CLAIMS

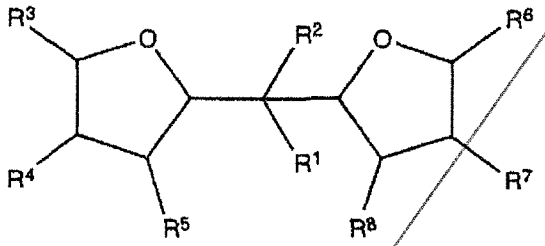
1. A process for polymerization of a polymer comprising monomeric units derived from a styrene monomer and a 1,3-butadiene monomer, the process comprising:

polymerizing the monomeric units in the presence of an initiator, a first polar agent, and a second polar agent;

wherein the first polar agent comprises a structure (I):

$$R^{1'}R^{2'}N\text{-}Q\text{-}NR^{3'}R^{4'} \quad (I);$$

wherein the second polar agent comprises a structure (II):



(II);

wherein $R^{1'}$, $R^{2'}$, $R^{3'}$, and $R^{4'}$ are each independently selected from the group consisting of an alkyl group and hydrogen;

wherein Q comprises an alkylene group;

wherein R^1 and R^2 are each independently an alkyl group; and

wherein R^3, R^4, R^5, R^6, R^7 and R^8 are each independently selected from the group consisting of an alkyl group and hydrogen.

2. The process as in claim 1 wherein $R^{1'}$, $R^{2'}$, $R^{3'}$, and $R^{4'}$ are each independently selected from the group consisting of hydrogen and a C_1-C_4 alkyl group.

3. The process as in any of the preceding claims wherein the alkylene group comprises a structure $-(CH_2)_n-$, wherein n is an integer equal to or greater than 2, preferably 2 or 3.

4. The process as in any of the preceding claims wherein R^1 and R^2 are

each independently a C^1-C^4 alkyl group, preferably methyl.

5. The process as in any of the preceding claims wherein R^3, R^4, R^5, R^6, R^7 and R^8 are each independently selected from the group consisting of hydrogen and a C^1-C^4 alkyl group.

6. The process as in any of the preceding claims wherein a molar ratio of the second polar agent to the first polar agent is between about 0.01 and about 10, preferably between about 0.1 and about 3, and more preferably between about 0.3 and about 1.

7. The process as in any of the preceding claims wherein the first polar agent comprises tetramethylethylenediamine.

8. The process as in any of the preceding claims wherein the second polar agent comprises ditetrahydrofurylpropane.

9. The process as in any of the preceding claims wherein the polymer comprises a styrene content from about 20 to about 80 weight percent, preferably from about 40 to about 70 weight percent, based on total weight of the polymer.

10. The process as in any of the preceding claims wherein the polymer comprises a vinyl content from about 30 to about 80 weight percent, preferably from about 40 to about 70 weight percent, based on total amount of polymerized 1,3-butadiene.

11. The process as in any of the preceding claims wherein the polymer has a molecular weight distribution from about 1.05 to about 1.8, preferably from about 1.1 to about 1.7, more preferably from about 1.2 to about 1.6.

12. The process as in any of the preceding claims wherein the polymer has

a number-average molecular weight greater than or equal to about 100,000 g/mole, preferably greater than or equal to about 150,000 g/mole, and more preferably greater than or equal to about 300,000 g/mole.

13. The process as in any of the preceding claims wherein the polymer has a weight-average molecular weight greater than or equal to about 180,000 g/mole, preferably greater than or equal to about 200,000 g/mole, and more preferably greater than or equal to about 360,000 g/mole.

14. The process as in any of the preceding claims wherein the polymer has only one glass transition temperature (Tg), which is preferably about -50 °C to about 20 °C and more preferably from about -30 °C to about 10°C.

15. The process as in any of the preceding claims wherein a molar ratio of the first polar agent to active initiator is greater than about 0.3, preferably greater than about 0.5, and more preferably greater than about 1.0.

16. The process as in any of the preceding claims wherein a molar ratio of the second polar agent to active initiator is greater than about 0.3, preferably greater than about 0.4, and more preferably greater than about 0.5.

17. The process as in any of the preceding claims wherein the polymerization is run at a temperature of between about 10 °C and about 80 °C, preferably between 20 °C and 75°C.

