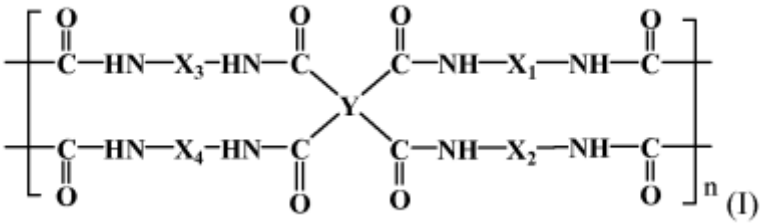
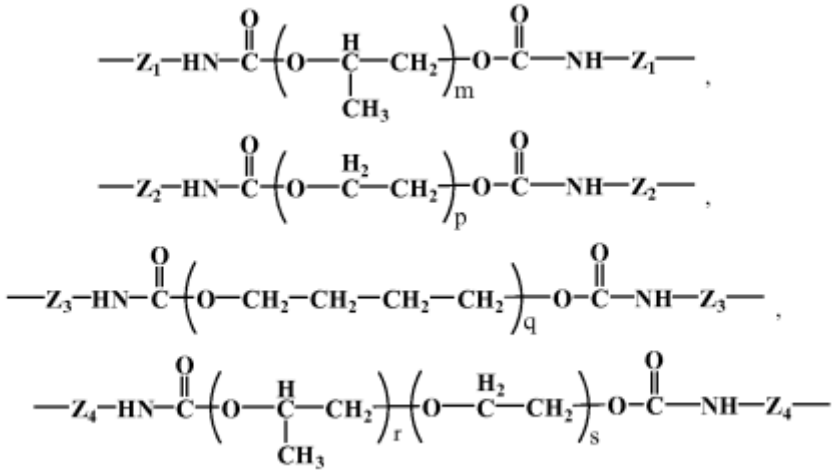
CLAIMS

1. A cross-linked rubbery polyurethane-ether polymeric membrane comprising a cross-linked rubbery polyurethane-ether polymer with a plurality of repeating units of a formula (I), wherein said formula (I) is represented by a structure comprising:

