Claims

1. A pharmaceutical composition comprising a liposome, wherein the liposome comprises a plurality of lipids; a weakly basic anticancer compound; and oxalic acid or a salt of oxalic acid; wherein the weight ratio of the lipids to the weakly basic anticancer compound is from about 50:1 to about 100:1.

2. The pharmaceutical composition of claim 1, wherein the weakly basic anticancer compound is doxorubicin, irinotecan, mitoxantrone, or a combination of two or more thereof.

3. The pharmaceutical composition of claim 1, wherein the plurality of lipids comprise a poloxamer.

4. The pharmaceutical composition of claim 1, wherein the plurality of lipids comprise a plurality of free cholesterols; a plurality of phospholipids; or a combination thereof.

5. The pharmaceutical composition of claim 4, wherein the plurality of lipids comprise a plurality of free cholesterols and a plurality of phospholipids, and wherein the molar ratio of the phospholipids to the free cholesterols is at least 0.5 to 1 to about 4 to 1.

6. The pharmaceutical composition of claim 1, wherein the weakly basic anticancer compound is substantially released from the liposome at pH < 7.4.

7. The pharmaceutical composition of claim 1, wherein at least 40-80% of the weakly basic anticancer compound is released from the liposome at pH 5 under standard assay conditions; wherein at least 10-50% of the weakly basic anticancer compound is released from the liposome at pH 6.0 under standard assay conditions; wherein at least 7-30% of the weakly basic anticancer compound is released from the liposome at pH 6.7 under standard assay conditions; or wherein less than 5% of the weakly basic anticancer compound is released from the liposome at pH 7.4 under standard assay conditions.

8. The pharmaceutical composition of claim 1, wherein the liposome comprises a plurality of weakly basic anticancer compounds and retains greater than 50% of the plurality of weakly basic anticancer compound for up to about 8 hours of incubation in serum or blood when

tested under standard assay conditions.

9. The pharmaceutical composition of claim 7, wherein the standard assay conditions comprise 50 times dilution of the liposomes in serum or blood and incubation at 37 °C for 2, 4, or 8 hours at pH 7.4.

10. The pharmaceutical composition of claim 1, wherein the pharmaceutical composition comprises a plurality of the liposome having a mean longest dimension of about 40 nm to about 100 nm determined by the intensity-averaged particle diameters measured by dynamic light scattering; or wherein the pharmaceutical composition comprises a plurality of the liposome having a mean longest dimension from about 1 nm to about 50 nm determined by cryo-transmission electron microscopy.

11. The pharmaceutical composition of claim 1, wherein the liposome comprises about 500 μg/mL to about 1,000 μg/mL of the weakly basic anticancer compound.

12. The pharmaceutical composition of claim 1, wherein the liposome comprises about 750 μg/mL to about 850 μg/mL of the weakly basic anticancer compound.

13. The pharmaceutical composition of claim 1, wherein the liposome comprises a plurality of the weakly basic anticancer compound and retains greater than 90% of the plurality of weakly basic anticancer compound after 40 days when stored at 2-8°C under standard storage conditions.

14. The pharmaceutical composition of claim 1, further comprising a compound selected from the group consisting of ascorbic acid, N-acetylcysteine, ascorbyl palmitate, ubiquinone, and ethylenediaminetetraacetic acid.

15. The pharmaceutical composition of claim 1, wherein the weakly basic anticancer compound has a pKa from about 7.5 to about 9.0.

16. The pharmaceutical composition of claim 5, wherein the molar ratio of the phospholipids to the free cholesterols is from about 1 to 1 to about 4 to 1.

17. A pharmaceutical composition comprising a liposome, wherein the liposome comprises a plurality of lipids; a weakly basic anticancer compound; and tartaric acid or a salt of tartaric acid;

wherein the weight ratio of the lipids to the weakly basic anticancer compound is from about 50:1 to about 100:1.

18. The pharmaceutical composition of claim 17, wherein the weakly basic anticancer compound is doxorubicin, irinotecan, mitoxantrone, or a combination of two or more thereof.

19. The pharmaceutical composition of claim 17, wherein the plurality of lipids comprise a poloxamer.

20. The pharmaceutical composition of claim 17, wherein the plurality of lipids comprise a plurality of free cholesterols; a plurality of phospholipids; or a combination thereof.

21. The pharmaceutical composition of claim 20, wherein the plurality of lipids comprise a plurality of free cholesterols and a plurality of phospholipids, and wherein the molar ratio of the phospholipids to the free cholesterols is at least 0.5 to 1 to about 4 to 1.

22. The pharmaceutical composition of claim 17, wherein the weakly basic anticancer compound is substantially released from the liposome at pH < 7.4.

23. The pharmaceutical composition of claim 17, wherein at least 40-80% of the weakly basic anticancer compound is released from the liposome at pH 5 under standard assay conditions; wherein at least 10-50% of the weakly basic anticancer compound is released from the liposome at pH 6.0 under standard assay conditions; wherein at least 7-30% of the weakly basic anticancer compound is released from the liposome at pH 6.7 under standard assay conditions; or wherein less than 5% of the weakly basic anticancer compound is released from the liposome at pH 7.4 under standard assay conditions.

24. The pharmaceutical composition of claim 17, wherein the liposome comprises a plurality of weakly basic anticancer compounds and retains greater than 50% of the plurality of weakly basic anticancer compound for up to about 8 hours of incubation in serum or blood when tested under standard assay conditions.

25. The pharmaceutical composition of claim 23, wherein the standard assay conditions comprise 50 times dilution of the liposomes in serum or blood and incubation at 37 °C for 2, 4, or 8 hours at pH 7.4.

26. The pharmaceutical composition of claim 17, wherein the pharmaceutical composition comprises a plurality of the liposome having a mean longest dimension of about 40 nm to about 100 nm determined by the intensity-averaged particle diameters measured by dynamic light scattering; or wherein the pharmaceutical composition comprises a plurality of the liposome having a mean longest dimension from about 1 nm to about 50 nm determined by cryo-transmission electron microscopy.

27. The pharmaceutical composition of claim 17, wherein the liposome comprises about 500 μg/mL to about 1,000 μg/mL of the weakly basic anticancer compound.

28. The pharmaceutical composition of claim 17, wherein the liposome comprises about 750 μg/mL to about 850 μg/mL of the weakly basic anticancer compound.

29. The pharmaceutical composition of claim 17, wherein the liposome comprises a plurality of the weakly basic anticancer compound and retains greater than 90% of the plurality of weakly basic anticancer compound after 40 days when stored at 2-8°C under standard storage conditions.

30. The pharmaceutical composition of claim 17, further comprising a compound selected from the group consisting of ascorbic acid, N-acetylcysteine, ascorbyl palmitate, ubiquinone, and ethylenediaminetetraacetic acid.

31. The pharmaceutical composition of claim 17, wherein the weakly basic anticancer compound has a pKa from about 7.5 to about 9.0.

32. The pharmaceutical composition of claim 21, wherein the molar ratio of the phospholipids to the free cholesterols is from about 1 to 1 to about 4 to 1.