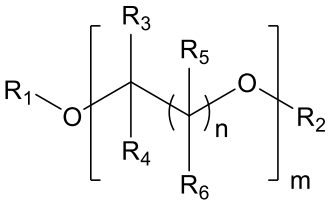
one or more dielectric compounds of formula (I):



(I)

wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

m is an integer 1, 2, or 3;

R_1 is C_1-C_5 alkyl;

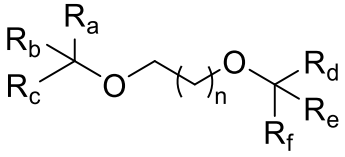
R_2 is C_1-C_5 alkyl;

each R_3, R_4, R_5, and R_6 are independently selected from H, C_1-C_8 alkyl, and R_7O-$(CH_2)_{0-1}$-, wherein R_7 is C_1-C_5 alkyl,

provided no more than two of R_3, R_4, R_5, and R_6 are R_7O-$(CH_2)_{0-1}$-;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid.

[0008a] In another aspect, the present disclosure provides a thermal management fluid comprising one or more compounds of formula (I) having the formula



wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 ,11, or 12; and

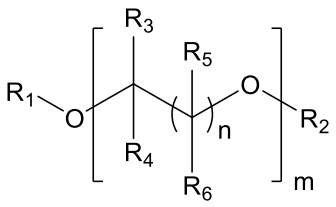
each of R_a and R_b is independently methyl, and each of R_c, R_d, R_e, and R_f is independently methyl or ethyl;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

wherein the thermal management fluid has a flash point of at least 100 °C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25 °C.

[0009] Another aspect of the disclosure provides a battery system. The battery system includes a housing; one or more electrochemical cells disposed in the housing; a fluid path extending in the housing and in substantial thermal communication with the one or more electrochemical cells; and a thermal management fluid of the disclosure as described herein disposed in the fluid path.

[0009a] In one aspect, the present disclosure provides a battery system comprising a housing; one or more electrochemical cells disposed in the housing; a fluid path extending in the housing and in substantial thermal communication with the one or more electrochemical cells; and a thermal management fluid disposed in the fluid path; wherein the thermal management fluid comprises one or more dielectric compounds of the formula (I):



(I)

wherein:

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

m is an integer 1;

R_1 is C_1-C_5 alkyl;

R_2 is C_1-C_5 alkyl;

each R_3, R_4, R_5, and R_6 are independently selected from H, C_1-C_8 alkyl, and R_7O-$(CH_2)_{0-1}$-, wherein R7 is C1-C5 alkyl,

provided no more than two of R_3, R_4, R_5, and R_6 are R_7O-$(CH_2)_{0-1}$-;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

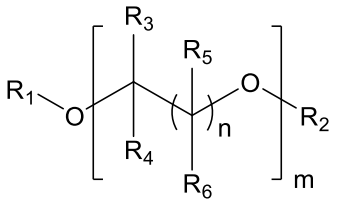
wherein the thermal management fluid has a flash point of at least 100°C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25°C.

[0010] In another aspect, the disclosure provides an electric vehicle comprising the battery system of the disclosure as described herein.

[0011] In another aspect the disclosure provides a thermal management circuit including: a fluid path extending around and/or through a heat source; and a thermal management fluid of the disclosure, disposed in and configured to circulate in the fluid path and to absorb thermal energy produced by the heat source, wherein the fluid is disposed in the fluid path, the heat exchanger, the pump and the connecting duct.

