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DESCRIPTION

TECHNICAL FIELD

[0001] The technical field relates to a polymer and a method for preparing the same.

BACKGROUND

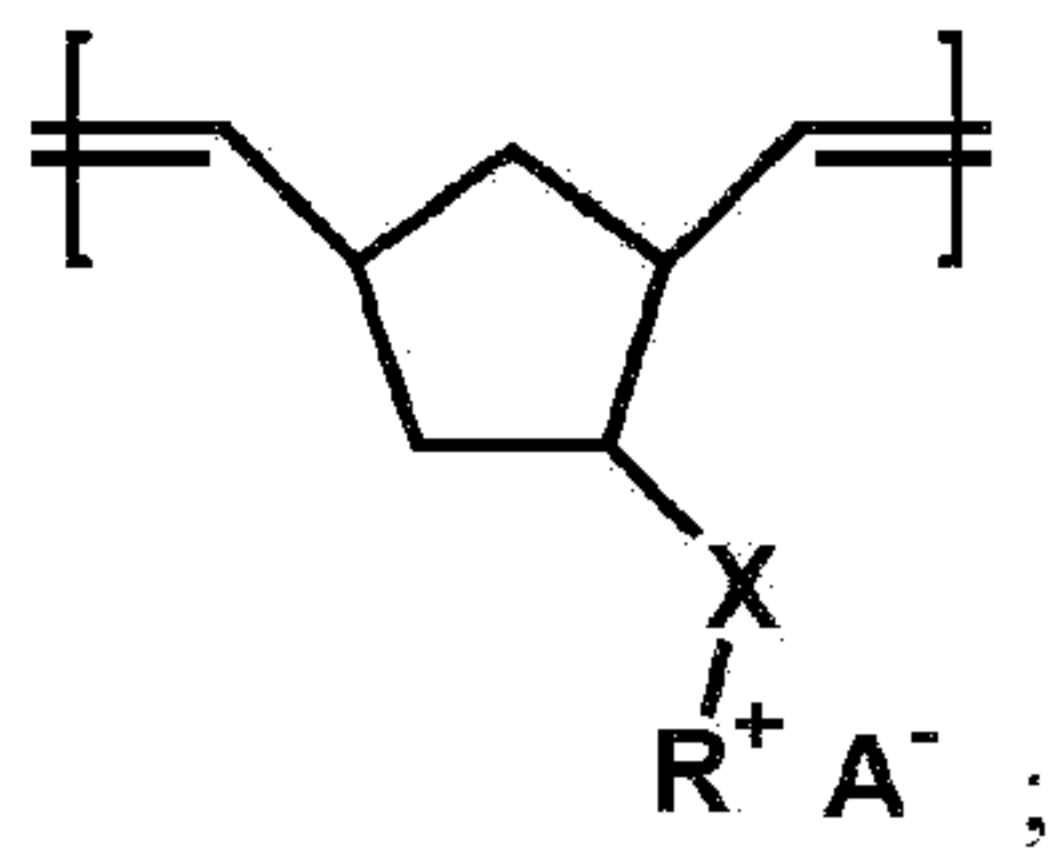
[0002] Ion exchange membranes are widely used in electro dialysis purification, fuel cells, electroplating, and the food industry.

[0003] An ion exchange membrane includes a polymer material having negatively charged groups or positively charged groups serving as the film body, and migratable cations or anions under electrical or chemical potential. A cation exchange membrane has negatively charged groups fixed on the polymer and migratable cations. Identically, an anion exchange membrane has positively charged groups fixed on the polymer and migratable cations. In general, the characteristics of the ion exchange membrane are determined by the number, type, and distribution of the fixed charged group. Anion exchange membranes made of conventional polymer material are not suitable for use in an ion exchange membrane fuel cell, due to the poor solubility, mechanical strength, and solvent selectivity of the conventional polymer material.

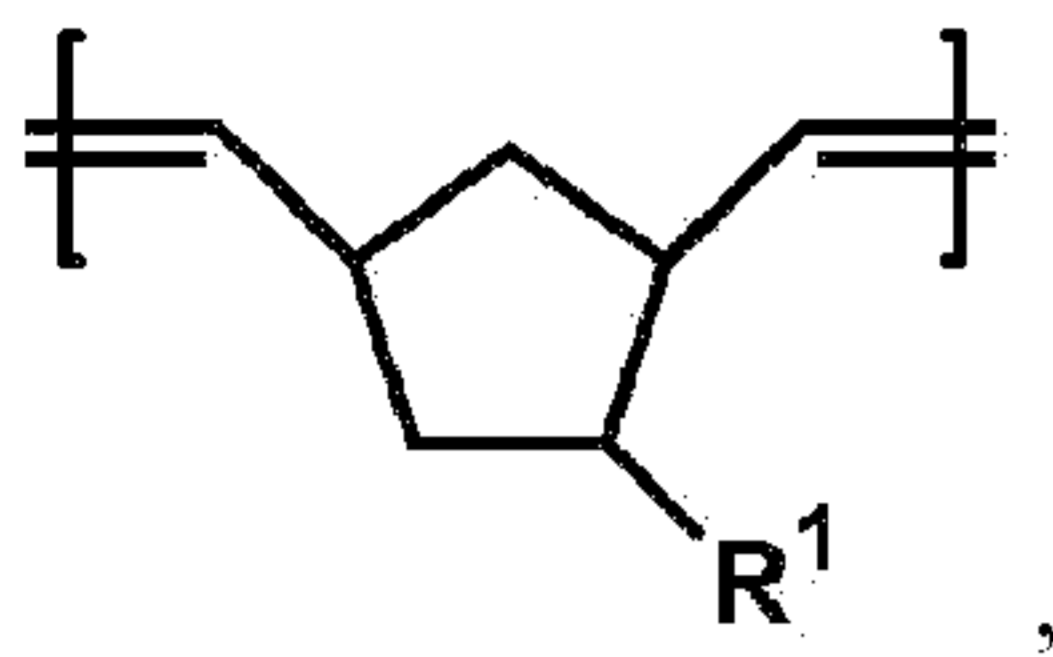
[0004] From EP 2 270 104 A1 a polymer electrolyte composition comprising a component (A) and a component (B) described below is known, wherein if the equivalent weight of cation exchange groups in the component (A) is termed I_c , and the equivalent number of anion exchange groups in the component (B) is termed I_a , then the equivalent weight ratio represented by I_c/I_a is from 1 to 10,000. (A) a cation exchange resin (B) an anion exchange resin having a heterocyclic group containing a cationic nitrogen atom. Further, US 2011/244368 A1 describes vinyl addition and ROMP polymers having at least one type of repeating unit that encompasses a comprise $N^+(CH_3)_3OH^-$ moiety. Other embodiments in accordance with the disclosure include alkali anion-exchange membranes (AAEMs) made from one of such polymers, anion fuel cells (AFCs) that encompass such AAEMs and components of such AFCs, other than the AAEM, that encompass one of such polymers.

SUMMARY

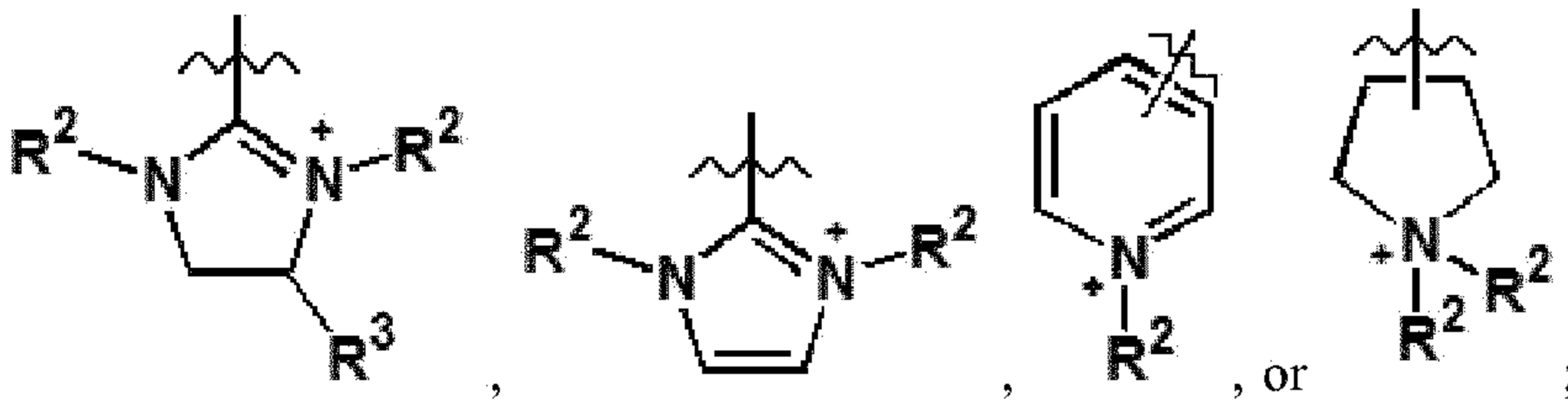
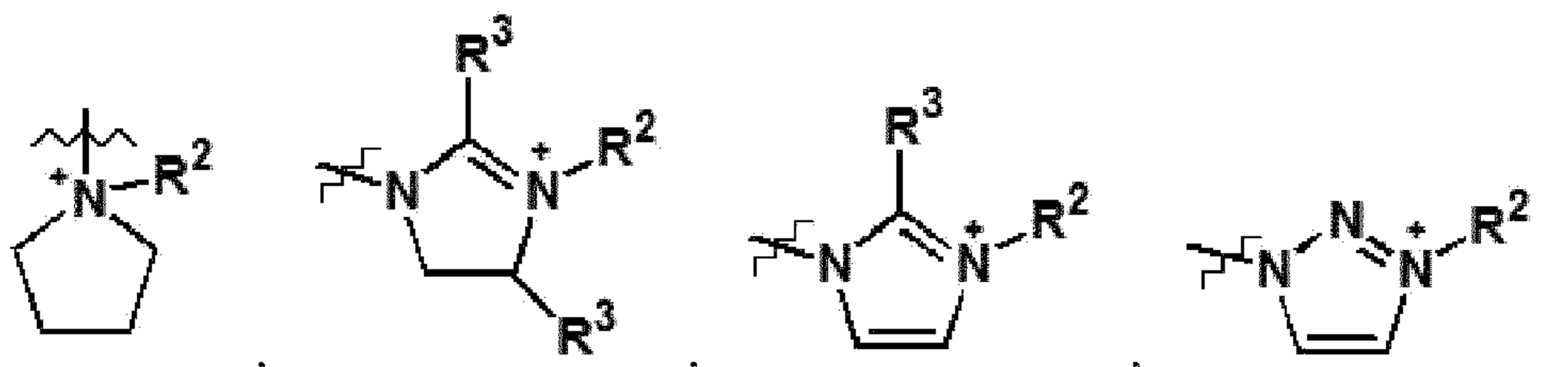
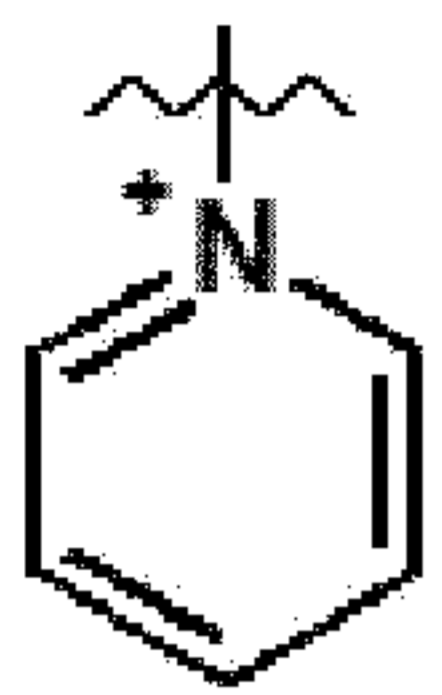
[0005] The invention is described in the independent claims. Preferred embodiments are described in the sub claims. According to an embodiment of the disclosure, the disclosure provides a polymer including a first repeat unit and a second repeat unit, wherein the first repeat unit can be