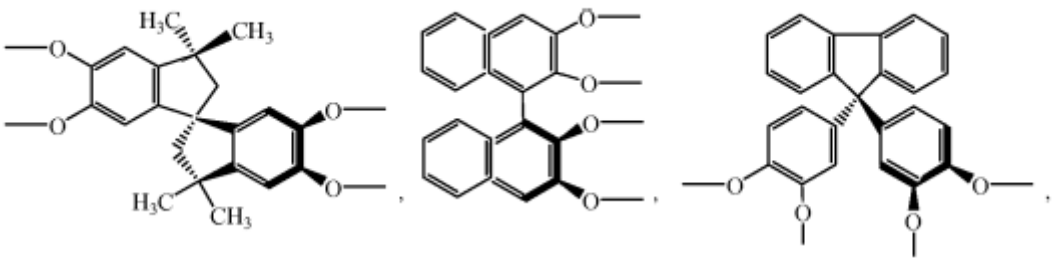


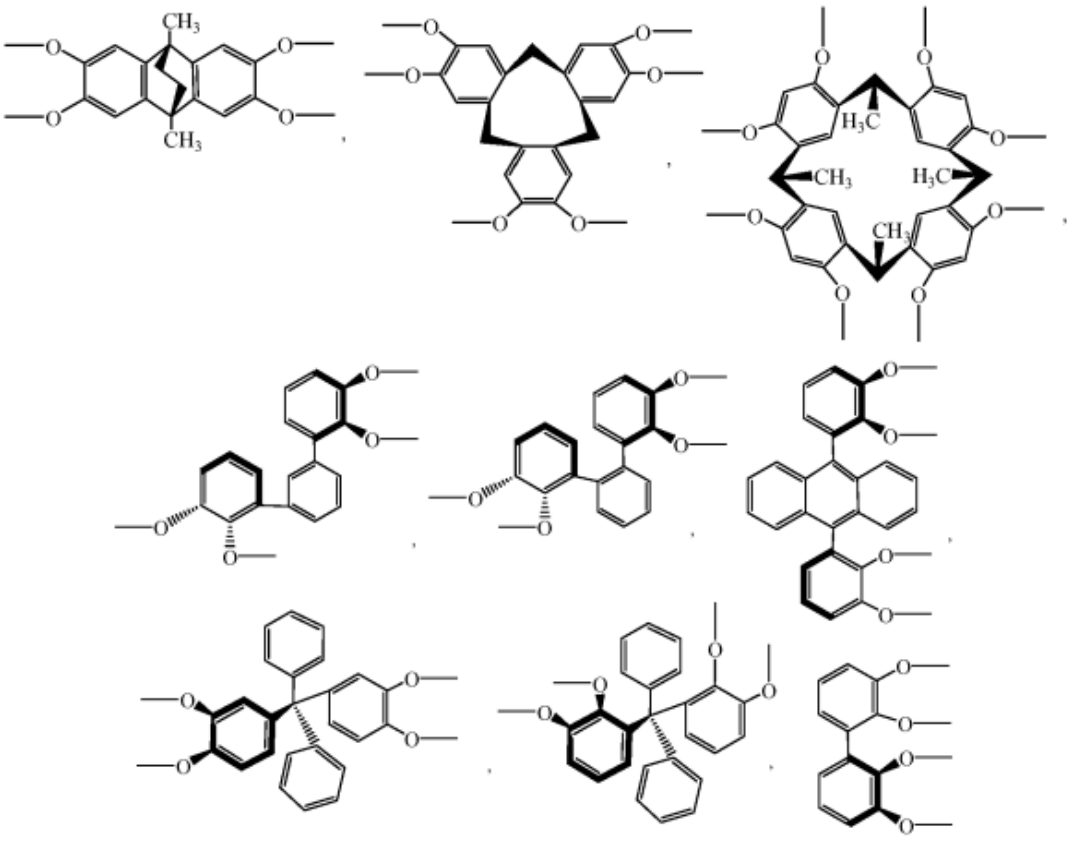
(I)

wherein X_1, X_2, X_3, and X_4 are selected from the group consisting of

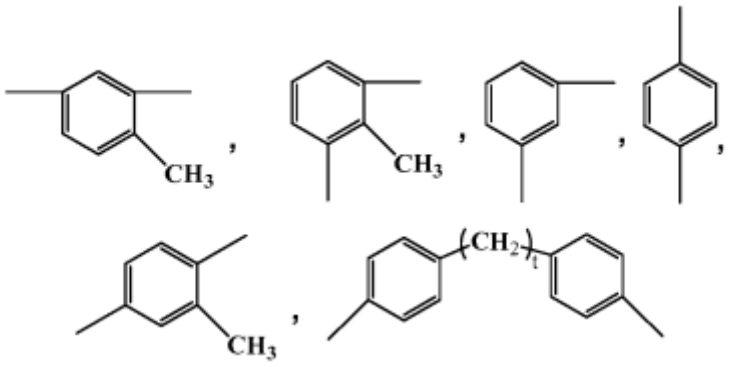


and mixtures thereof, respectively; X_1, X_2, X_3 and X_4 are the same or different from each other, wherein Y is selected from the group consisting of



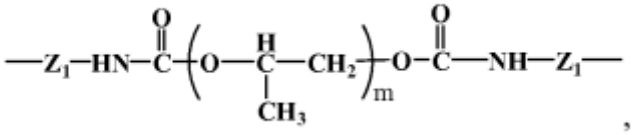


and mixtures thereof; wherein Z_1, Z_2, Z_3 and Z_4 are selected from the group consisting of

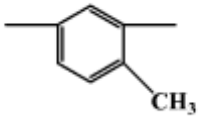


and mixtures thereof, respectively; Z_1, Z_2, Z_3 and Z_4 are the same or different from each other and t is 0 to 4; and wherein n, m, p, q, r, and s are independent integers from 2 to 500.

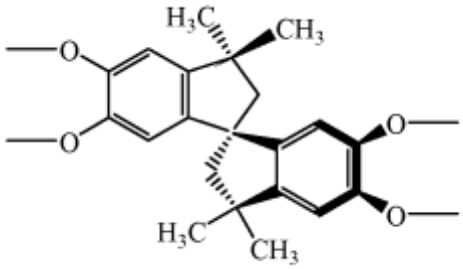
2. The membrane of claim 1 wherein X_1, X_2, X_3 and X_4 of formula (I) are the same and have a chemical structure comprising