[0011a] In another aspect, the present disclosure provides a thermal management circuit comprising a fluid path extending around and/or through a heat source; a thermal management fluid disposed in and configured to circulate in the fluid path and to absorb thermal energy produced by the heat source, wherein the fluid is disposed in the fluid path,

the heat exchanger, the pump and the connecting duct, wherein the thermal management fluid comprises one or more dielectric compounds of the formula (I):



(I)

wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

m is an integer 1;

R_1 is C_1-C_5 alkyl;

R_2 is C_1-C_5 alkyl;

each R_3, R_4, R_5, and R_6 are independently selected from H, C_1-C_8 alkyl, and R_7O-$(CH_2)_{0-1}$-, wherein R7 is C1-C5 alkyl,

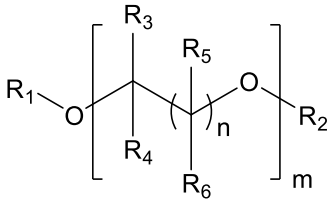
provided no more than two of R_3, R_4, R_5, and R_6 are R_7O-$(CH_2)_{0-1}$-;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

wherein the thermal management fluid has a flash point of at least 100 °C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25 °C.

[0012] Another aspect of the disclosure provides a method including contacting a thermal management fluid of the disclosure with a surface having a temperature of at least 25 °C (e.g., at least 30 °C), the surface being in substantial thermal communication with a heat source; and absorbing thermal energy in the thermal management fluid from the heat source through the surface.

[0012a] In another aspect, the present disclosure provides a method comprising contacting a thermal management fluid with a surface having a temperature of at least 25 °C, the surface being in substantial thermal communication with a heat source; and
absorbing thermal energy in the thermal management fluid from the heat source through the surface; wherein the thermal management fluid comprises one or more dielectric compounds of the formula:



(I)

wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

m is an integer 1;

R_1 is C_1-C_5 alkyl;

R_2 is C_1-C_5 alkyl;

each R_3, R_4, R_5, and R_6 are independently selected from H, C_1-C_8 alkyl, and R_7O-$(CH_2)_{0-1}$-, wherein R_7 is C_1-C_5 alkyl,

provided no more than two of R_3, R_4, R_5, and R_6 are R_7O-$(CH_2)_{0-1}$-;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

wherein the thermal management fluid has a flash point of at least 100 °C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25 °C

[0013] Another aspect of the disclosure provides a method for preparing the thermal management fluid of the disclosure. Such method includes contacting a compound of formula (II)

We claim:

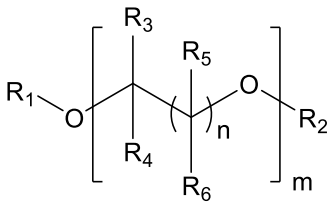
1. A method comprising:

contacting a thermal management fluid with a surface having a temperature of at least 25 °C, the surface being in substantial thermal communication with a heat source; and

absorbing thermal energy in the thermal management fluid from the heat source through the surface;

wherein the thermal management fluid comprises:

one or more dielectric compounds of the formula:



(I)

wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

m is an integer 1;

R_1 is C_1-C_5 alkyl;

R_2 is C_1-C_5 alkyl;

each R_3, R_4, R_5, and R_6 are independently selected from H, C_1-C_8 alkyl, and R_7O-$(CH_2)_{0\text{-}1}$-, wherein R_7 is C_1-C_5 alkyl,

provided no more than two of R_3, R_4, R_5, and R_6 are R_7O-$(CH_2)_{0\text{-}1}$-;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

wherein the thermal management fluid has a flash point of at least 100 °C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25 °C.

2. The method of claim 1, wherein the heat source is an electrical component, e.g., a battery system, a capacitor, inverter, electrical cabling, a fuel cell, a motor, a computer, or high power charging equipment.

3. A battery system comprising:

a housing;

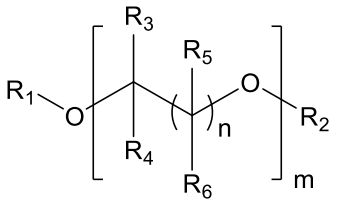
one or more electrochemical cells disposed in the housing;

a fluid path extending in the housing and in substantial thermal communication with the one or more electrochemical cells; and

a thermal management fluid disposed in the fluid path;

wherein the thermal management fluid comprises:

one or more dielectric compounds of the formula (I):



(I)

wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

m is an integer 1;

R_1 is C_1-C_5 alkyl;

R_2 is C_1-C_5 alkyl;

each R_3, R_4, R_5, and R_6 are independently selected from H, C_1-C_8 alkyl, and R_7O-$(CH_2)_{0-1}$-, wherein R7 is C1-C5 alkyl,

provided no more than two of R_3, R_4, R_5, and R_6 are R_7O-$(CH_2)_{0-1}$-;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

wherein the thermal management fluid has a flash point of at least 100°C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25°C.