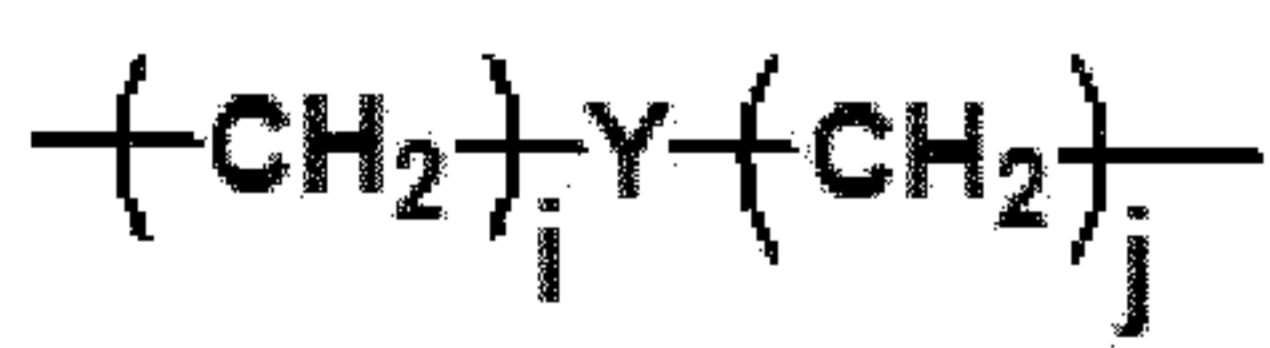
the second repeat unit can be



wherein R⁺ can be

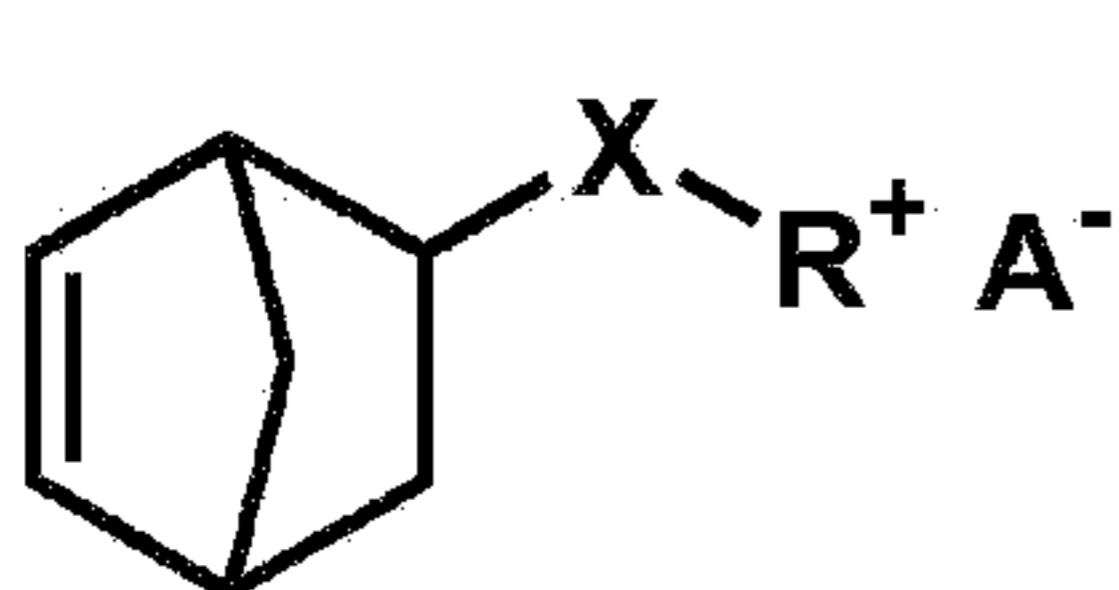


A⁻ can be F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻, or H₂PO₂⁻; X can be

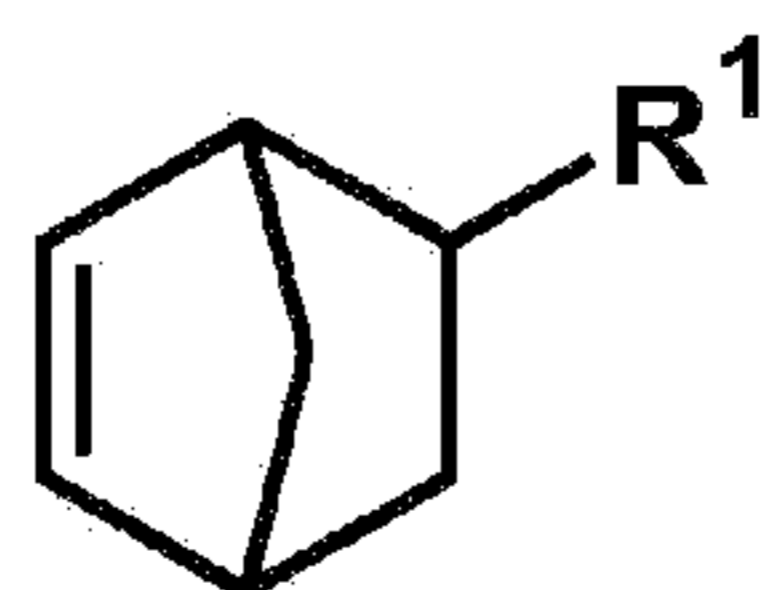


i and j can be independently 0, or an integer from 1 to 6, Y can be -O-, -S-, -CH₂-, or -NH-; R¹ can be independently C₁₋₈ alkyl group; and, R² and R³ can be independently hydrogen, or C₁₋₈ alkyl group. The ratio between the first repeat unit and the second repeat unit is between about 1:99 and 99:1.

[0006] According to other embodiments of the disclosure, the disclosure provides a method for preparing the aforementioned polymer. The method includes subjecting a composition to a polymerization. In particular, the composition includes a first monomer having a structure of Formula (I) and a second monomer having a structure of Formula (II)

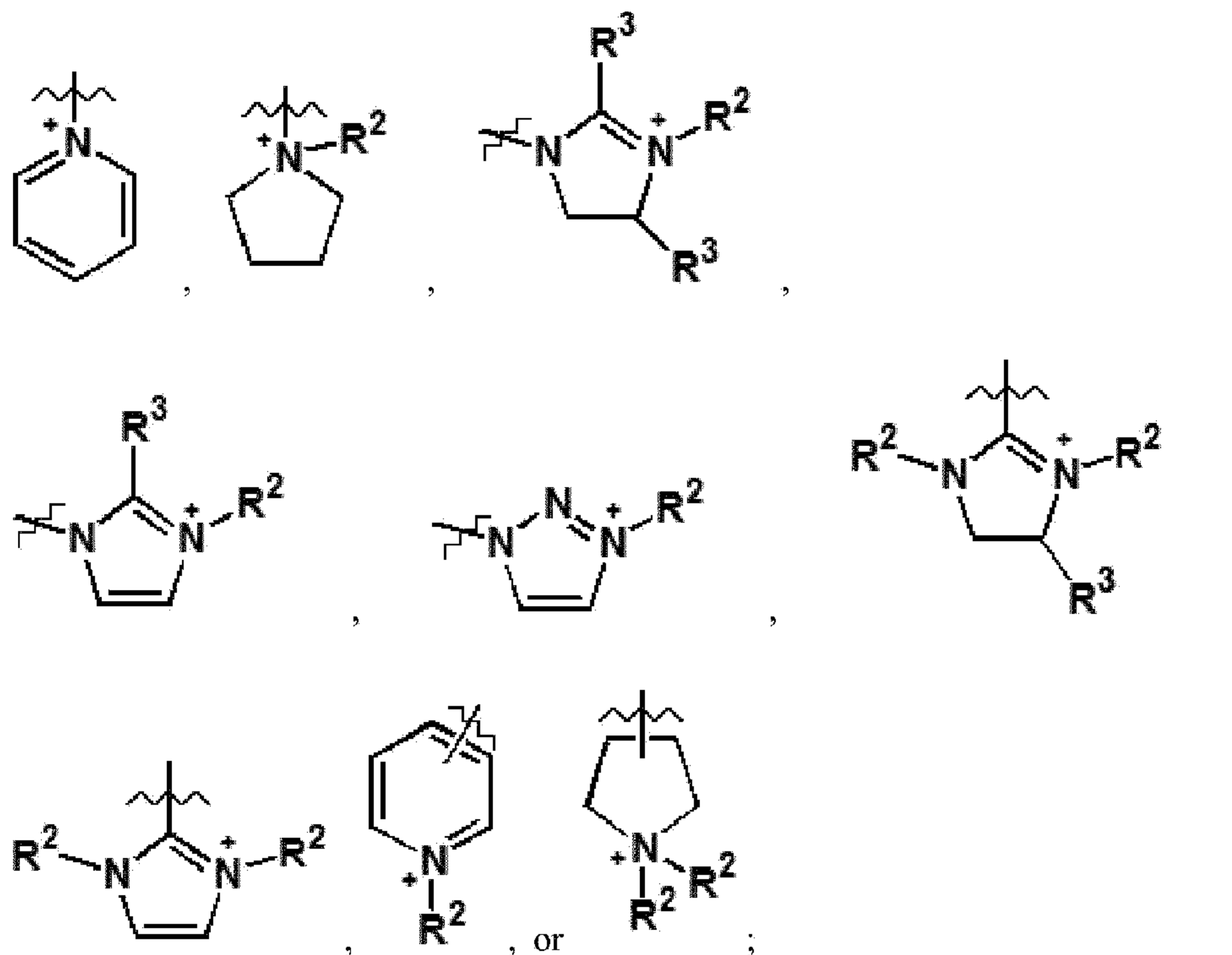


Formula (I)



Formula (II)

, wherein R⁺ can be



A⁻ can be F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻, or H₂PO₂⁻; X can be



i and j can be independently 0, or an integer from 1 to 6, Y can be -O-, -S-, -CH₂-, or -NH-; R¹ can be independently C₁₋₈ alkyl group; and, R² and R³ can be independently hydrogen, or C₁₋₈ alkyl group.

[0007] A detailed description is given in the following embodiments with reference to the accompanying drawings.

