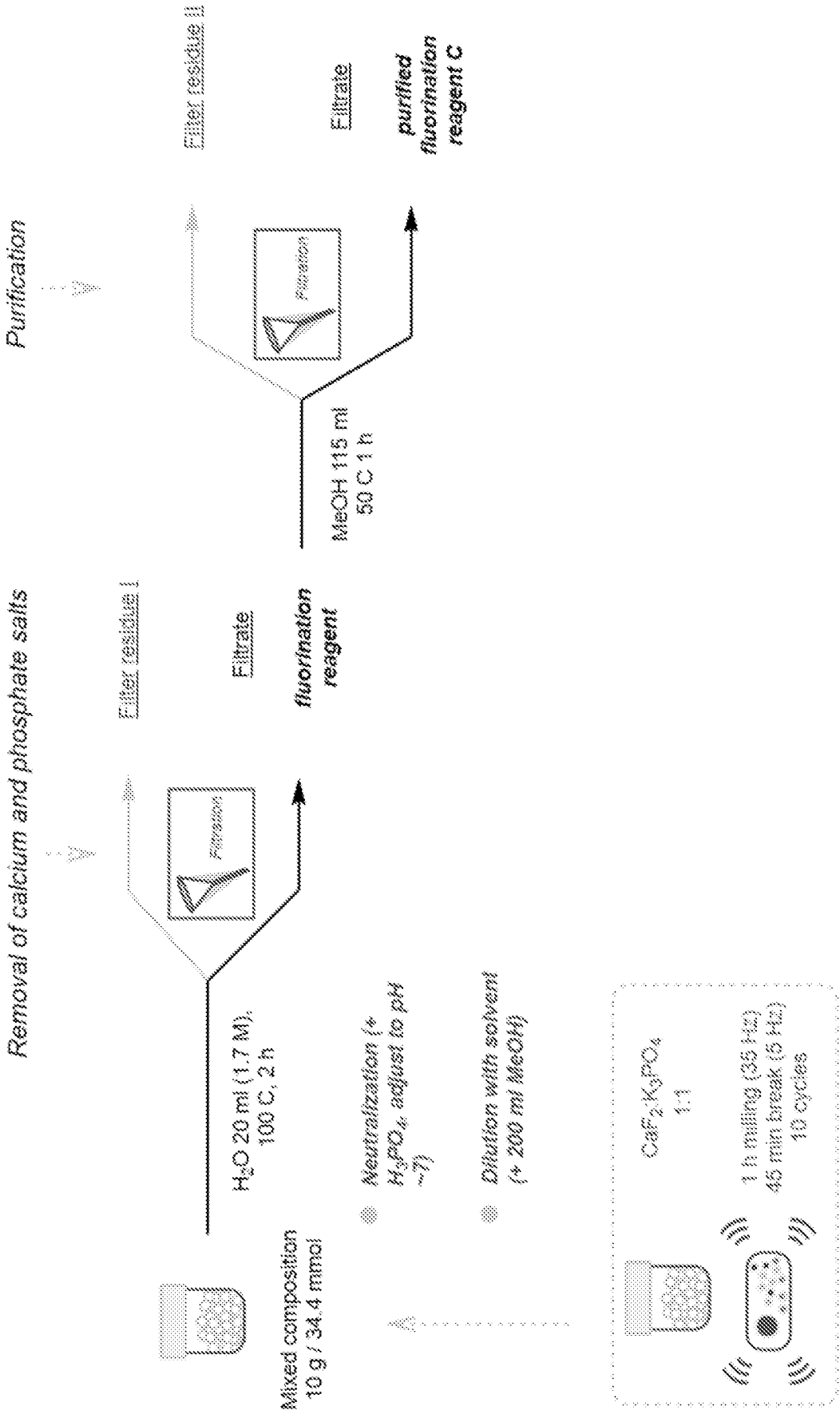


FIG. 3

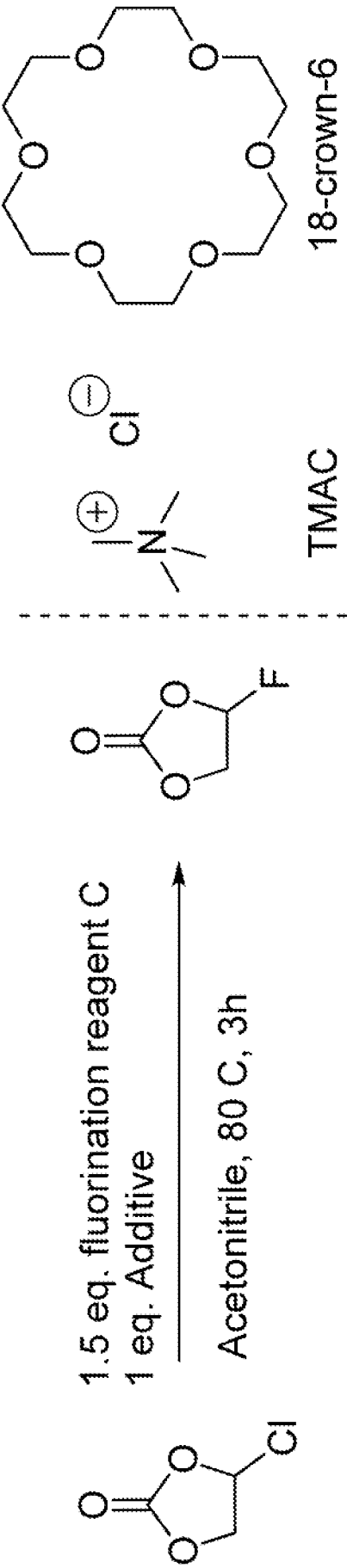


FIG. 4

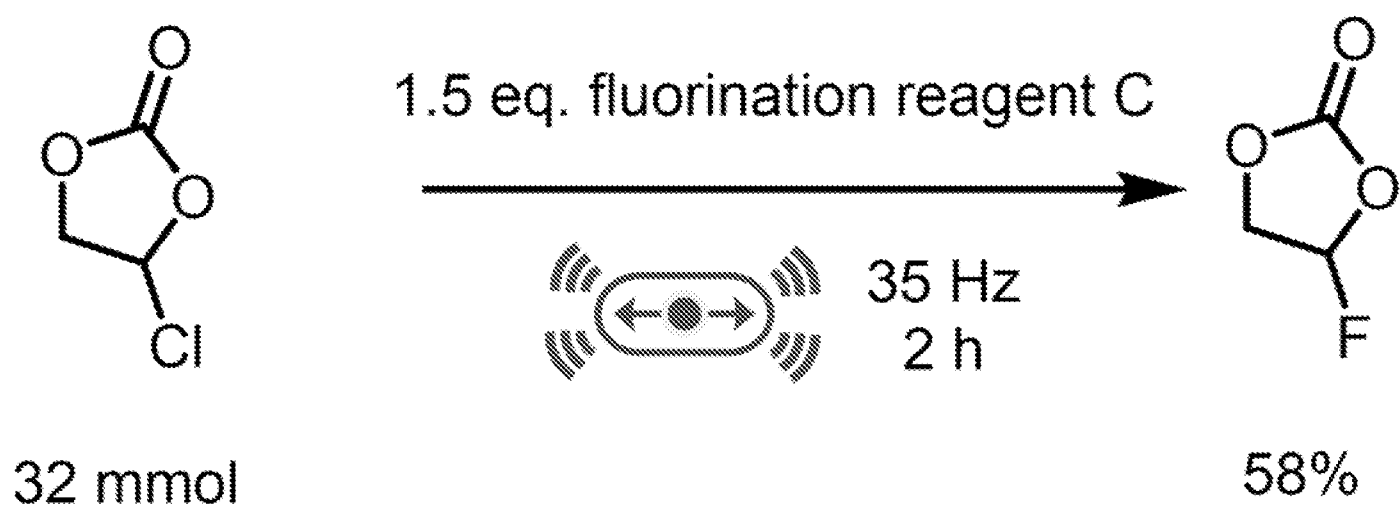
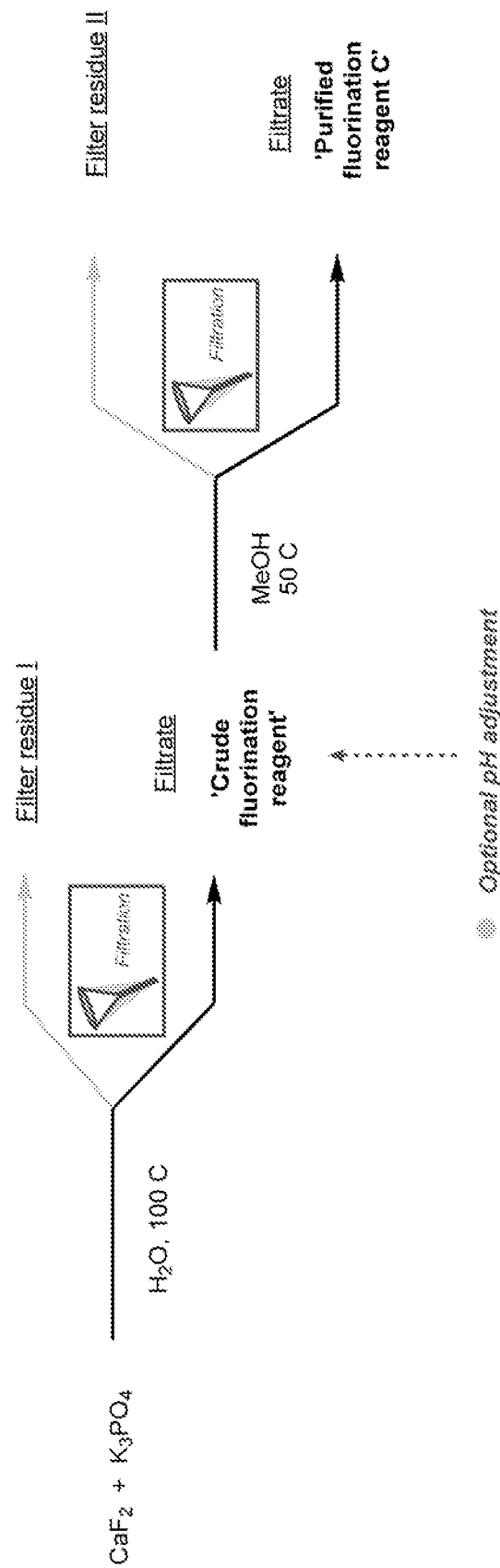


FIG. 5



## INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2024/000279

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. C07D317/42 C01F11/22  
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

C07D C01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, CHEM ABS Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                          | Relevant to claim No. |
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

4 October 2024

Date of mailing of the international search report

22/10/2024

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2

NL - 2280 HV Rijswijk

Tel. (+31-70) 340-2040,

Fax: (+31-70) 340-3016

Authorized officer

Gutke, Hans-Jürgen

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No  
PCT/IB2024/000279

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)  | Publication<br>date         |
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