4. A thermal management circuit comprising:

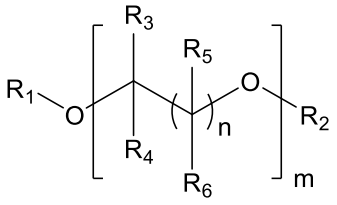
a fluid path extending around and/or through a heat source;

a thermal management fluid disposed in and configured to circulate in the fluid path and to absorb thermal energy produced by the heat source,

wherein the fluid is disposed in the fluid path, the heat exchanger, the pump and the connecting duct,

wherein the thermal management fluid comprises:

one or more dielectric compounds of the formula (I):



(I)

wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

m is an integer 1;

R_1 is C_1-C_5 alkyl;

R_2 is C_1-C_5 alkyl;

each R_3, R_4, R_5, and R_6 are independently selected from H, C_1-C_8 alkyl, and R_7O-$(CH_2)_{0-1}$-, wherein R7 is C1-C5 alkyl,

provided no more than two of R_3, R_4, R_5, and R_6 are R_7O-$(CH_2)_{0-1}$-;

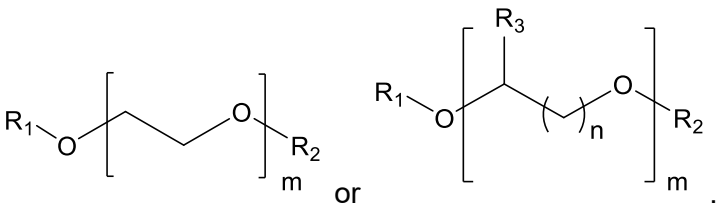
the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

wherein the thermal management fluid has a flash point of at least 100 °C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25 °C.

5. The method, battery system or thermal management circuit of any of claims 1-4, wherein each of the one or more compounds contains a total number of carbon atoms from 10 to 50 (e.g., from 10 to 40, from 10 to 30, from 10 to 20, from 16 to 50, from 16 to 40, from 16 to 30, from 16 to 20, from 18 to 50, from 18 to 40, from 18 to 30, from 18 to 22, from 18 to 20, from 20 to 50, from 20 to 40, or from 20 to 30); or wherein each of the one or more compounds contains a total number of carbon atoms from 12 to 22.

6. The method, battery system or thermal management circuit of any of claims 1-5, wherein n is an integer in the range of 5-12 (e.g., 5-10 or 5-8), and R_3 is H or C_1-C_8 alkyl (e.g., C_1-C_6 alkyl, or C_1-C_5 alkyl, or C_3-C_6 alkyl); or wherein n is an integer in the range of 1-4 (e.g., 1 or 2, or 1-3), and R_3 is H or C_1-C_8 alkyl (e.g., C_4-C_8 alkyl, or C_5-C_8 alkyl, or C_6-C_8 alkyl).

7. The method, battery system or thermal management circuit of claim 6, wherein each of R_4, R_5, and R_6 is H, i.e., the compounds have the formula



.

8. The method, battery system or thermal management circuit of any of claims 1-5, wherein n is 1, and R_3 is R_7O-$(CH_2)_{0-1}$- (e.g., R_7O-CH_2-), preferably wherein each of R_4, R_5, and R_6 is H.

9. The method, battery system or thermal management circuit of any of claims 1-5, wherein n is 2, and one R_5 and one R_6 are independently R_7O-$(CH_2)_{0-1}$- (e.g., R_7O-CH_2-), preferably wherein R_3, R_4, one of R_5 and one of R_6 is independently H.