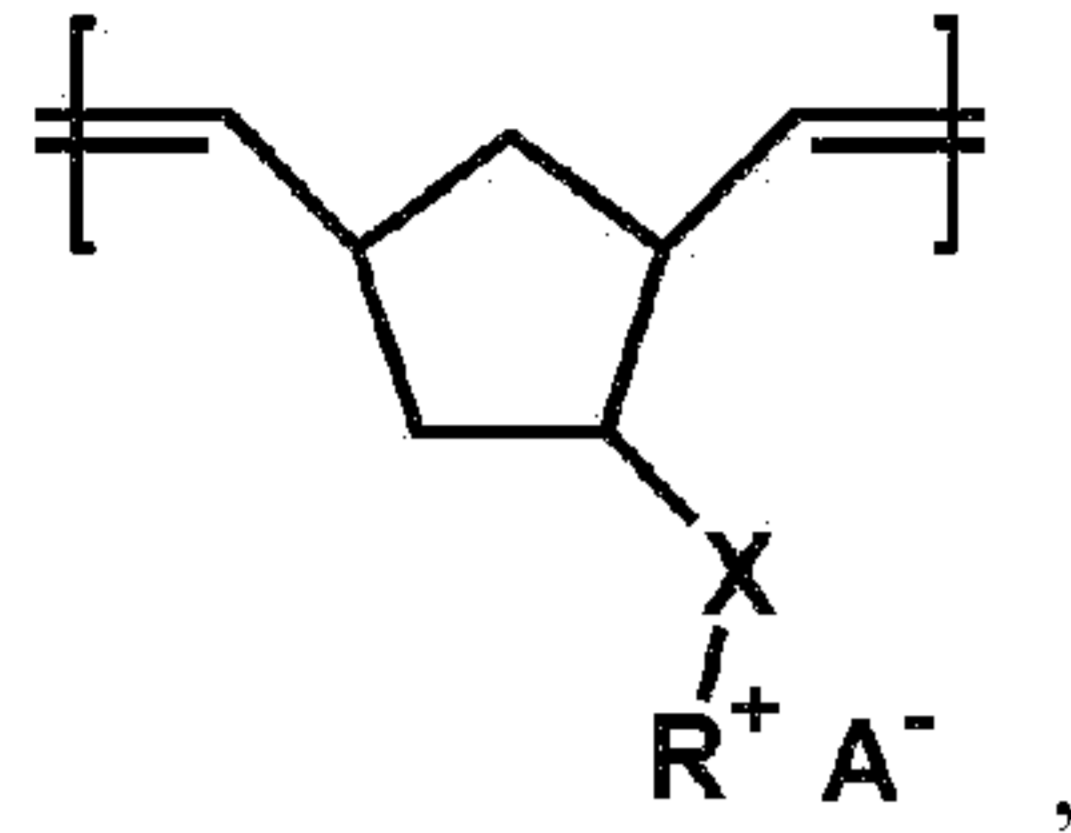
DETAILED DESCRIPTION

[0008] In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details.

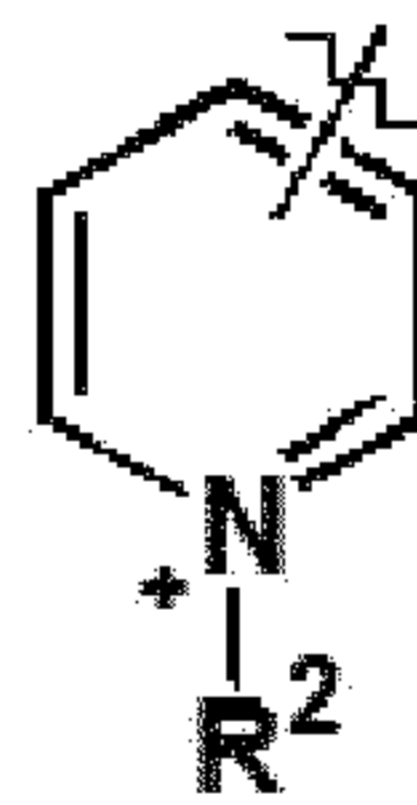
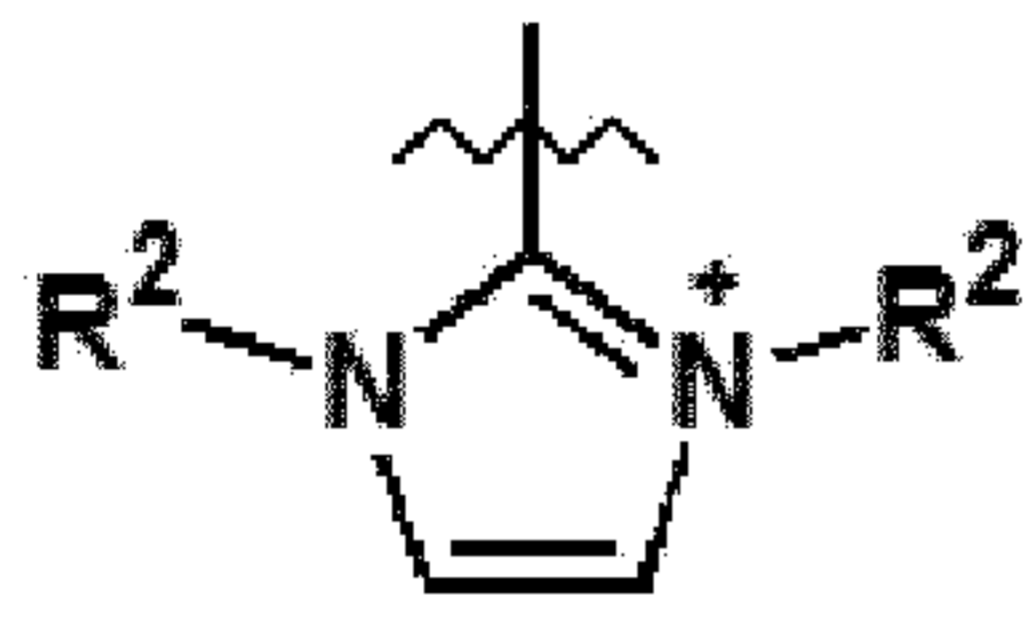
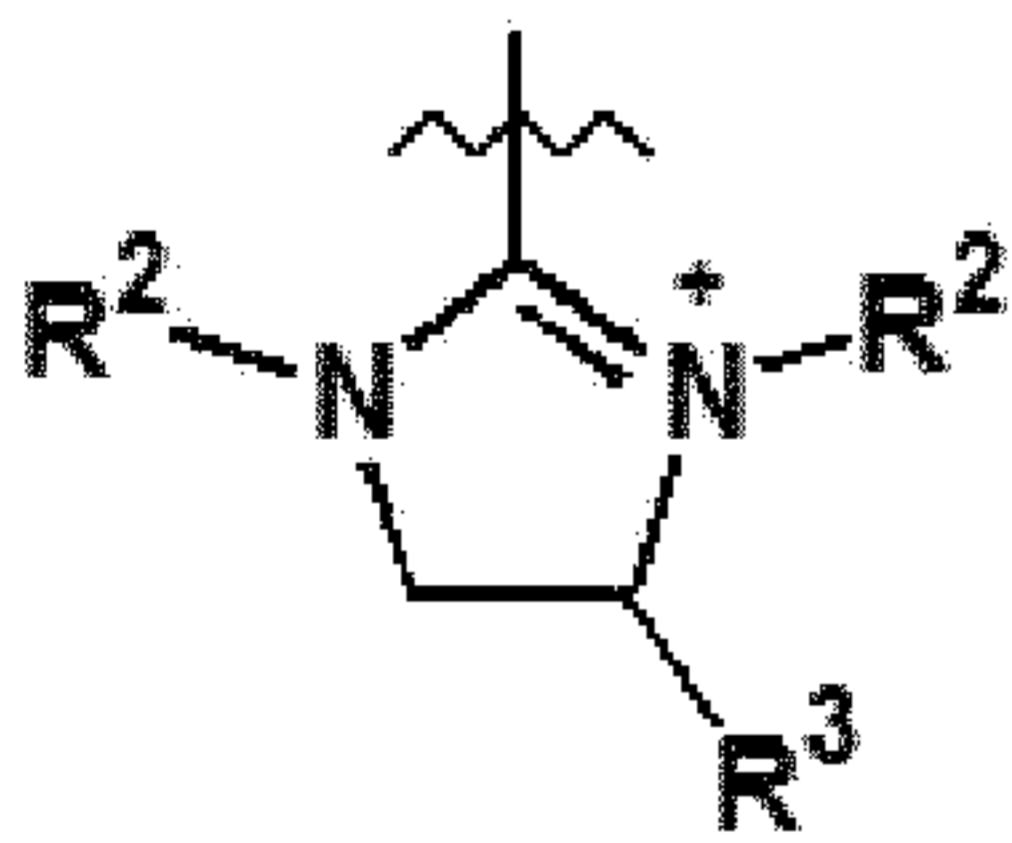
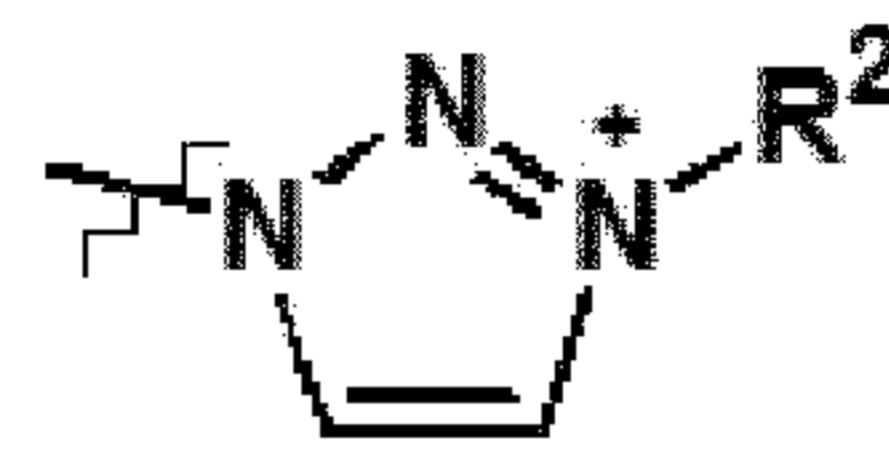
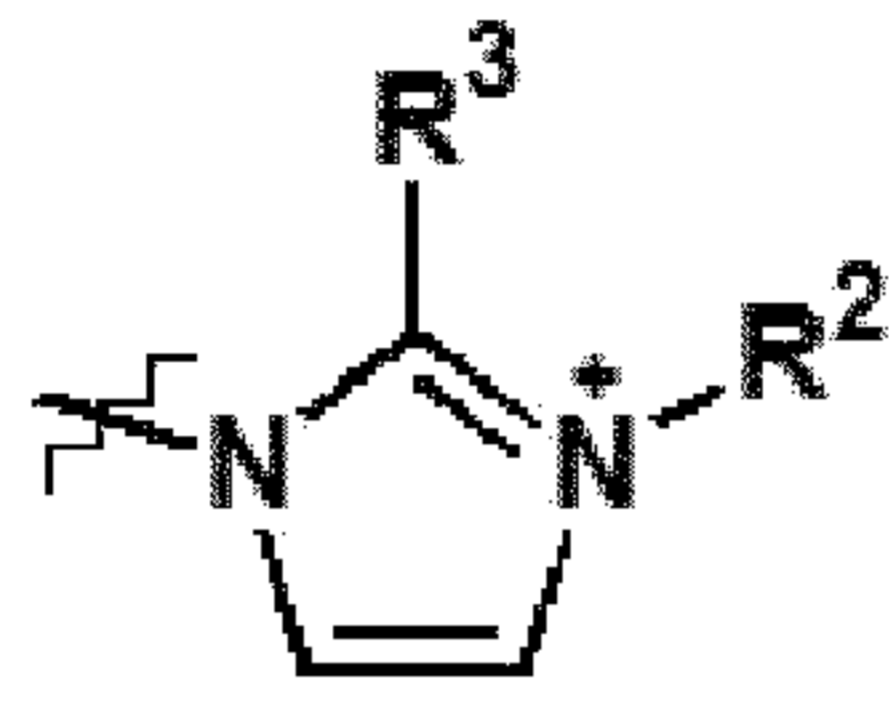
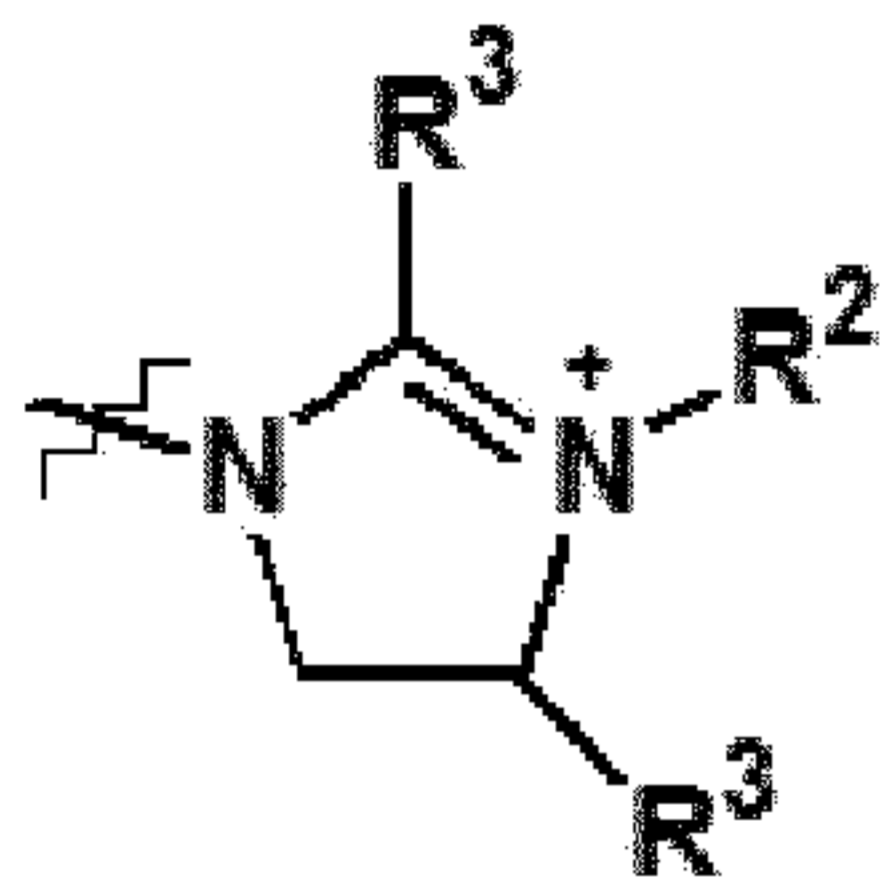
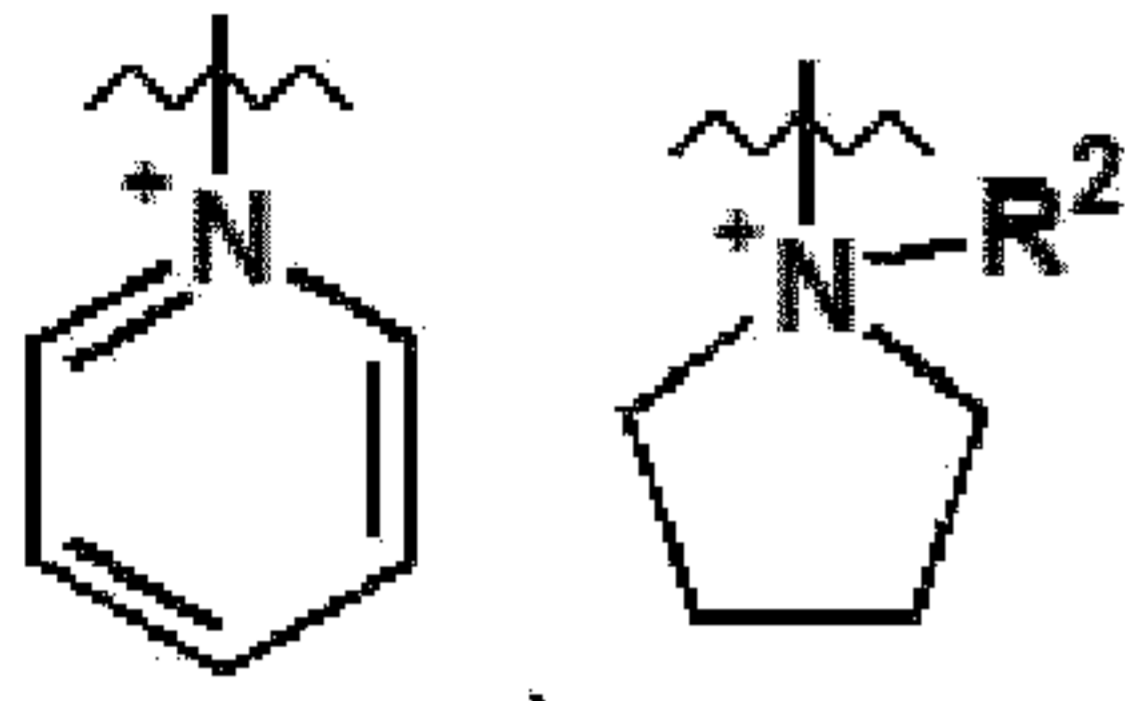
[0009] The disclosure provides a polymer and a method for preparing the same. The polymer of the disclosure can be a polymer with a cationic group (such as a highly stable cyclic conjugated cationic group) and non-ionic group (such as long-chain group). In the chemical structure design, in order to enhance the electrical conductivity of the polymer, the polymer of the disclosure has a repeat unit with a cationic group. In addition, the polymer of the disclosure has a repeat unit with a non-ionic group, in order to prevent the solubility of the polymer having

