CLAIMS

1. A method of making a crosslinked alkoxysilyl polynorbornene homopolymer comprising:

polymerizing a norbornene monomer comprising at least one alkoxysilyl moiety in the presence of a catalyst to produce an alkoxysilyl modified polynorbornene homopolymer, and

producing a crosslinked alkoxysilyl polynorbornene homopolymer through sol-gel initiated crosslinking of the alkoxysilyl modified polynorbornene homopolymer at ambient conditions, acid-catalyzed, or base-catalyzed conditions.

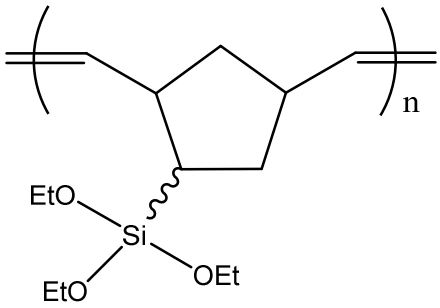
2. The method of claim 1, where the polymerizing step comprises an addition polymerization process, which utilizes a transition metal catalyst.

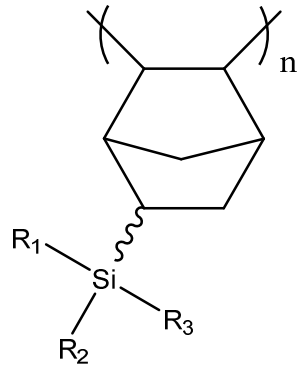
3. The method of claim 2, where the transition metal catalyst comprises a palladium metallocene derivative catalyst, and optionally at least one of a trityl borate, a phosphine, or combinations thereof.

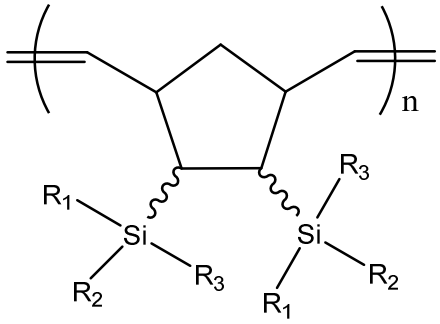
4. The method of claim 1, where the polymerizing step comprises a ring opening metathesis polymerizing (ROMP) process, which utilizes a Grubbs 1st Generation catalyst, or any later generation of Grubbs catalyst.

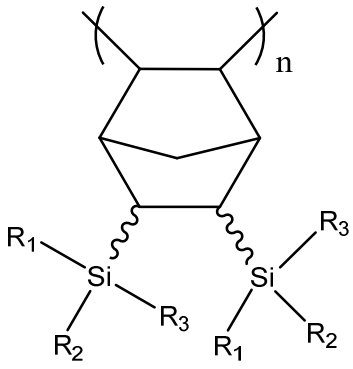
5. The method of claim 1, where the alkoxysilyl moiety includes from one to eighteen alkoxy groups.

6. The method of claim 1, where the crosslinked alkoxysilyl polynorbornene homopolymer has either of the following structures:









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where R1 is an alkyl, an alkoxy, or alkoxysiloxane, R2 is an alkyl, an alkoxy, or alkoxysiloxane, R3 is an alkyl, an alkoxy, or alkoxysiloxane, and n is at least one, where at least one of R1, R2, and R3, is an alkoxy or alkoxysiloxane.

7. The method of claim 6 where at least two of R1, R2, and R3 is an alkoxy or an alkoxysiloxane, where at least two alkoxys are the same or a different moiety.

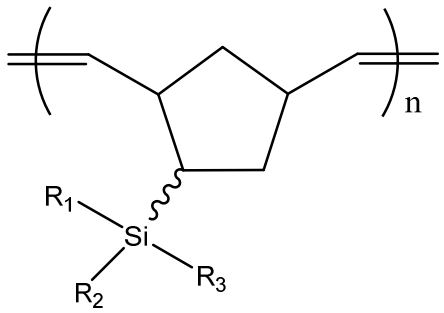
8. The method of claim 1 where the norbornene monomer comprises methyldiethoxysilylnorbornene, dimethylethoxysilylnorbornene, or triethoxysilylnorbornene.

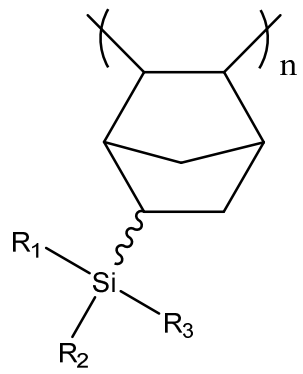
9. The method claim 1, where the sol-gel initiated crosslinking involves hydrolysis in water or exposure to the atmosphere.

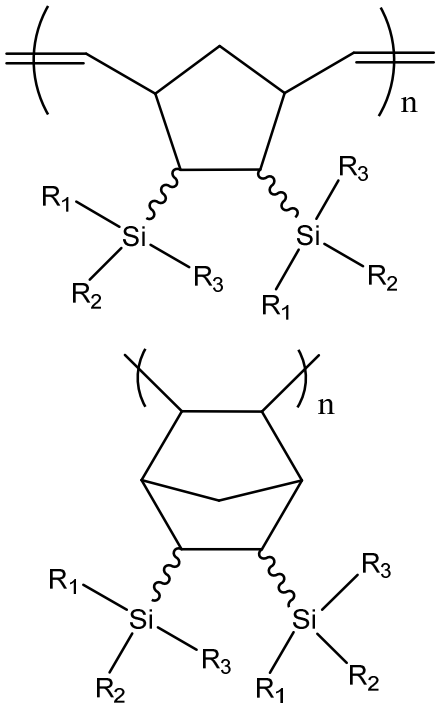
10. The method claim 9, where the sol-gel initiated crosslinking is acid or base catalyzed.

11. The method of claim 1, where the degree of cross-linking is measured by gel content, and has about 10% to about 100% gel content.

12. A formulation comprising a crosslinked alkoxysilyl polynorbornene homopolymer having any of the following structures:







where R1 is an alkyl, an alkoxy, or alkoxysiloxane, R2 is an alkyl, an alkoxy, or alkoxysiloxane, R3 is an alkyl, an alkoxy, or alkoxysiloxane, and n is at least one, where at least one of R1, R2, and R3, is an alkoxy or alkoxysiloxane; and

where the cross-linking is characterized by 10% to 100% by weight gel content.

13. The formulation according to claim 12 where the crosslinked alkoxysilyl polynorbornene homopolymer includes at least a first chain packing region, a second chain packing region, optionally a third packing region, and optionally a fourth packing region where the first chain packing region is defined by a first interchain distance, the second chain packing region is defined by a second interchain distance, the third chain packing region is defined by a third interchain distance, and the fourth chain packing region is defined by a fourth interchain distance, the first interchain distance being smaller than the second interchain distance, the third interchain distance being larger than the first interchain distance and second interchain distance, and the fourth interchain distance being smaller than the first, second, and third interchain distances, where the first interchain distance, the second interchain distance, the third interchain distance, and the fourth interchain distance are calculated from Bragg's Law for angle peaks measured by Wide Angle X-ray diffraction (WAXRD).

14. The formulation according to claim 12, where the crosslinked alkoxysilyl polynorbornene homopolymer comprises a molecular weight distribution (MWD) from 1 to 3, where MWD is defined as M_w/M_n with M_w being a weight average molecular weight and M_n being a number average molecular weight.

15. A natural gas separation membrane comprising the formulation of claim 12.