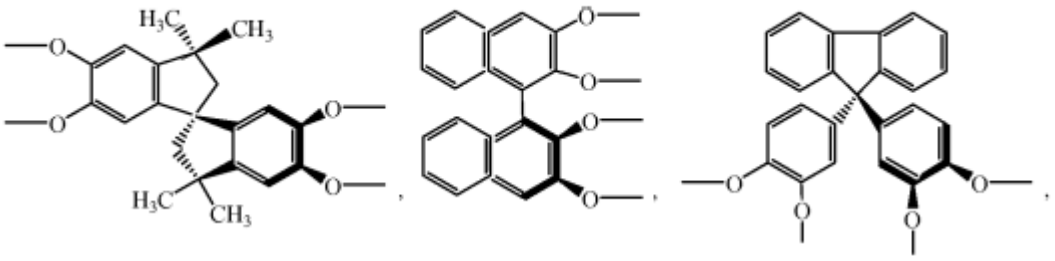
wherein Z_1 of X_1, X_2, X_3, and X_4 of formula (I) is

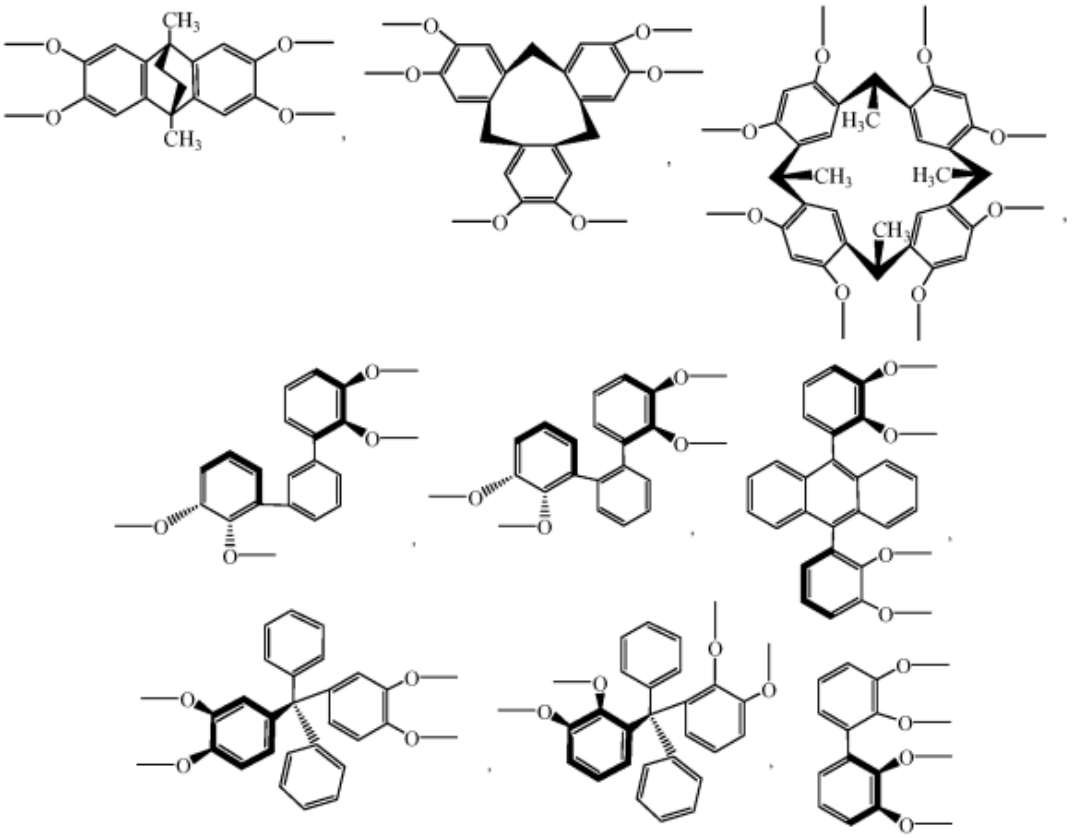


and wherein Y of formula (I) is



3. A method of making the cross-linked rubbery polyurethane-ether membrane of claim 1 comprising dissolving a diisocyanate-terminated polyether and a rigid cross-linking agent comprising at least four hydroxyl functional groups in a solvent to form a homogenous solution; 2) then heating the homogenous solution at a temperature of 30°C to 100°C for 0.5 to 12 hours to form a polyurethane-ether prepolymer solution; 3) coating a layer of the polyurethane-ether prepolymer solution on a porous membrane support; and 4)heating the coated membrane at a temperature of 30°C to 100°C for 0.5 to 12 hours to provide a thin selective layer comprising a cross-linked rubbery polyurethane-ether material on the porous membrane support, wherein the cross-linking agent is selected from the group consisting of