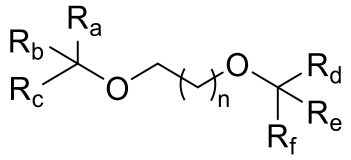
10. The method, battery system or thermal management circuit of any of claims 1-9, wherein

R_1 is C_3-C_5 alkyl, or R_1 is a branched C_1-C_5 alkyl, such as branched C_3-C_5 alkyl, or R_1 is -$C(R_a)(R_b)(R_c)$, wherein each of R_a, R_b, and R_c is independently methyl or ethyl; and/or

R_2 is C_3-C_5 alkyl, or R_2 is a branched C_1-C_5 alkyl, such as branched C_3-C_5 alkyl, or R_2 is -$C(R_a)(R_b)(R_c)$, wherein each of R_a, R_b, and R_c is independently methyl or ethyl; and/or

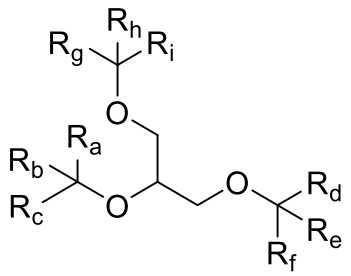
if present, R_7 is C_3-C_5 alkyl, or R_7 is a branched C_1-C_5 alkyl, such as branched C_3-C_5 alkyl, or R_7 is -$C(R_g)(R_h)(R_i)$, wherein each of R_g, R_h, and R_i is independently methyl or ethyl.

11. The method, battery system or thermal management circuit of any of claims 1-5, wherein the one or more compounds of formula (I) have the formula



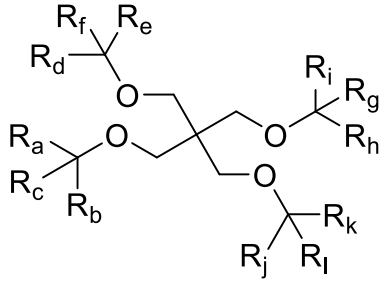
in which each of R_a and R_b is independently methyl, and each of R_c, R_d, R_e and R_f is independently methyl or ethyl;