cationic groups from decreasing when dissolving in a solvent. According to embodiments of the disclosure, besides the high solubility, the polymer of the disclosure exhibits improved mechanical strength and increased solvent selectivity.

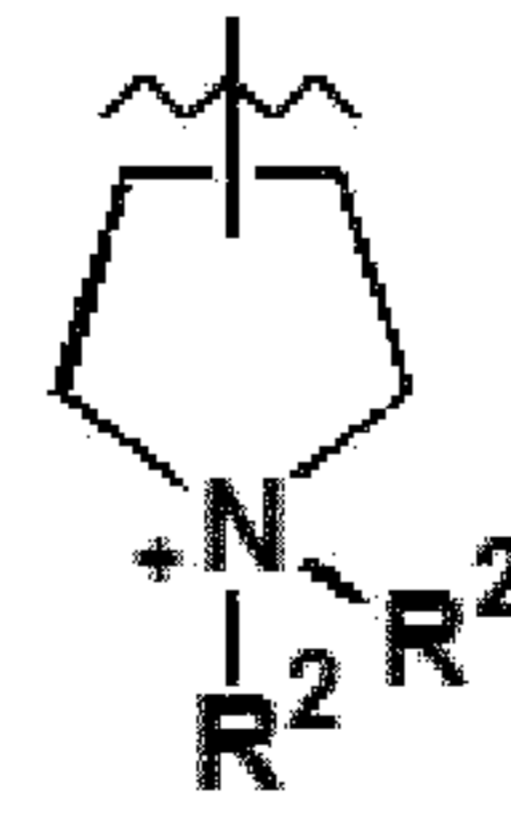
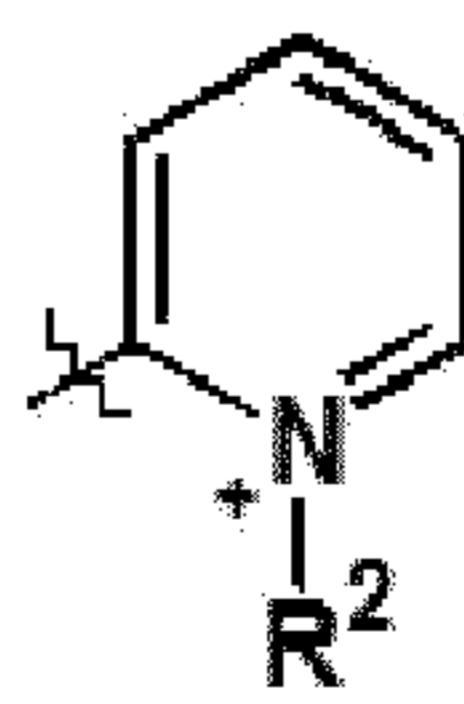
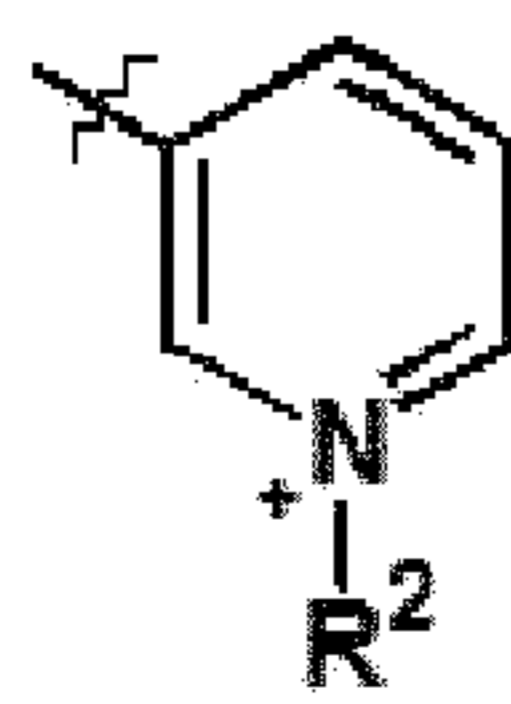
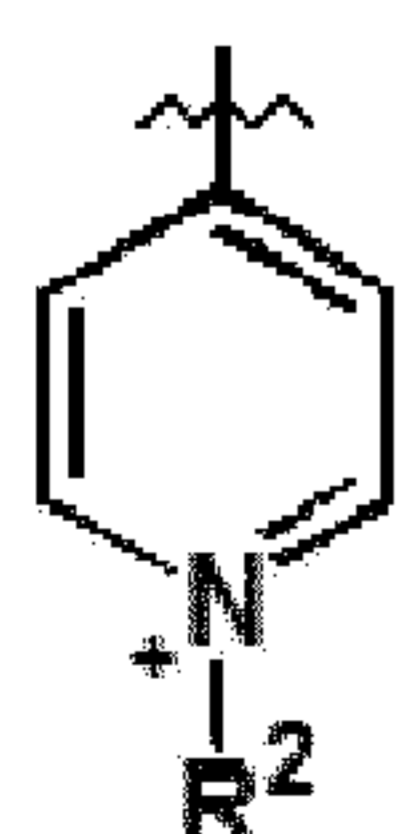
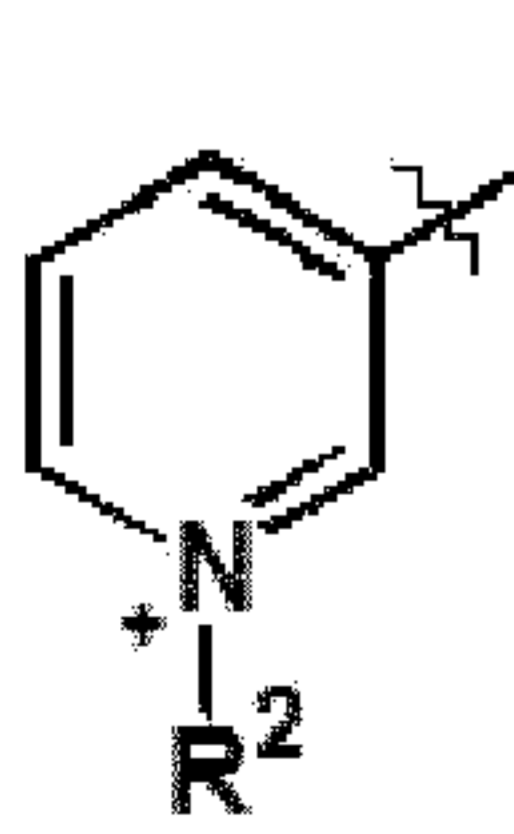
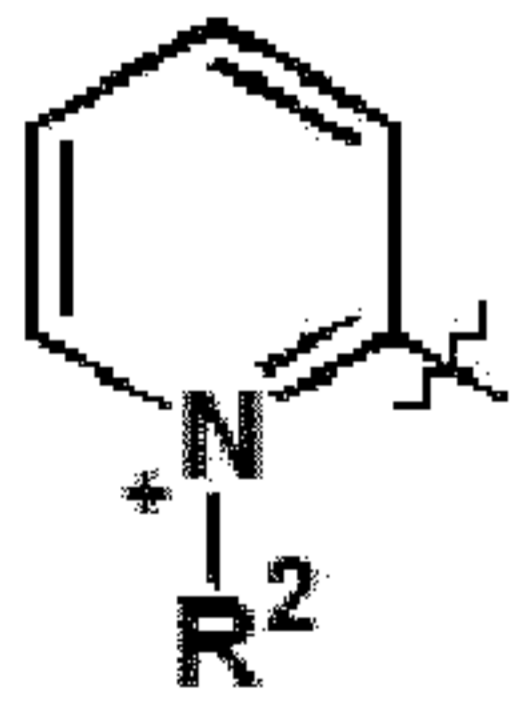
[0010] According to an embodiment of the disclosure, the polymer of the disclosure includes a first repeat unit and a second repeat unit. The first repeat unit can be



