

apparent pro-arrhythmic potential, could potentially be used to treat acute and recurrent atrial fibrillation in the presence of organic heart disease, prolonged QR syndrome, and ventricular arrhythmias, including premature ventricular contractions (PVCs), ventricular tachycardia (VT), and ventricular fibrillation (VF), in either acute- or chronic-administration settings owing to their ability to be formulated into intravenous and oral dosing formulations.

SUMMARY

[0004a] In one aspect of the present disclosure, there is provided a hydrate of an ethane-1,2-disulfonic acid salt of sulcardine.

[0004b] In another aspect of the present disclosure, there is provided a solid salt of ethane-1,2-disulfonic acid and sulcardine.

[0004c] In a further aspect of the present disclosure, there is provided a crystalline salt of ethane-1,2-disulfonic acid and sulcardine.

[0005] In some examples, crystalline salts of sulcardine and salt formers other than sulfuric acid are provided. A “salt former” is a compound (*e.g.*, an acid counterion) which may be used to create a salt with, for example, sulcardine.

[0006] In some examples, provided herein is a solid form comprising an acid salt of sulcardine, wherein the acid is ethane-1,2-disulfonic acid, naphthalene-1,5-disulfonic acid, 1-hydroxy-2-naphthoic acid, naphthalene-2-sulfonic acid, hydrochloric acid, or hydrobromic acid. In some examples, the solid form is crystalline. In some examples, the solid form is amorphous.

[0007] In further examples, crystalline salts of sulcardine and halide salt formers are provided.

[0008] In additional examples, crystalline salts of sulcardine and a sulfonic acid salt former are provided.

[0009] In other examples, salts of sulcardine and mononaphthalene salt formers are provided.

[0010] In further examples, salts of sulcardine and naphthalene-1,5-disulfonic acid, 1-hydroxy-2-naphthoic acid, naphthalene-2-sulfonic acid, hydrochloric acid, or hydrobromic acid are provided.

[0011] In additional examples, crystalline salts of sulcardine and naphthalene-1,5-disulfonic acid, 1-hydroxy-2-naphthoic acid, naphthalene-2-sulfonic acid, hydrochloric acid, or hydrobromic acid are provided.

[0012] In additional examples, Form I and Form II of crystalline salts of sulcardine and 1-hydroxy-2-naphthoic acid are provided.

- [0013]** In further examples, Form I and Form II of crystalline salts of sulcardine and hydrochloric acid are provided.
- [0014]** In additional examples, monoedisylate salts (*i.e.*, mono- ethane-1,2-disulfonic acid salts) of sulcardine are provided. In some examples, the monoedisylate salts of sulcardine are hydrates.
- [0015]** In other examples, crystalline monoedisylate salts of sulcardine are provided. In additional examples, amorphous monoedisylate salts of sulcardine are provided.
- [0016]** In still further examples, Form I and Form II of crystalline salts of monoedisylate sulcardine are provided.
- [0017]** In additional examples, pharmaceutical compositions comprising sulcardine salts provided herein, including crystalline salts, and one or more pharmaceutically acceptable excipients are provided.
- [0018]** In some examples, provided herein is a pharmaceutical composition comprising a solid form provided herein, and one or more pharmaceutically acceptable excipients.
- [0019]** In yet additional examples, methods of treating arrhythmias with sulcardine salts provided herein, including crystalline sulcardine salts, comprising administering such salts to a patient in need thereof are provided.
- [0020]** In some examples, provided herein is a method of treating arrhythmia, comprising administering to a subject in need thereof a therapeutically effective amount of a solid form provided herein, or a pharmaceutical composition provided herein. In some examples, the arrhythmia is atrial fibrillation, supraventricular tachyarrhythmia, premature ventricular contraction, ventricular tachycardia, or ventricular fibrillation.

BRIEF DESCRIPTION OF THE FIGURES

- [0021]** FIG. 1 is a representative XRPD pattern of a crystalline salt of sulcardine and naphthalene-1,5-disulfonic acid.
- [0022]** FIG. 2 is a representative TG/DTA thermogram of a crystalline salt of sulcardine and naphthalene-1,5-disulfonic acid.

What is claimed is:

1. A hydrate of an ethane-1,2-disulfonic acid salt of sulcardine.
2. The hydrate of claim 1, wherein the hydrated ethane-1,2-disulfonic acid salt of sulcardine is crystalline.
3. The hydrate of claim 2, wherein the hydrated ethane-1,2-disulfonic acid salt of sulcardine is a dihydrate.
4. The hydrate of claim 2, wherein the crystalline salt is a monoedisylate salt of sulcardine.
5. The crystalline monoedisylate salt of claim 4, wherein the salt is a dihydrate.
6. The crystalline monoedisylate salt of claim 4, having an x-ray powder diffraction pattern comprising a peak at about $5.2^{\circ} 2\theta$.
7. The crystalline monoedisylate salt of claim 6, having an x-ray powder diffraction pattern further comprising one or more peaks at about $9.1^{\circ} 2\theta$, about $10.2^{\circ} 2\theta$, about $10.8^{\circ} 2\theta$, about $11.3^{\circ} 2\theta$, about $13.6^{\circ} 2\theta$, and about $15.7^{\circ} 2\theta$.
8. The crystalline monoedisylate salt of claim 6, having an x-ray powder diffraction pattern further comprising peaks at about $15.7^{\circ} 2\theta$, about $16.9^{\circ} 2\theta$, and about $23.6^{\circ} 2\theta$.
9. The crystalline monoedisylate salt of claim 6, having an x-ray powder diffraction pattern further comprising peaks at about $9.1^{\circ} 2\theta$ and about $11.3^{\circ} 2\theta$.
10. The crystalline monoedisylate salt of sulcardine of claim 4, characterized by x-ray powder diffraction pattern presented in FIG. 28.
11. The crystalline monoedisylate salt of claim 5, wherein the salt provides an in vivo plasma profile comprising a median C_{max} of higher than about 4,500 ng/mL with a T_{max} of within about 0.5 hours post administration when orally administered to a subject.
12. The crystalline monoedisylate salt of claim 4, wherein the salt is a monohydrate.
13. The crystalline monoedisylate salt of claim 4, having an x-ray powder diffraction pattern comprising a peak at about $14.2^{\circ} 2\theta$.
14. The crystalline monoedisylate salt of claim 13, having an x-ray powder diffraction pattern further comprising two peaks between about $9.0^{\circ} 2\theta$ and about $9.8^{\circ} 2\theta$.
15. The crystalline monoedisylate salt of claim 13, having an x-ray powder diffraction pattern further comprising one or more peaks at about $9.2^{\circ} 2\theta$, about $9.6^{\circ} 2\theta$, about $10.4^{\circ} 2\theta$, about $13.8^{\circ} 2\theta$, and about $14.9^{\circ} 2\theta$.

16. The crystalline monoedisylate salt of claim 13, having an x-ray powder diffraction pattern further comprising peaks at about $18.8^{\circ} 2\theta$, about $20.2^{\circ} 2\theta$, and about $21.2^{\circ} 2\theta$.
17. The crystalline monoedisylate salt of sulcardine of claim 4, characterized by an x-ray powder diffraction pattern presented in FIG. 26.
18. A solid salt of ethane-1,2-disulfonic acid and sulcardine.
19. A crystalline salt of ethane-1,2-disulfonic acid and sulcardine.