

Claims

1. A method of fabricating a composite, comprising
 - a) mixing porous carbon with a rylene dye in order to form a mixture;
 - 5 b) heating the mixture from about 300 °C to about 600 °C under an inert atmosphere; and
 - c) carbonising the mixture at a temperature of about 700 °C to about 1300 °C.
2. The method according to claim 1, wherein the composite comprises ultra-
10 micropores, the ultra-micropores having a pore diameter (based on CO₂ adsorption) of about 0.2 nm to about 0.8 nm.
3. The method according to claim 1 or 2, wherein the composite has a BET (CO₂)
specific surface area of about 10 m² g⁻¹ to about 220 m² g⁻¹.
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4. The method according to any one of claims 1 to 3, wherein a mass ratio of porous
carbon to rylene dye is about 1:1 to about 1:4.
5. The method according to any one of claims 1 to 4, wherein the porous carbon is
20 selected from activated carbon, mesoporous carbon, carbonised sugar, low specific surface
area carbon and low specific surface area carbon.
6. The method according to any one of claims 1 to 5, wherein the rylene dye is selected
from perylenetetracarboxylic dianhydride (PTCDA), perylenediimide, terrylendiimide,
25 terrylen, perylen, quaterrylen and naphthalin.
7. The method according to any one of claims 1 to 6, wherein the inert atmosphere is
argon.
- 30 8. The method according to any one of claims 1 to 7, wherein the heating step is
performed for about 2 h to about 10 h.

9. The method according to any one of claims 1 to 8, wherein the carbonisation step is performed for at least 3 h under a rate of about 3 °C/min to about 10 °C/min.
- 5 10. A modified porous carbon composite comprising:
- a) a porous carbon structure; and
 - b) a carbonised rylene dye;
- wherein the carbonised rylene dye coats at least inner pores of the porous carbon structure.
- 10 11. The composite according to claim 10, wherein the composite comprises ultra-micropores, the ultra-micropores having a pore diameter (based on CO₂ adsorption) of about 0.2 nm to about 0.8 nm.
12. The composite according to claim 10 or 11, wherein the composite has a BET (N₂)
15 specific surface area of about 5 m² g⁻¹ to about 80 m² g⁻¹.
13. The composite according to any one of claims 10 to 12, wherein the composite has a BET (CO₂) specific surface area of about 10 m² g⁻¹ to about 220 m² g⁻¹.
- 20 14. The composite according to any one of claims 10 to 13, wherein a mass ratio of porous carbon structure to at least partially carbonised rylene dye is about 1:1 to about 1:4.
15. The composite according to any one of claims 10 to 14, wherein the composite has a BET (CO₂) specific surface area to BET (N₂) specific surface area ratio of about 0.1 to about
25 50.
16. The composite according to any one of claims 10 to 15, the composite having an XRD pattern which indicates the presence of a (002) peak of a carbon derived from the carbonised rylene dye and a (002) peak of the porous carbon structure.

17. The composite according to claim 16, wherein the (002) peak of a carbon derived from the carbonised rylene dye is about 25.2° .
18. The composite according to claim 16 or 17, wherein the (002) peak of the porous carbon is about 21.2° .
19. The composite according to any one of claims 10 to 18, the composite having a total volume (based on N_2 adsorption) of about $0.01 \text{ cm}^3 \text{ g}^{-1}$ to about $0.13 \text{ cm}^3 \text{ g}^{-1}$.
20. The composite according to any one of claims 10 to 19, the composite having a total volume (based on CO_2 adsorption) of about $0.08 \text{ cm}^3 \text{ g}^{-1}$ to about $0.4 \text{ cm}^3 \text{ g}^{-1}$.
21. The composite according to any one of claims 10 to 20, the composite having a R value of about 2 to about 5.
22. The composite according to any one of claims 10 to 21, the composite having a skeletal density of about 1.8 g cm^{-3} to about 2.5 g cm^{-3} .
23. A method of fabricating an electrode, comprising:
- mixing a composite according to any one of claims 10 to 22 with a binder solution to form a slurry;
 - applying the slurry on a surface of an electrical conductor; and
 - drying the slurry.
24. The method according to claim 23, wherein a weight ratio of composite to binder solution is about 80:20 to about 95:5.
25. The method according to claim 23 or 24, wherein the binder solution has a concentration of about 10 mg/mL to about 20 mg/mL .

26. The method according to any one of claims 23 to 25, wherein the binder solution comprises a binder selected from sodium carboxymethyl cellulose and/or polyvinylidene fluoride (PVDF).

5 27. The method according to any one of claims 23 to 26, wherein the drying step is performed at about 40 °C to about 80 °C.

28. The method according to any one of claims 23 to 27, wherein the drying step is performed for about 2 h to about 6 h.

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29. The method according to any one of claims 23 to 28, wherein the drying step further comprises vacuum drying the slurry at about 100 °C to about 140 °C for at least 8 h.

30. An electrode, comprising:

- 15 a) a composite according to any one of claims 10 to 22;
b) a binder; and
c) an electrical conductor;

wherein the composite and the binder are homogenously combined; and
wherein the composite and the binder coats at least a surface of the electrical conductor.

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31. The electrode according to claim 30, the electrode having a capacity of more than 100 mAh g⁻¹ at a current density of about 2000 mA g⁻¹ or a capacity of more than 300 mAh g⁻¹ at a current density of about 30 mA g⁻¹.

25 32. The electrode according to claim 30 or 31, the electrode having a retention of at least 80% of its initial capacity after 200 cycles.

33. The electrode according to any one of claims 30 to 32, wherein a mass loading of the composite and binder on the electrical conductor is at least 15 mg cm⁻².

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34. The electrode according to any one of claims 30 to 33, the electrode having an areal capacity of about 6 mAh cm^{-2} at a current density of about 0.1 mA cm^{-2} or an areal capacity of about 3 mAh cm^{-2} at a current density of about 0.5 mA cm^{-2} .
- 5 35. The electrode according to any one of claims 30 to 34, wherein at least 80% of an area capacity is retained at about -20°C .
36. A battery, comprising:
- a) an organic cathode;
- 10 b) an anode, the anode comprising the composite according to any one of claims 9 to 22; and
- c) sodium metal, the sodium metal applied on at least a surface of the anode.
37. The battery according to claim 36, wherein the organic cathode comprises a rylene dye.
- 15 38. The battery according to claim 36 or 37, wherein a mass loading ratio of the organic cathode to the anode is about 1:2 to about 1:3.
- 20 39. The battery according to any one of claims 36 to 38, wherein a N/P ratio (the areal capacity ratio of negative to positive electrode) is about 1.1:1 to about 1.2:1.
40. The battery according to any one of claims 36 to 39, wherein during a charging and/or discharge of the battery, the battery is characterised by a peak at 4.44 ppm in *ex-situ* ^{23}Na MAS NMR.
- 25 41. The battery according to any one of claims 36 to 40, wherein when the battery is fully discharged, the battery is characterised by a peak at 4.44 ppm and a peak from about -20 ppm to about -30 ppm in *ex-situ* ^{23}Na MAS NMR.