18. The process as in any of the preceding claims wherein the initiator comprises n-butyl lithium

19. The process as in any of the preceding claims wherein the polymerizing takes place in a hydrocarbon solvent.

20. A polymer formed by the process as in any of the preceding claims.

21. A composition comprising the polymer of claim 20.

22. An article comprising at least one component formed from the composition of claim 21.

23. A polymer having at least the following characteristics:

(a) a styrene content from about 40 to about 70 weight percent based on total polymer weight;

(b) a vinyl content from about 30 to about 80 weight percent, preferably from about 40 to about 70 weight percent, based on total amount of polymerized 1,3-butadiene; and

(c) a molecular weight distribution from about 1.05 to about 1.8.

Claims

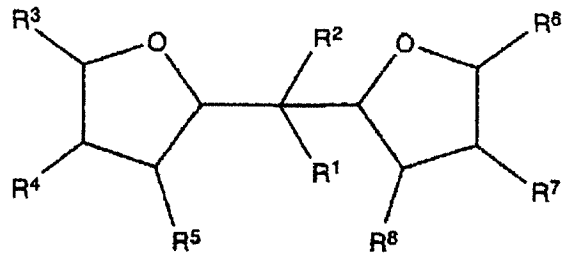
1. A process for polymerization of a polymer comprising monomeric units derived from a styrene monomer and a 1,3-butadiene monomer, the process comprising:

polymerizing the monomeric units in the presence of an initiator, a first polar agent, and a second polar agent;

wherein the first polar agent comprises a structure (I):

$R^{1'}R^{2'}N\text{-}Q\text{-}NR^{3'}R^{4'}$ (I);

wherein the second polar agent comprises a structure (II):



(II)

wherein $R^{1'}$, $R^{2'}$, $R^{3'}$, and $R^{4'}$ are each independently selected from the group consisting of an alkyl group and hydrogen;

wherein Q comprises an alkylene group;

wherein R^1 and R^2 are each independently an alkyl group; and wherein R^3, R^4, R^5, R^6, R^7 and R^8 are each independently selected from the group consisting of an alkyl group and hydrogen.

2. The process according to claim 1 wherein $R^{1'}$, $R^{2'}$, $R^{3'}$, and $R^{4'}$ are each independently selected from the group consisting of hydrogen and a C_1-C_4 alkyl group.

3. The process according to claim 1 or 2 wherein the alkylene group comprises a structure $-(CH_2)_n-$, wherein n is an integer equal to or greater than 2.

4. The process according to any one of claims 1 to 3 wherein R^1 and R^2 are each independently a C_1-C_4 alkyl group.

5. The process according to any one of claims 1 to 4 wherein R^3, R^4, R^5, R^6, R^7 and R^8 are each independently selected from the group consisting of hydrogen and a C_1-C_4 alkyl group.

6. The process according to any one of claims 1 to 5 wherein a molar ratio of the second polar agent to the first polar agent is between 0.01 and 10.

7. The process according to any one of claims 1 to 6 wherein the first polar agent comprises tetramethylethylenediamine.

8. The process according to any one of claims 1 to 7 wherein the second polar agent comprises ditetrahydrofurylpropane.

9. The process according to any one of claims 1 to 8 wherein the polymer comprises a styrene content from 20 to 80 weight percent, based on total weight of the polymer.

10. The process according to any one of claims 1 to 9 wherein the polymer comprises a vinyl content from 30 to 80 weight percent, based on total amount of polymerized 1,3-butadiene.

11. The process according to any one of claims 1 to 10 wherein the polymer has a molecular weight distribution from 1.05 to 1.8.

12. The process according to any one of claims 1 to 11 wherein the polymer has a number-average molecular weight greater than or equal to 100,000 g/mole.

13. The process according to any one of claims 1 to 12 wherein the polymer has a weight-average molecular weight greater than or equal to 180,000 g/mole.

14. The process according to any one of claims 1 to 13 wherein the polymer has only one glass transition temperature (Tg).

15. The process according to any one of claims 1 to 14 wherein a molar ratio of the first polar agent to active initiator is greater than 0.3.

16. The process according to any one of claims 1 to 15 wherein a molar ratio of the second polar agent to active initiator is greater than 0.3.

17. The process according to any one of claims 1 to 16 wherein the polymerization is run at a temperature of between 10 degree C and 80 degree C.

18. The process according to any one of claims 1 to 17 wherein the initiator comprises n-butyl lithium.

19. The process according to any one of claims 1 to 18 wherein the polymerizing takes place in a hydrocarbon solvent.

20. A polymer formed by the process according to any one of claims 1 to 19.

21. A composition comprising the polymer of claim 20.

22. An article comprising at least one component formed from the composition of claim 21.