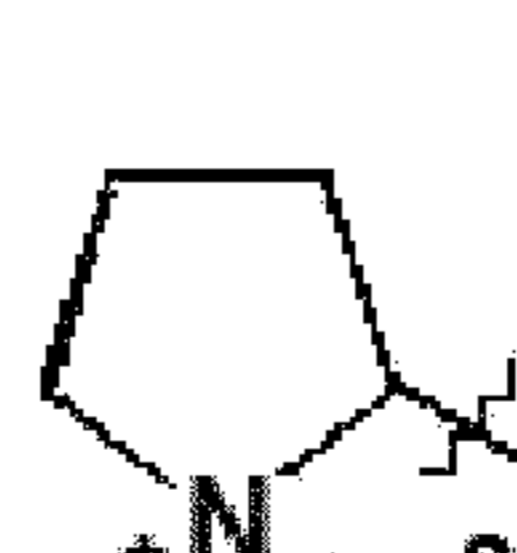
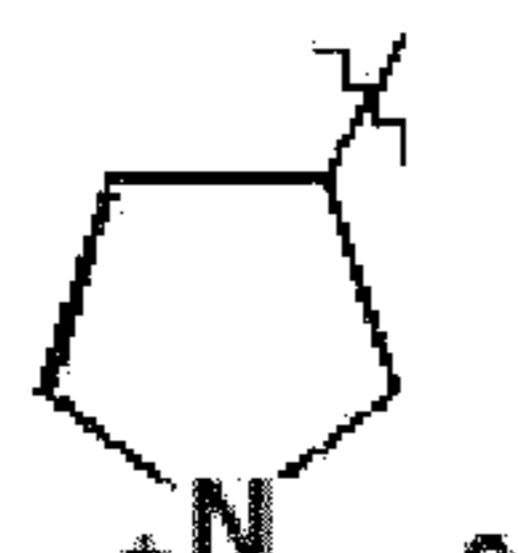
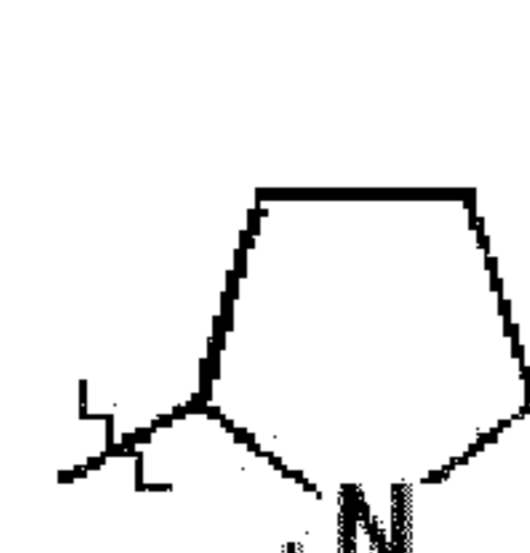
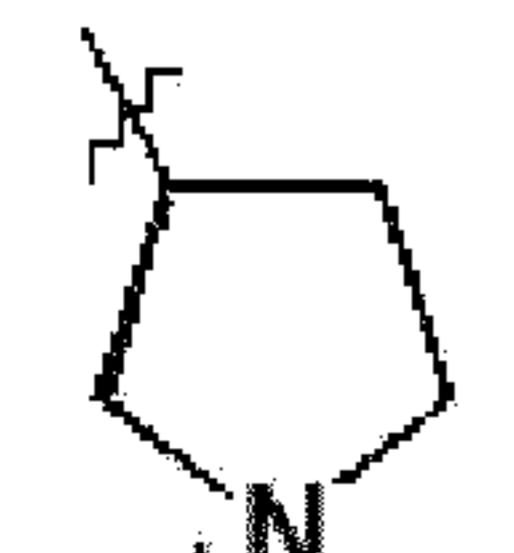
wherein R^+ can be



(such as :

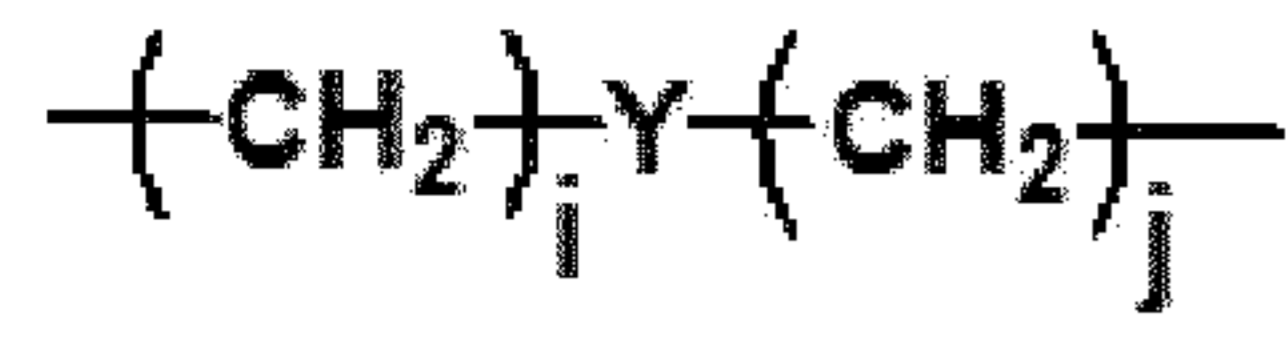


(such as

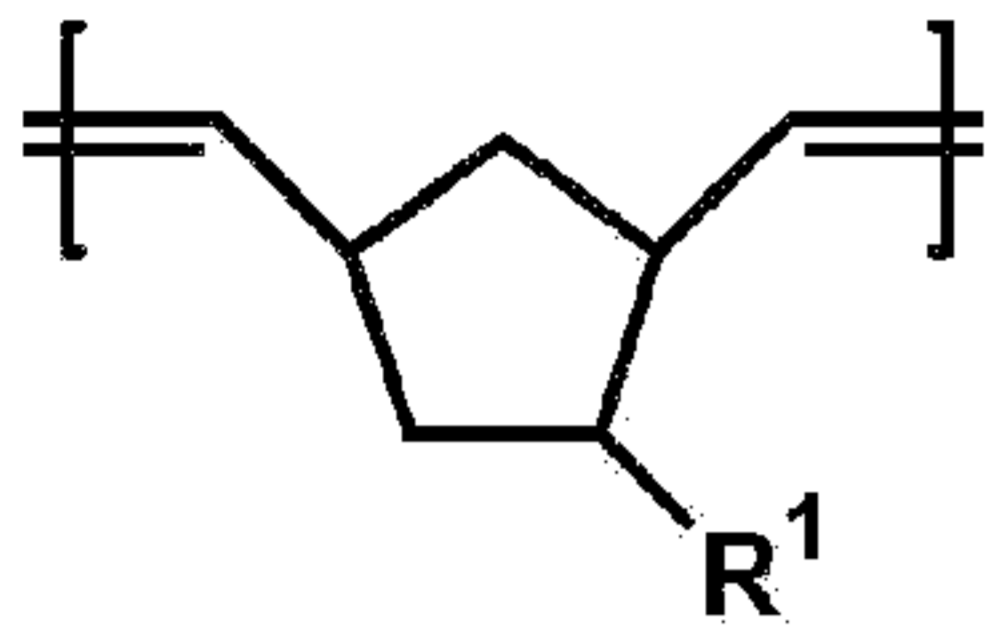




); A⁻ can be F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻, or H₂PO₂⁻; X is