wherein the one or more compounds of formula (I) have the formula



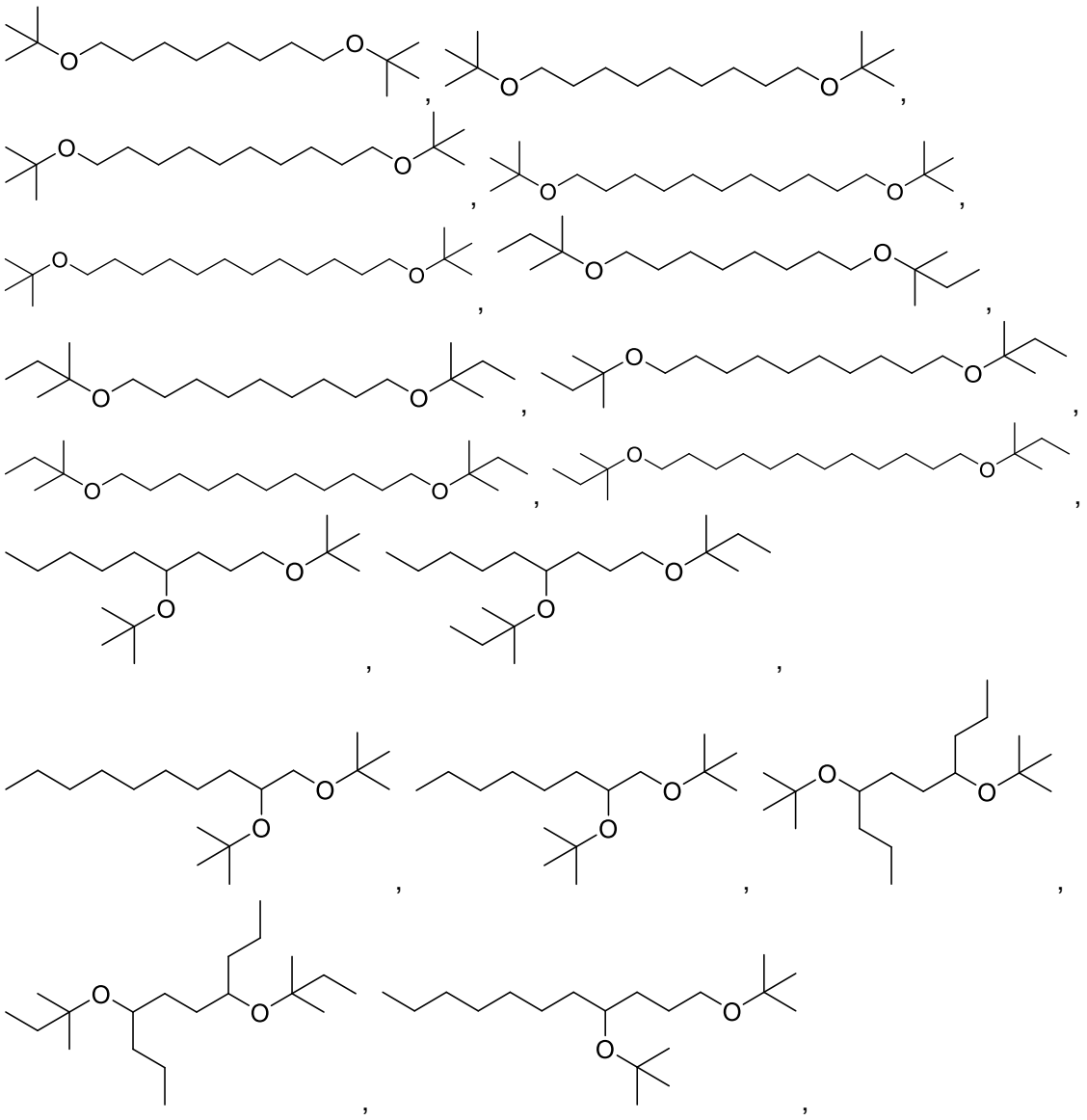
in which each of R_a, R_b, R_d, R_e, R_g and R_h is independently methyl, and each of R_c, R_f, and R_i is independently methyl or ethyl; and/or

