C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present are each independently H, C_{1-30} alkyl, or C_3 to C_{30} alkenyl.

[0006b] In another aspect, the present disclosure refers to a macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene), comprising (a) alkane repeating units have the structure -RHC-CHR- and, optionally, (b) alkene repeating units have the structure -RC=CR- or–C(=CR_2)-, where, (i) if -RC=CR- alkene repeating groups are present, the R of the -RC=CR-alkene repeating units are the same as the R units of at least one -RHC-CHR, and where R is independently: H; a substituted or unsubstituted C_1 to C_{30} alkyl, or,

(ii) when absent an alkene repeating unit the R of the –RHC-CHR- units is independently C_{1-3}, C_5, C_{8-12}, or C_{14-30}; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkane and/or cycloalkene where the alkylene portion of the cycloalkane and/or alkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present, are each independently H, C_{1-30} alkyl, C_3 to C_{30} alkenyl, or,

(iii) when -RC=CR- alkene repeating units are present and the poly(alkane-co-alkene) comprises exclusively one unsubstituted alkane repeating units, R of the alkane repeating units is independently C_{1-3}, C_5, C_{8-12}, or C_{14-30} alkyl and R of the alkene repeating units is independently C_{1-3}, C_5, C_{8-12}, or C_{14-30} alkyl; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkane and/or cycloalkene where the alkylene portion of the cycloalkane and/or alkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present, are each independently H, C_{1-30} alkyl, C_3 to C_{30} alkenyl, or

(iv) when a copolymer with –H_2C-CH_2- repeating units, the R of the -RC=CR-alkene repeating units or the –RHC-CHR- units independently is C_{1-3}, C_5, C_{8-12}, or C_{14-30}; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups

are combined as a C_8-C_{30} cycloalkane and/or cycloalkene where the alkylene portion of the cycloalkane and/or alkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present, are each independently H, C_{1-30} alkyl, C_3 to C_{30} alkenyl.

[0006c] In yet another aspect, the present disclosure refers to a method of forming a macrocyclic polyalkane or a macrocyclic poly(alkane-co-alkene) disclosed herein comprising:

reacting a macrocyclic polyalkene and hydrogen in the presence of a hydrogenation catalyst to form the polyalkane or poly(alkane-co-alkene); and

isolating the macrocyclic polyalkane or a macrocyclic poly(alkane-co-alkene).

[0006d] In a further aspect, the present disclosure refers to a method of forming a macrocyclic polyalkane or a macrocyclic poly(alkane-co-alkene) disclosed herein comprising:

reacting a macrocyclic poly(cycloalkene) with an excess of an alkene and an olefin metathesis catalyst thereby forming a macrocyclic poly(alkane-co-alkene) comprising vicinal $–C(=CR_2)-$ groups; and

optionally isolating the macrocyclic polyalkane or the macrocyclic poly(alkane-co-alkene) comprising –C(=CR_2)- groups.

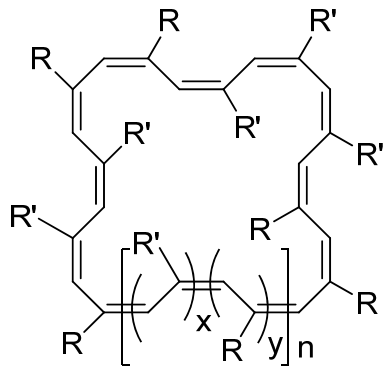
[0007] Provided herein are macrocyclic polyalkene copolymers that are a conjugated polyalkene having no chain ends and in the form of a macrocycle, comprising at least two different repeating units have the structure -RC=CR-. The R groups are independently: H; a substituted or unsubstituted C_1 to C_{30} alkyl, provided that when all R are an unsubstituted C_1 to C_{30} alkyl, at least one R is not a C_4, C_6, C_7, or C_{13} alkyl; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkene where the alkylene portion of the cycloalkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R'

CLAIMS

What is claimed is:

1. A conjugated macrocyclic polyalkene copolymer, comprising a fully conjugated polyalkene having no chain ends and in the form of a macrocycle, comprising at least two different repeating units have the structure -RC=CR- where R is independently: H; a substituted or unsubstituted C_1 to C_{30} alkyl, provided that when all R are an unsubstituted C_1 to C_{30} alkyl, at least one R is not a C_4, C_6, C_7, or C_{13} alkyl; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkene where the alkylene portion of the cycloalkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present are each independently H, $C_{1\text{-}30}$ alkyl, or C_3 to C_{30} alkenyl.