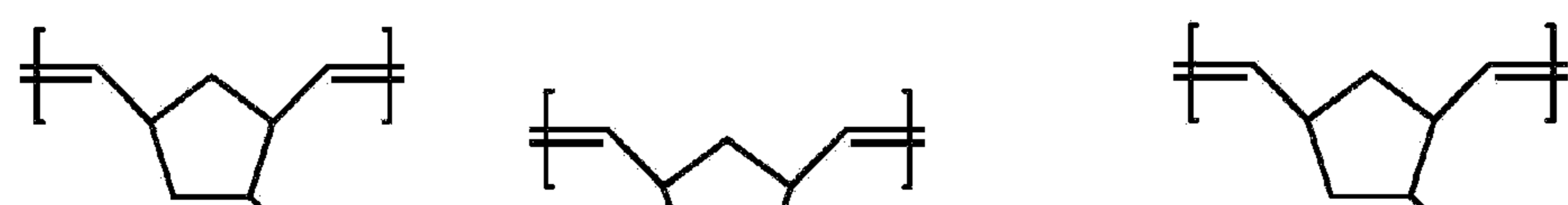
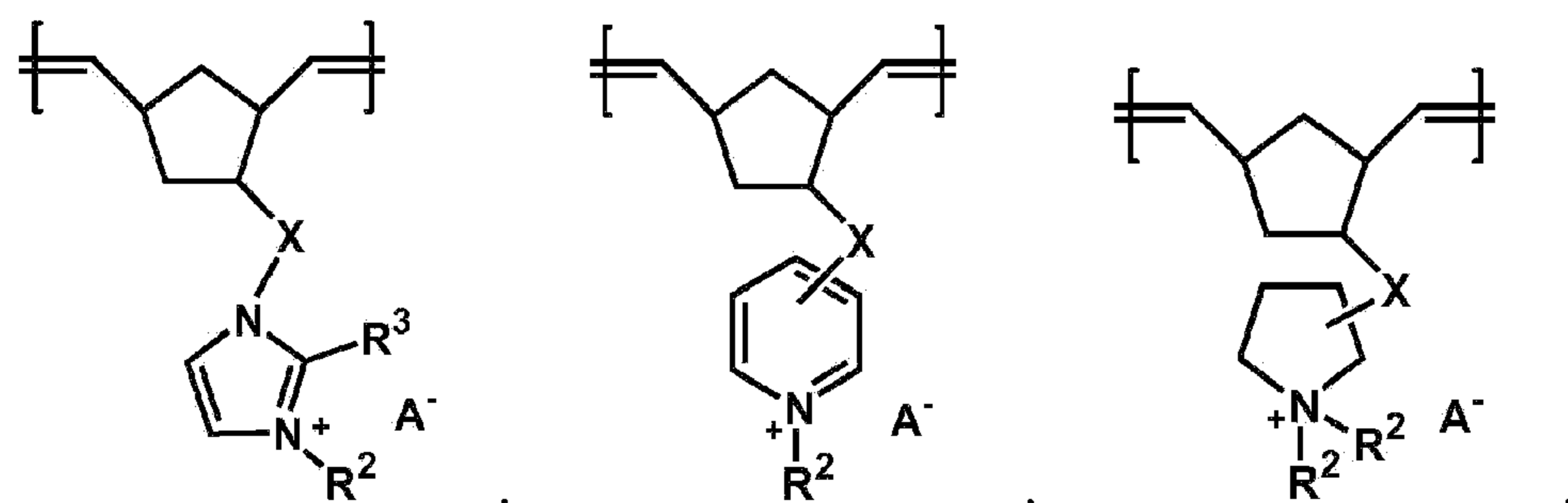
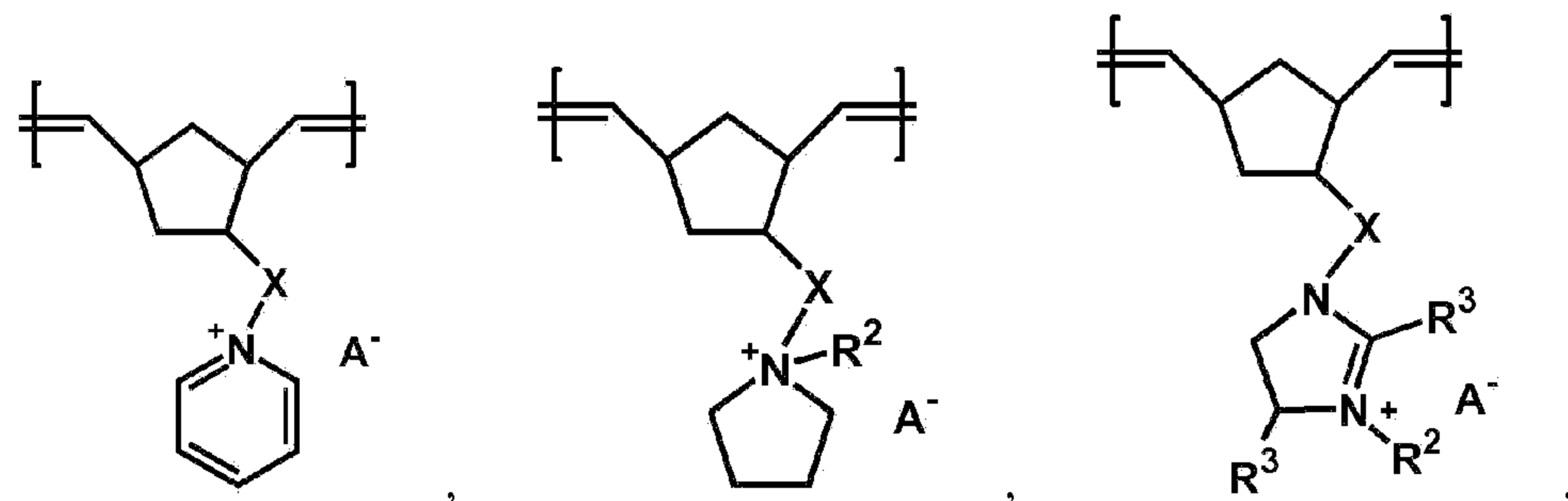
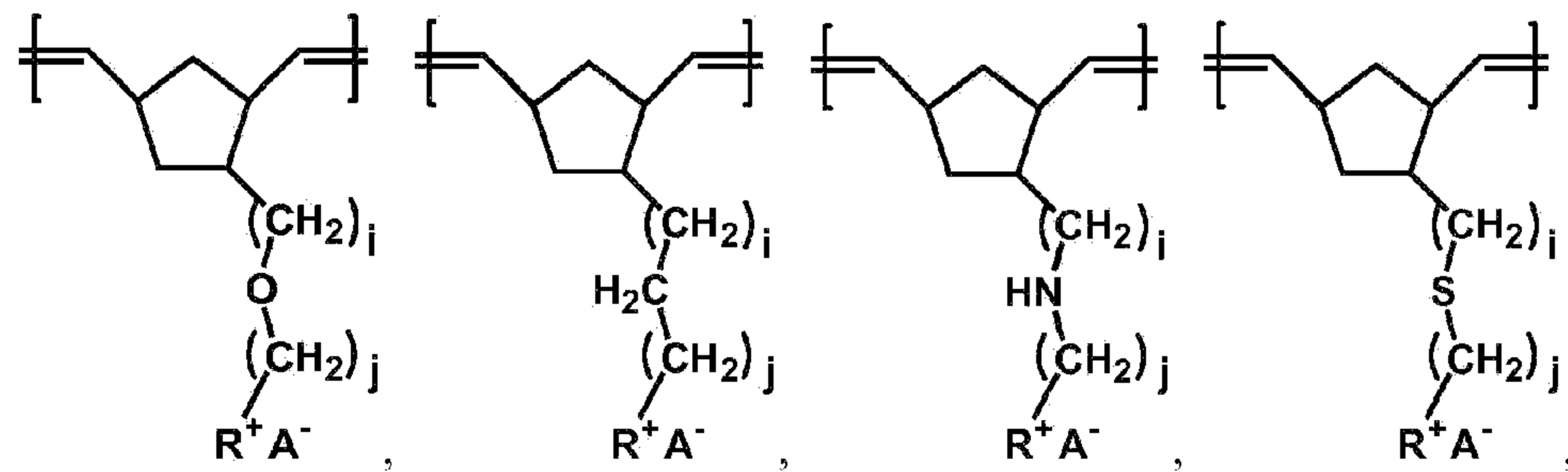


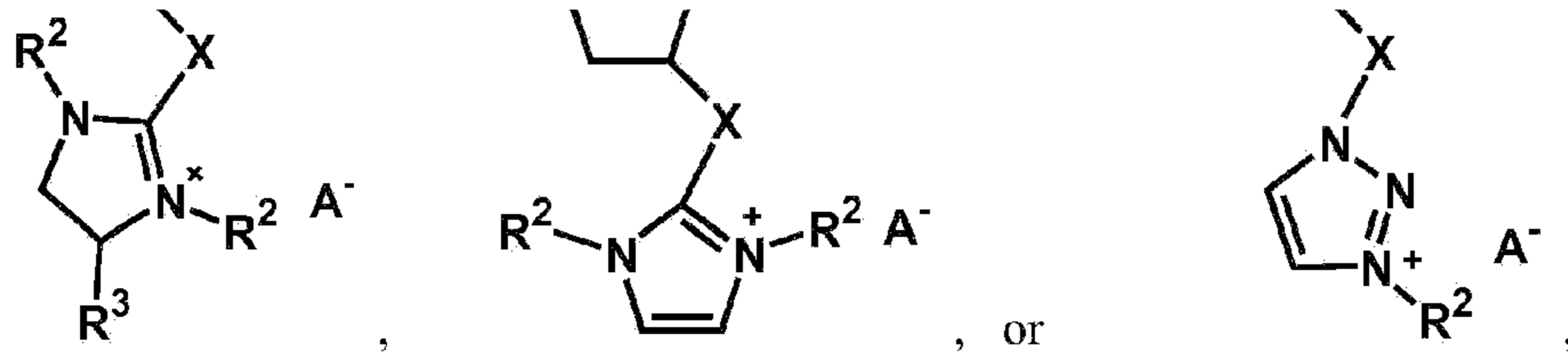
i and j can be independently 0, or an integer from 1 to 6, Y can be -O-, -S-, -CH₂-, or -NH-; and, R² and R³ can be independently hydrogen, or C₁₋₈ alkyl group (such as : methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, cyclohexyl, cyclopentyl, heptyl, or octyl). In addition, the second repeat unit can be



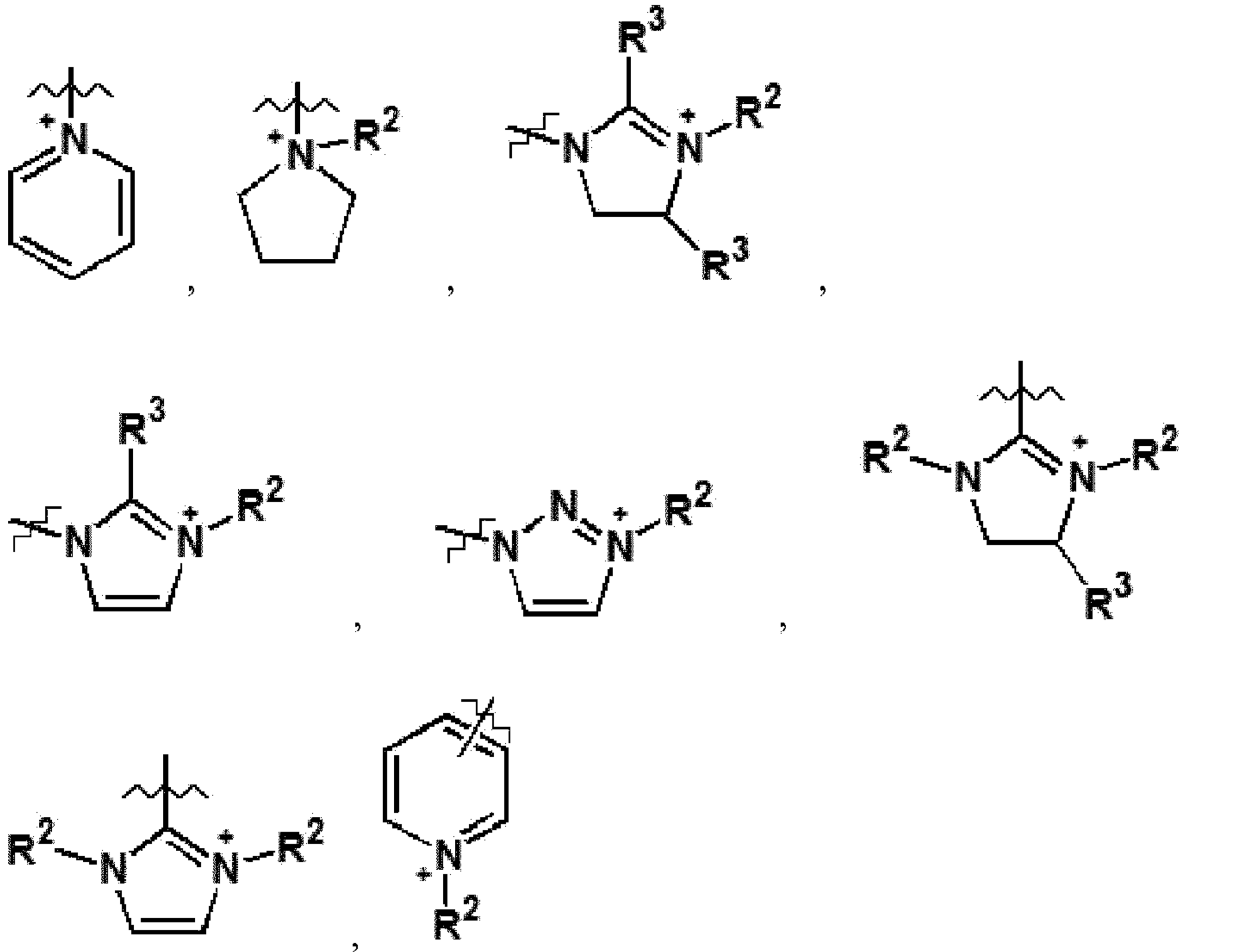
wherein R¹ can be independently C₁₋₈ alkyl group (such as methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, cyclohexyl, cyclopentyl, heptyl, or octyl).