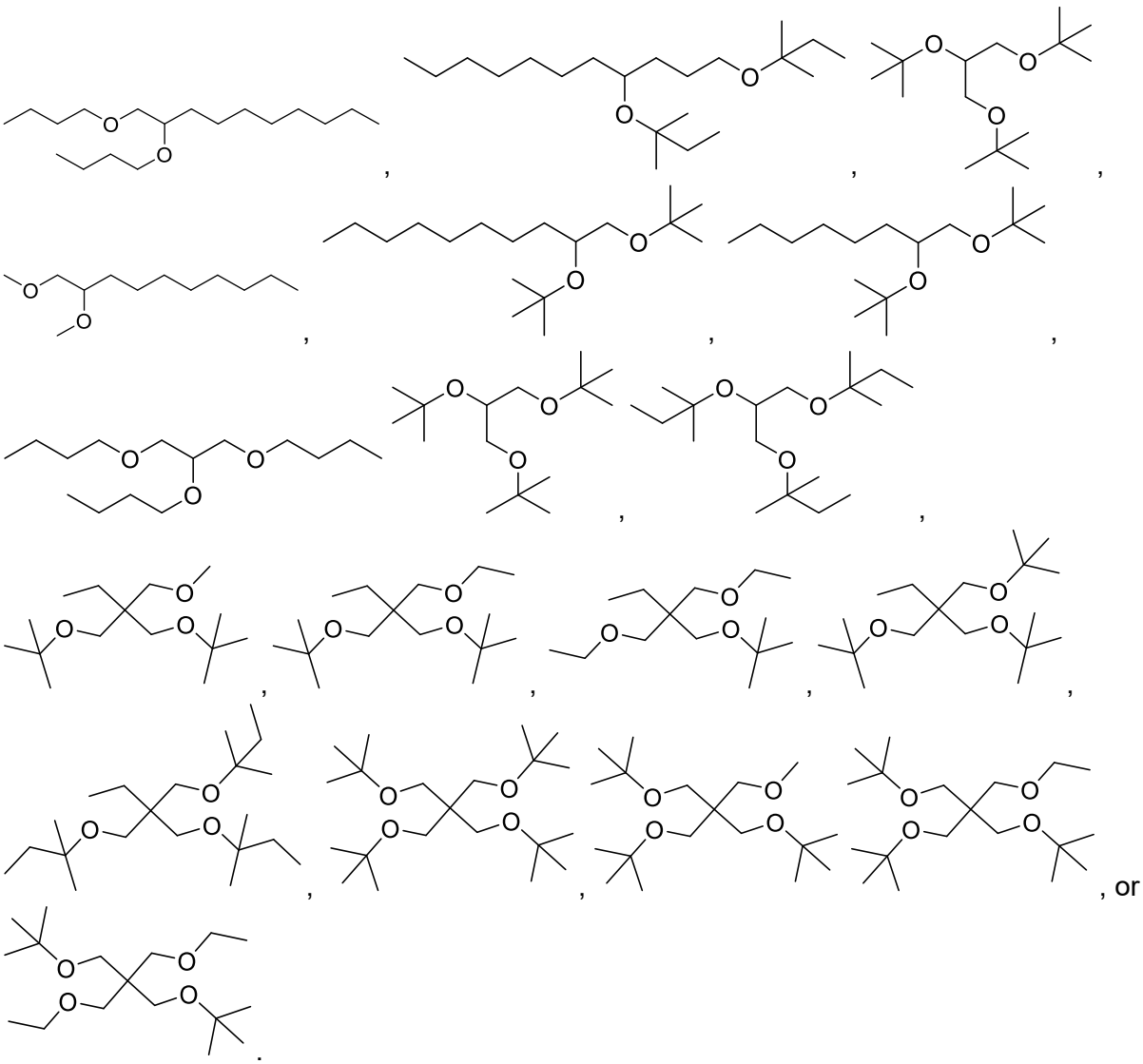
wherein the one or more compounds of formula (I) have the formula



in which each of R_a, R_b, R_d, R_e, R_g, R_h, R_e, R_j, and R_k is independently methyl, and each of R_c, R_f, R_i, and R_l is independently methyl or ethyl.

12. The method, battery system or thermal management circuit of any of claims 1-4, wherein the one or more dielectric compounds are independently selected from:

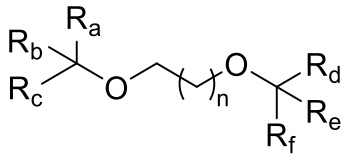




13. The method, battery system or thermal management circuit of any of claims 1-12, wherein the one or more dielectric compounds is present in an amount in the range of 50 wt% to 99.9 wt%, for example, 60 wt% to 99.9 wt%, or 70 wt% to 99.9 wt%, or 75 wt% to 99.9 wt%, or 80 wt% to 99.9 wt%, or 85 wt% to 99.9 wt%, or 90 wt% to 99.9 wt%, or 95 wt% to 99.9 wt%, or 98 wt% to 99.9 wt%.

14. The method, battery system or thermal management circuit of any of claims 1-13, wherein the thermal management fluid has a flash point of at least 100 °C, as measured in accordance with ASTM D93, and a kinematic viscosity at 40 °C in the range of 0.0000015 to 0.00002 m^2/s (1.5 to 20 cSt), as measured in accordance with ASTM D455.

15. A thermal management fluid comprising:
one or more compounds of formula (I) having the formula



wherein

n is an integer 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 ,11, or 12; and

each of R_a and R_b is independently methyl, and each of R_c, R_d, R_e, and R_f is independently methyl or ethyl;

the one or more dielectric compounds being present in a total amount in the range of 1 wt% to 100 wt%, based on the total weight of the thermal management fluid; and

wherein the thermal management fluid has a flash point of at least 100 °C, measured in accordance with ASTM D93, and the thermal management fluid has a dielectric constant of at least 1.5 at 25 °C.