2. The macrocyclic polyalkene copolymer according to claim 1, having a structure of:



wherein R and R' in the structure are each independently an R as defined in claim 1, and each of n, x, and y is independently an integer of 1 to 100.

3. The macrocyclic polyalkene copolymer according to claim 2, wherein each of n, x, and y is independently an integer of 1 to 50.

4. The macrocyclic polyalkene copolymer according to claim 2 or 3, wherein each of n, x, and y is independently an integer of 1 to 25.

5. The macrocyclic polyalkene copolymer according to any one of claims 1 to 4, wherein at least one R is substituted C_1 to C_{30} alkyl, substituted C_3 to C_{30} alkenyl, which is substituted with hydroxy, C_2-C_{30} alkoxy, C_6-C_{14} aryloxy, C_7-C_{30} arylalkyloxy, C_2-C_{30} alkenyloxy, C_2-C_{30} alkynyloxy, C_8-C_{30} arylalkenyloxy, C_8-C_{30} arylalkynyloxy, CO_2H, C_2-C_{30} alkylester, C_7-C_{15} arylester, C_8-C_{30} alkylarylester, C_3-C_{30} alkenylester, NH_2, C_3-C_{30} alkylamino, C_6-C_{14} arylamino, C_7-C_{30} (arylalkyl)amino, C_3-C_{30} alkenylamino, C_3-C_{30} alkynylamino, C_8-C_{30} (arylalkenyl)amino, C_8-C_{30} (arylalkynyl)amino,C_3-C_{30} dialkylamino, C_{12}-C_{28} diarylamino, C_4-C_{30} dialkenylamino, C_4-C_{30} dialkynylamino, C_7-C_{30} aryl(alkyl)amino, C_7-C_{30} di(arylalkyl)amino, C_8-C_{30} alkyl(arylalkyl)amino, C_{15}-C_{30} aryl(arylalkyl)amino, C_8-C_{30} alkenyl(aryl)amino, C_8-C_{30} alkynyl(aryl)amino, $C(O)NH_2$, C_2-C_{30} alkylamido, C_7-C_{14} arylamido, C_8-C_{30} (arylalkyl)amido, C_2-C_{30} dialkylamido, C_{12}-C_{28} diarylamido, C_8-C_{30} aryl(alkyl)amido, C_{15}-C_{30} di(arylalkyl)amido, C_9-C_{30} alkyl(arylalkyl)amido, C_{16}-C_{30} aryl(arylalkyl)amido, thiol, C_2-C_{30} hydroxyalkyl, C_6-C_{14} hydroxyaryl, C_7-C_{30} hydroxyarylalkyl, C_3-C_{30} hydroxyalkenyl, C_3-C_{30} hydroxyalkynyl, C_8-C_{30} hydroxyarylalkenyl, C_8-C_{30} hydroxyarylalkynyl, C_3-C_{30} polyether, C_3-C_{30} polyetherester, C_3-C_{30} polyester, C_3-C_{30} polyamino, C_3-C_{30} polyaminoamido, C_3-C_{30} polyaminoether, C_3-C_{30} polyaminoester, or C_3-C_{30} polyamidoester.

6. The macrocyclic polyalkene copolymer according to any one of claims 1 to 4, wherein each R is independently: H; a substituted or unsubstituted C_1 to C_{30} alkyl; or a substituted or unsubstituted C_3 to C_{30} alkenyl.

7. The macrocyclic polyalkene copolymer according to any one of claims 1 to 4, wherein each R is independently H or a substituted or unsubstituted $C_{1\text{-}3}$, C_5, $C_{8\text{-}12}$, or $C_{14\text{-}30}$ alkyl.