[0011] According to embodiments of the disclosure, the first repeat unit can be

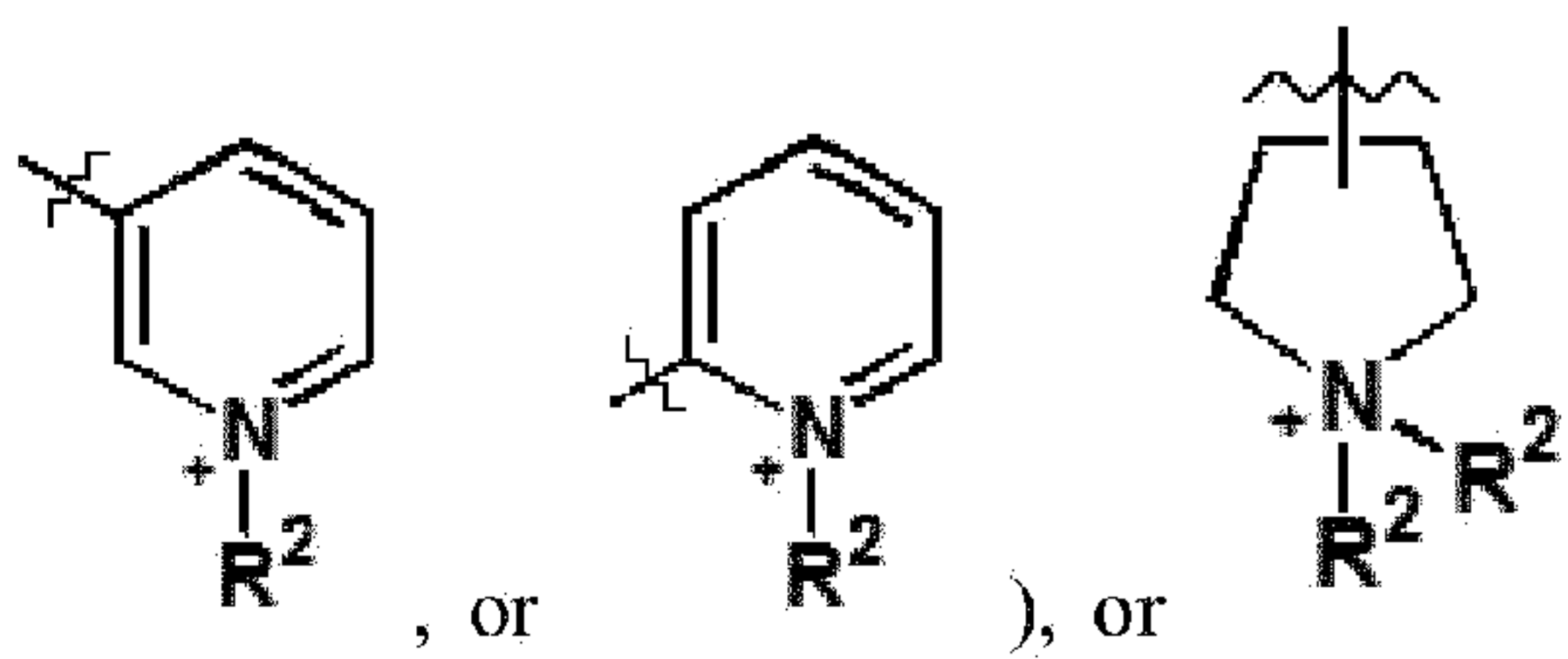
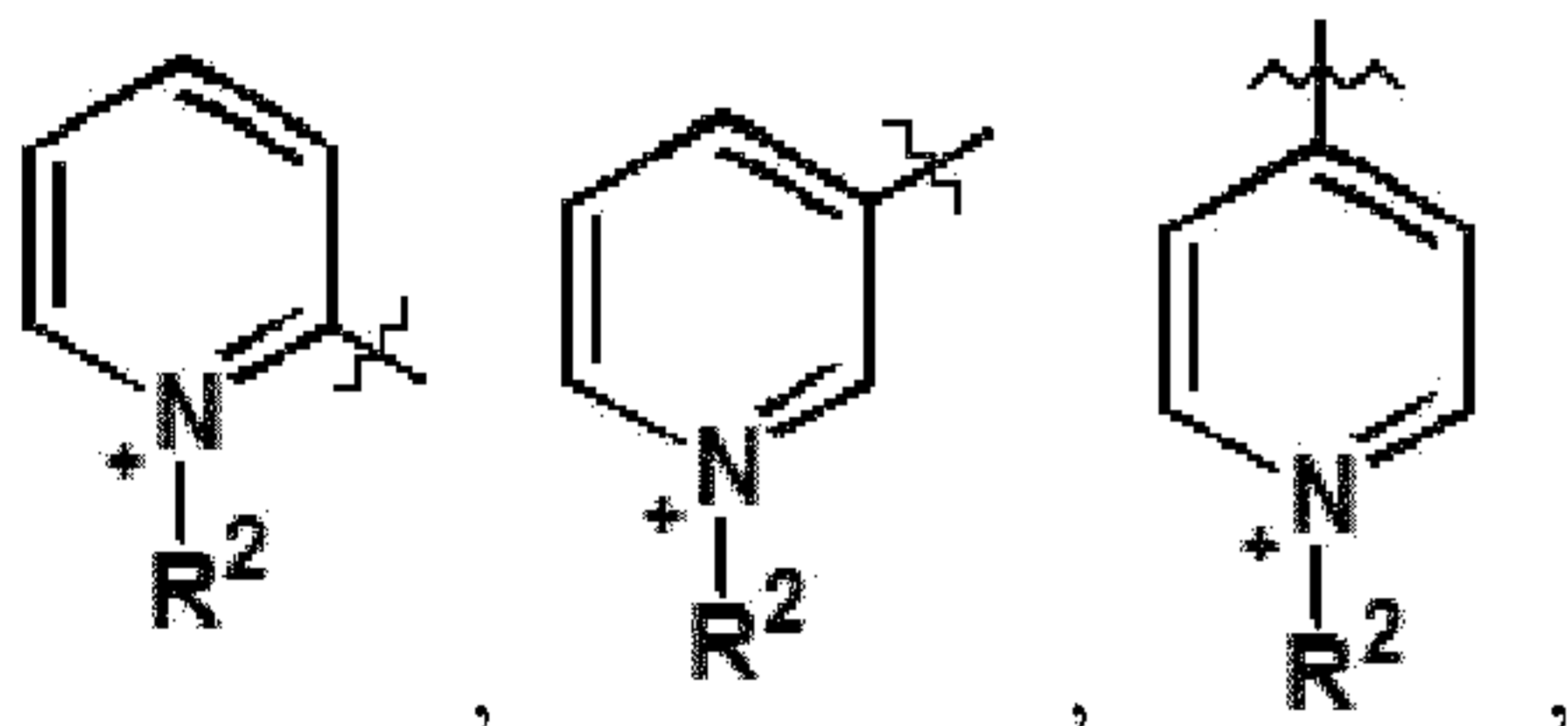