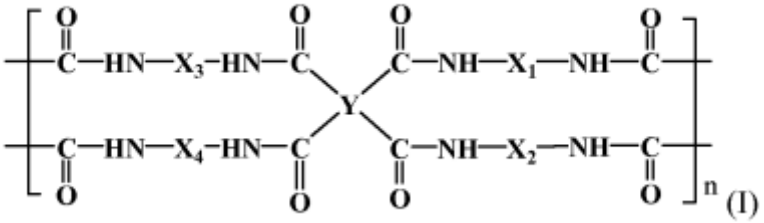




4. The method of claim 3 further comprising fabricating said cross-linked rubbery polyurethane-ether membrane into a sheet, disk, tube or hollow fiber.

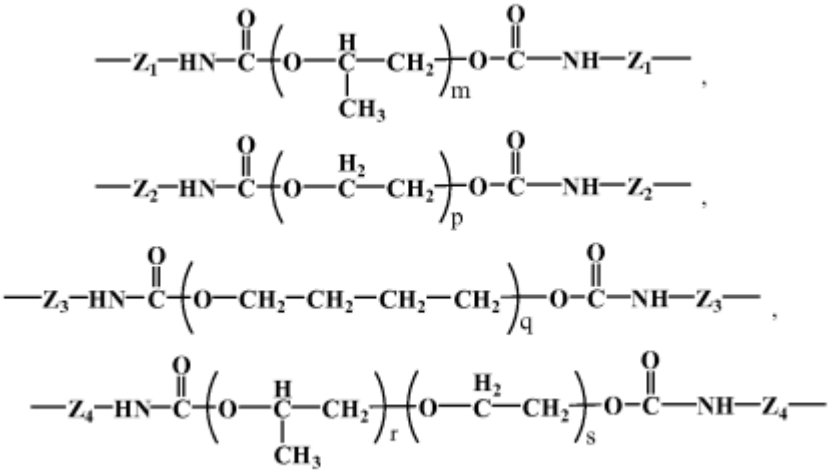
5. The method of claim 3 further comprising fabricating said cross-linked rubbery polyurethane-ether membranes into a thin film composite membrane incorporating a selective thin cross-linked rubbery polyurethane-ether layer and a porous supporting layer comprising a polymer material or an inorganic material.

6. A process for treating a fluid stream comprising contacting the fluid stream with a cross-linked rubbery polyurethane-ether polymer membrane having a plurality of repeating units of a formula (I), wherein said formula (I) is represented by a structure comprising:

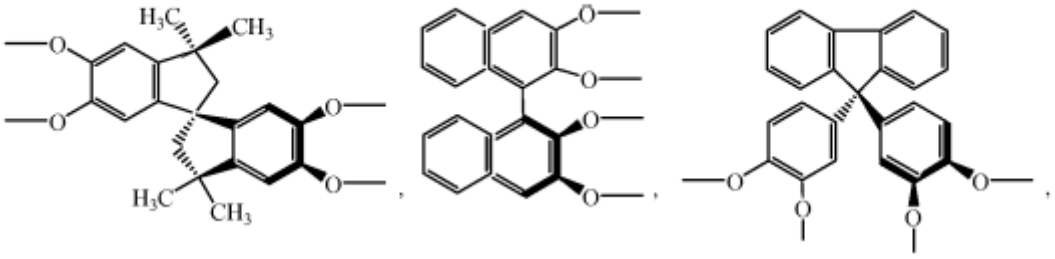


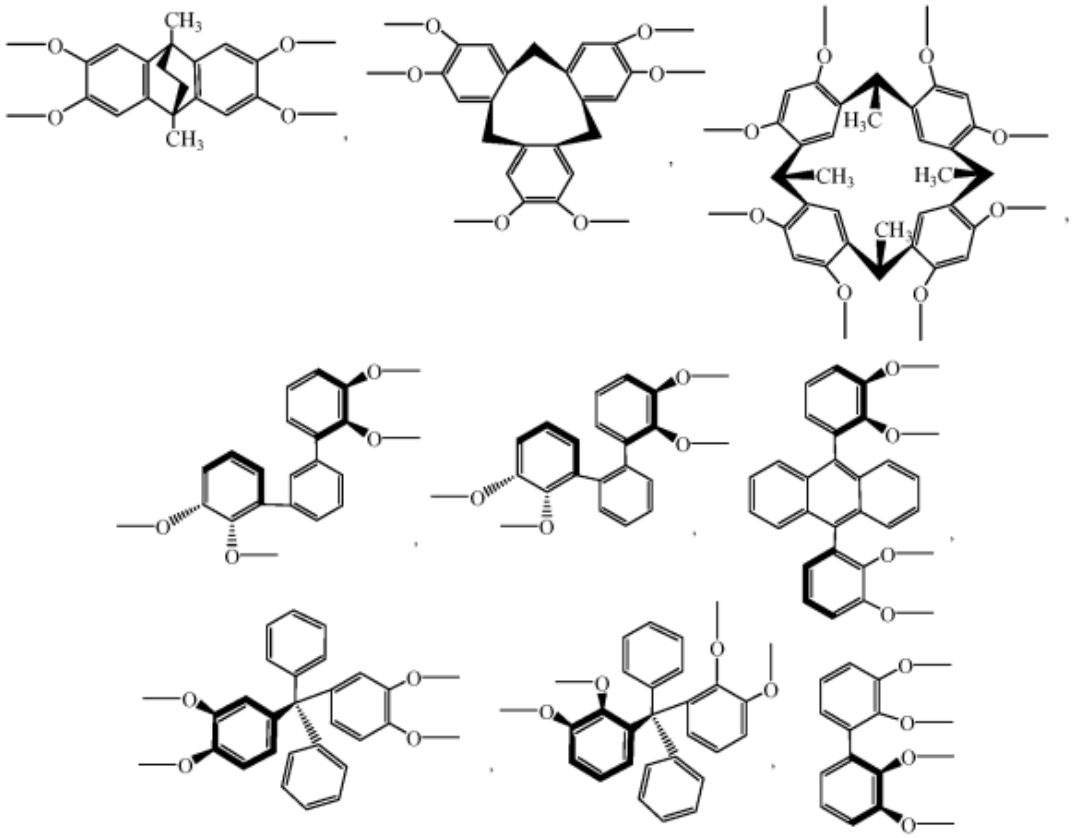
(I)

wherein X_1, X_2, X_3, and X_4 are selected from the group consisting of

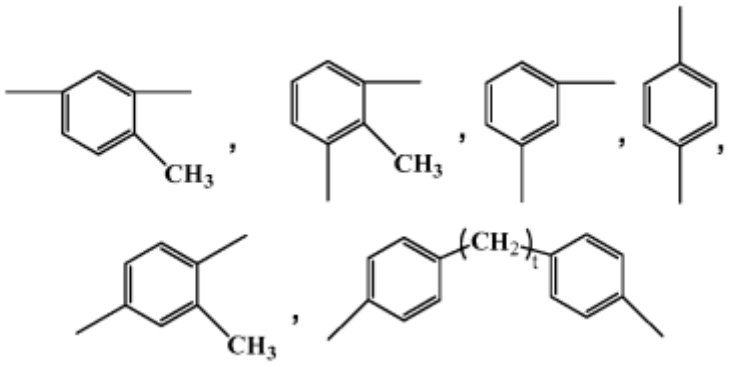


and mixtures thereof, respectively; X_1, X_2, X_3, and X_4 are the same or different from each other, wherein Y is selected from the group consisting of





and mixtures thereof; wherein Z_1, Z_2, Z_3, and Z_4 are selected from the group consisting of



and mixtures thereof, respectively; Z_1, Z_2, Z_3, and Z_4 are the same or different from each other and t is 0 to 4; and wherein n, m, p, q, r, and s are independent integers from 2 to 500 to produce a permeate stream and a retentate stream.

7. The process of claim 6 wherein said process for treating a fluid comprises removing C_3 to C_{35} hydrocarbons and carbon dioxide from natural gas.

8. The process of claim 6 wherein said permeate stream comprises propane, n-butane and other heavy hydrocarbons and said retentate stream comprises methane and ethane.

9. The process of claim 6 wherein said fluid stream is first sent through said cross-linked rubbery polyurethane-ether polymeric membrane and then is sent through a second membrane wherein said second membrane comprises a polymer selected from the group consisting of polysulfone, cellulose acetate, cellulose triacetate, polyamide, polyimide, polyketone, polyether ketone, and polyacrylonitrile.