8. A macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene), comprising:

(a) alkane repeating units have the structure -RHC-CHR- and,

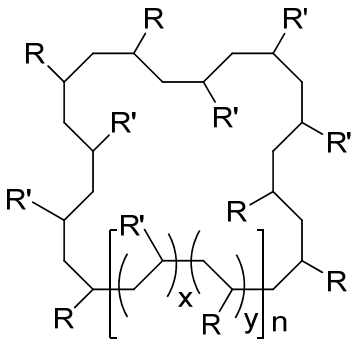
optionally, (b) alkene repeating units have the structure -RC=CR- or–C(=CR_2)-,

where, (i) if -RC=CR- alkene repeating groups are present, the R of the -RC=CR- alkene repeating units are the same as the R units of at least one -RHC-CHR-, and where R is independently: H; a substituted or unsubstituted C_1 to C_{30} alkyl, or,

(ii) when absent an alkene repeating unit the R of the –RHC-CHR- units is independently C_{1-3}, C_5, C_{8-12}, or C_{14-30}; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkane and/or cycloalkene where the alkylene portion of the cycloalkane and/or alkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present, are each independently H, C_{1-30} alkyl, C_3 to C_{30} alkenyl, or,

(iii) when -RC=CR- alkene repeating units are present and the poly(alkane-co-alkene) comprises exclusively one unsubstituted alkane repeating units, R of the alkane repeating units is independently C_{1-3}, C_5, C_{8-12}, or C_{14-30} alkyl and R of the alkene repeating units is independently C_{1-3}, C_5, C_{8-12}, or C_{14-30} alkyl; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkane and/or cycloalkene where the alkylene portion of the cycloalkane and/or alkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present, are each independently H, C_{1-30} alkyl, C_3 to C_{30} alkenyl, or

(iv) when a copolymer with –H_2C-CH_2- repeating units, the R of the -RC=CR- alkene repeating units or the –RHC-CHR- units independently is C_{1-3}, C_5, C_{8-12}, or C_{14-30}; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkane and/or cycloalkene where the alkylene portion of the cycloalkane and/or alkene is substituted or unsubstituted and/or interrupted one or more times with O, NR', C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present, are each independently H, C_{1-30} alkyl, C_3 to C_{30} alkenyl.

9. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to claim 8, having a structure of 

, wherein R and R' in the structure are each independently C_{1-3}, C_5, C_{8-12}, or C_{14-30}; substituted or unsubstituted C_3 to C_{30} alkenyl having one or more alkene bonds where a plurality of alkene bonds can be non-conjugated, conjugated, or a mixture thereof; or where two R groups are combined as a C_8-C_{30} cycloalkane and/or cycloalkene where the alkylene portion of the cycloalkane and/or alkene is substituted or unsubstituted and/or interrupted one or more times with O, NR", C(O), C(O)O, and/or C(O)NR", where R' and/or R", when present, are each independently H, C_{1-30} alkyl, C_3 to C_{30} alkenyl,, and each of n, x, and y is an integer of 1 to 100.

10. The macrocyclic polyalkene copolymer according to claim 9, wherein each of n, x, and y is independently an integer of 1 to 50.

11. The macrocyclic polyalkene copolymer according to claim 9 or 10, wherein each of n, x, and y is independently an integer of 1 to 25.

12. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 11, wherein at least one R is substituted C_1 to C_{30} alkyl, or substituted C_3 to C_{30} alkenyl, which is substituted singularly or plurally and each substitution is independently hydroxy, C_2-C_{30} alkoxy, C_6-C_{14} aryloxy, C_7-C_{30} arylalkyloxy, C_2-C_{30} alkenyloxy, C_2-C_{30} alkynyloxy, C_8-C_{30} arylalkenyloxy, C_8-C_{30} arylalkynyloxy, CO_2H, C_2-C_{30} alkylester, C_7-C_{15} arylester, C_8-C_{30} alkylarylester, C_3-C_{30} alkenylester, NH_2, C_3-C_{30} alkylamino, C_6-C_{14} arylamino, C_7-C_{30} (arylalkyl)amino, C_3-C_{30} alkenylamino, C_3-C_{30} alkynylamino, C_8-C_{30} (arylalkenyl)amino, C_8-C_{30} (arylalkynyl)amino,C_3-C_{30} dialkylamino, C_{12}-C_{28} diarylamino, C_4-C_{30} dialkenylamino, C_4-C_{30} dialkynylamino, C_7-C_{30} aryl(alkyl)amino, C_7-C_{30} di(arylalkyl)amino, C_8-C_{30} alkyl(arylalkyl)amino, C_{15}-C_{30} aryl(arylalkyl)amino, C_8-C_{30} alkenyl(aryl)amino, C_8-C_{30} alkynyl(aryl)amino, $C(O)NH_2$, C_2-C_{30} alkylamido, C_7-C_{14}

arylamido, C_8-C_{30} (arylalkyl)amido, C_2-C_{30} dialkylamido, C_{12}-C_{28} diarylamido, C_8-C_{30} aryl(alkyl)amido, C_{15}-C_{30} di(arylalkyl)amido, C_9-C_{30} alkyl(arylalkyl)amido, C_{16}-C_{30} aryl(arylalkyl)amido, thiol, C_2-C_{30} hydroxyalkyl, C_6-C_{14} hydroxyaryl, C_7-C_{30} hydroxyarylalkyl, C_3-C_{30} hydroxyalkenyl, C_3-C_{30} hydroxyalkynyl, C_8-C_{30} hydroxyarylalkenyl, C_8-C_{30} hydroxyarylalkynyl, C_3-C_{30} polyether, C_3-C_{30} polyetherester, C_3-C_{30} polyester, C_3-C_{30} polyamino, C_3-C_{30} polyaminoamido, C_3-C_{30} polyaminoether, C_3-C_{30} polyaminoester, C_3-C_{30} polyamidoester.

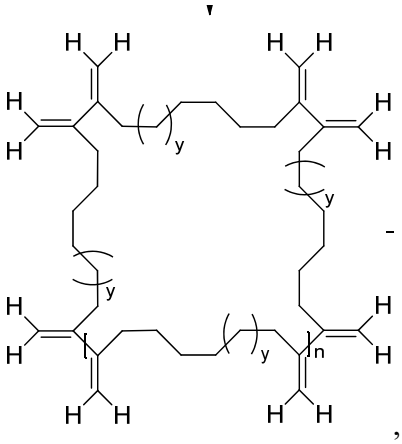
13. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 11, wherein each R is independently: H; a substituted or unsubstituted C_1 to C_{30} alkyl; or a substituted or unsubstituted C_3 to C_{30} alkenyl; provided that when all R are an unsubstituted C_1 to C_{30} alkyl, at least one R is not a C_4, C_6, C_7, or C_{13} alkyl.

14. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 11, wherein each R is independently H or a substituted or unsubstituted C_{1-3}, C_5, C_{8-12}, or C_{14-30} alkyl.

15. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 11, wherein the macrocyclic polyalkane has C_8-C_{30} cycloalkane repeating units.

16. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 11, wherein the macrocyclic polyalkane is macrocyclic polypropylene.

17. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 11, wherein the macrocyclic poly(alkane-co-alkene) comprises vicinal –C(=CR_2)- groups.

18. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to claim 17, having a structure , wherein the H atoms depicted in the structure can be H or another R group as defined in claim 8, and each of n and y is an integer of 1 to 100.

19. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to claim 18, wherein each y is independently an integer of 1 to 20 and n is an integer of 1 to 50.

20. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to claim 18 or claim 19, wherein each y is independently an integer of 1 to 10 and n is an integer of 1 to 25.

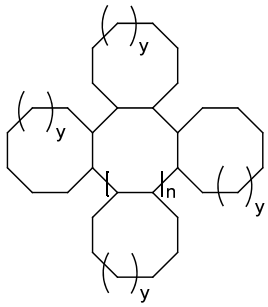
21. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 18 to 20, wherein each y is independently an integer of 1 to 5 and n is an integer of 1 to 10.

22. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 21, wherein the macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) comprises vicinal –C(CHR_2)- groups.

23. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 18 to 22, wherein each R is independently: H; a substituted or unsubstituted C_1 to C_{30} alkyl; or a substituted or unsubstituted C_3 to C_{30} alkenyl.

24. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 18 to 22, wherein each R is independently H or a substituted or unsubstituted C_{1-3}, C_5, C_{8-12}, or C_{14-30} alkyl.

25. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 18 to 22, wherein the macrocyclic polyalkane has C_8-C_{30} cycloalkane repeating units in the polymer backbone.

26. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to claim 25 having a structure: 

, wherein each y and n are independently integers from 1 to 100.

27. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to claim 26, wherein each y is independently an integer of 1 to 20 and n is an integer of 1 to 50.

28. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to claim 26 or claim 27, wherein each y is independently an integer of 1 to 10 and n is an integer of 1 to 25.

29. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 26 to 28, wherein each y is independently an integer of 1 to 5 and n is an integer of 1 to 10.

30. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 24, further comprising C=C bridges between a plurality of macrocyclic poly(alkane-co-alkene)s to form a poly(macrocyclic poly(alkane-co-alkene)).

31. The macrocyclic polyalkane or macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 24, further comprising one or more C=C bridges between alkene repeating units of the macrocyclic poly(alkane-co-alkene)s, in the form of bi-macrocyclic, tri-macrocyclic and/or multi-macrocyclic poly(alkane-co-alkene)s.

32. A method of forming a macrocyclic polyalkane or a macrocyclic poly(alkane-co-alkene) according to any one of claims 8 to 31 comprising:

reacting a macrocyclic polyalkene and hydrogen in the presence of a hydrogenation catalyst to form the polyalkane or poly(alkane-co-alkene); and

isolating the macrocyclic polyalkane or a macrocyclic poly(alkane-co-alkene).

33. The method of claim 32, wherein the hydrogen is provided in an amount of at least a molar equivalent of the macrocyclic polyalkene, thereby forming a polyalkane.

34. The method of claim 32, wherein the hydrogen is provided in an amount of less than a molar equivalent of the macrocyclic polyalkene, thereby forming a poly(alkane-co-alkene).

35. A method of forming a macrocyclic polyalkane or a macrocyclic poly(alkane-co-alkene) according to any one of claims 17 to 24 comprising:

reacting a macrocyclic poly(cycloalkene) with an excess of an alkene and an olefin metathesis catalyst thereby forming a macrocyclic poly(alkane-co-alkene) comprising vicinal $–C(=CR_2)-$ groups; and

optionally isolating the macrocyclic polyalkane or the macrocyclic poly(alkane-co-alkene) comprising $–C(=CR_2)-$ groups.

36. The method of claim 35, further comprising:

reacting the macrocyclic poly(alkane-co-alkene) comprising vicinal $–C(=CR_2)-$ groups and hydrogen in the presence of a hydrogenation catalyst thereby forming a macrocyclic polyalkane or a macrocyclic poly(alkane-co-alkene) comprising isolated $–C(C=CR_2)$ groups; and

optionally isolating the macrocyclic polyalkane or the macrocyclic poly(alkane-co-alkene) comprising isolated $–C(=CR_2)-$ groups.

37. The method according to claim 36, further comprising:

combining the macrocyclic poly(alkane-co-alkene) comprising isolated –C(=CR_2)- groups with an olefin metathesis catalyst; and

condensing isolated –C(=CR_2)- groups to form a poly(macrocyclic poly(alkane-co-alkene)) comprising C=C links between macrocyclic poly(alkane-co-alkene) repeating units to form a poly(macrocyclic poly(alkane-co-alkene)); and

optionally isolating the poly(macrocyclic poly(alkane-co-alkene)).

38. The method according to claim 37, further comprising:

combining the poly(macrocyclic poly(alkane-co-alkene)) with hydrogen in the presence of a hydrogenation catalyst, thereby

hydrogenating the poly(macrocyclic poly(alkane-co-alkene)) to form a poly(macrocyclic poly(alkane)).

39. The method according to claim 36, further comprising:

combining a dilute solution of the macrocyclic poly(alkane-co-alkene) comprising isolated –C(=CR_2)- groups with an olefin metathesis catalyst; and

condensing isolated –C(=CR_2)- groups to form bi-macrocyclic, tri-macrocyclic and/or multi-macrocyclic poly(alkane-co-alkene)s.

40. The method according to claim 39, further comprising:

combining the bi-macrocyclic, tri-macrocyclic and/or multi-macrocyclic poly(alkane-co-alkene)s with hydrogen in the presence of a hydrogenation catalyst, thereby hydrogenating the bi-macrocyclic, tri-macrocyclic and/or multi-macrocyclic poly(alkane-co-alkene)s to form bi-macrocyclic, tri-macrocyclic and/or multi-macrocyclic poly(alkane)s.