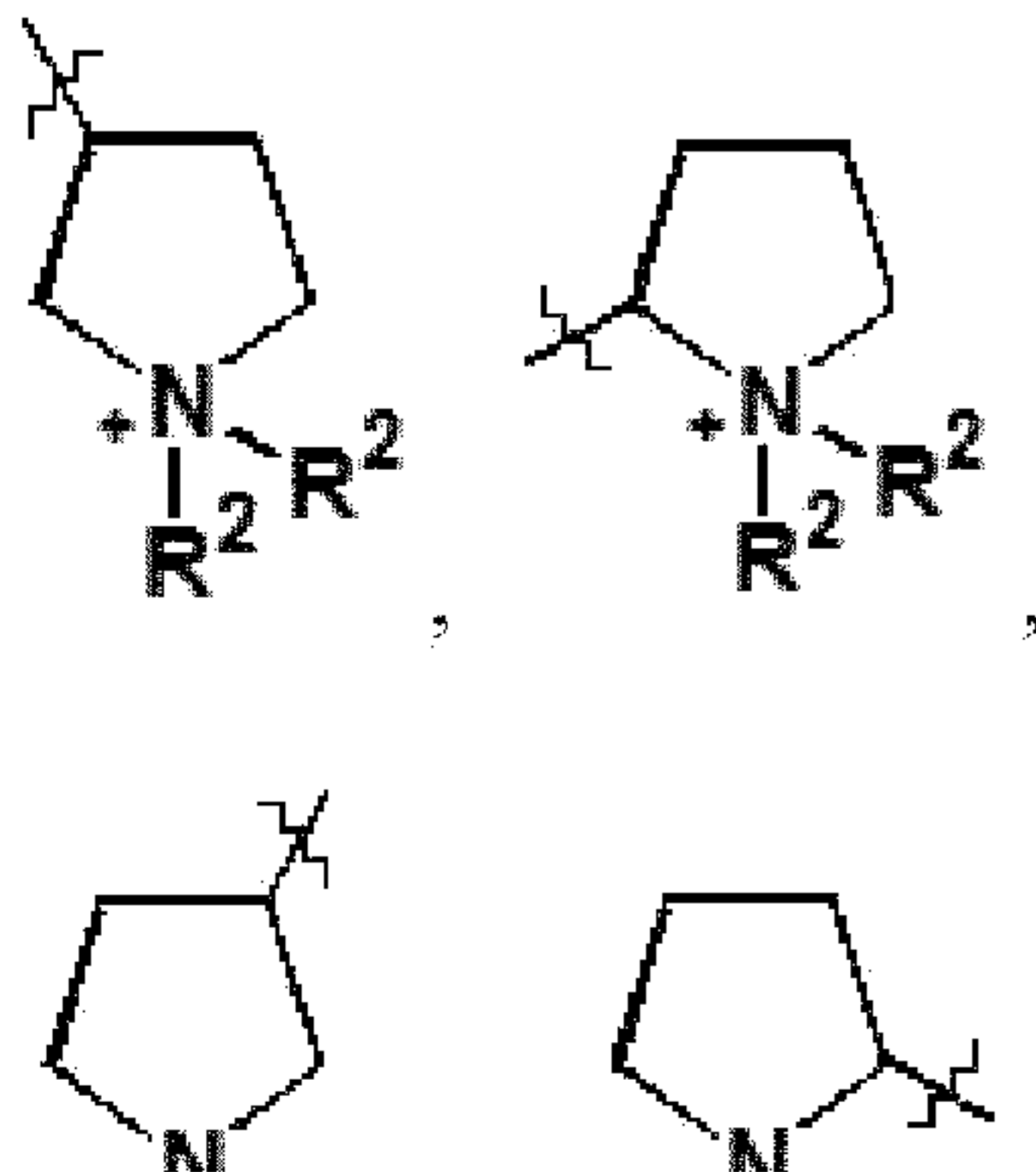
wherein R⁺ can be

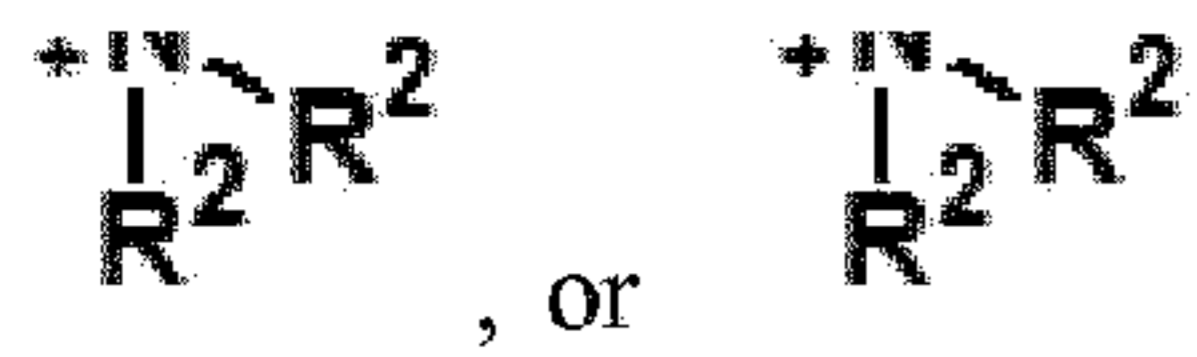


(such as

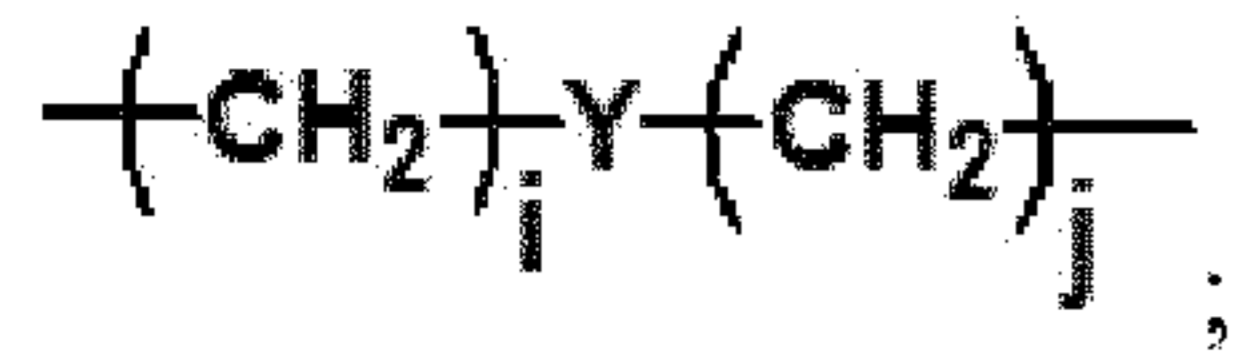


(such as





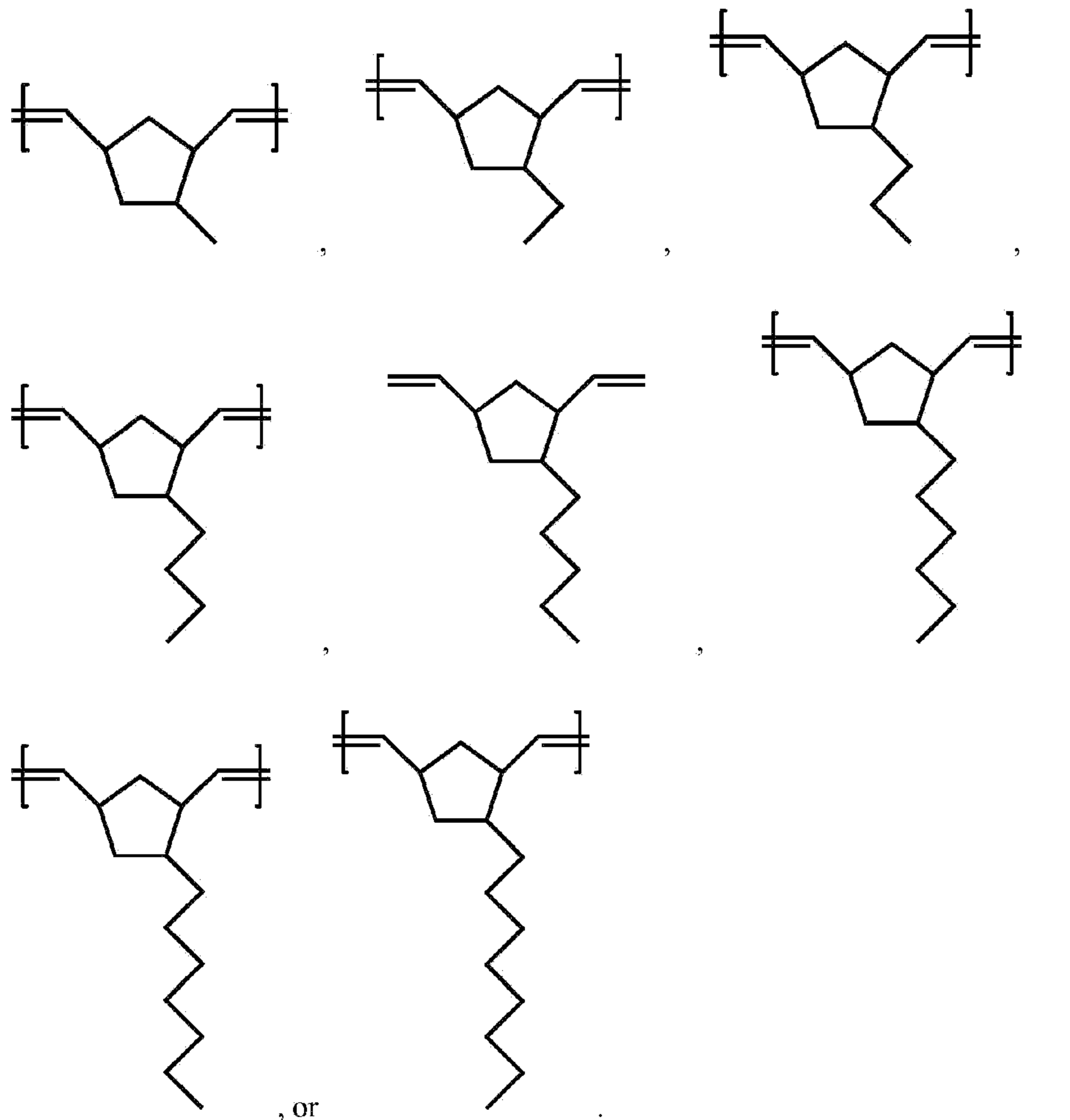
); A⁻ can be F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻, or H₂PO₂⁻; X is



Y can be -O-, -S-, -CH₂-, or -NH-; i and j can be independently 0, or an integer from 1 to 6; and, R² and R³ can be independently hydrogen, or C₁₋₈ alkyl group.

[0012] According to embodiments of the disclosure, the polymer of the disclosure has a molecular weight (such as number average molecular weight) between about 100, 000 and 250, 000.

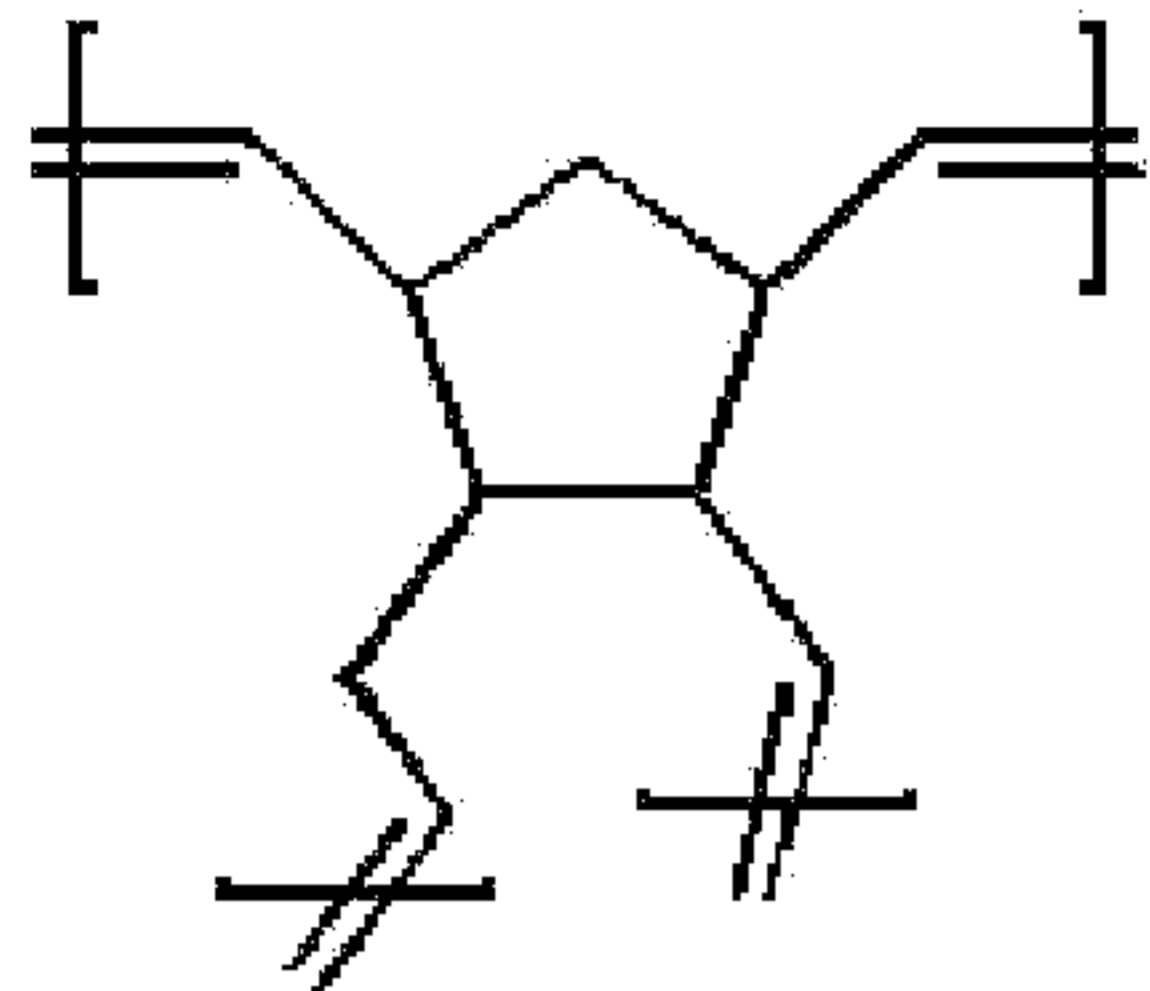
[0013] According to embodiments of the disclosure, the second repeat unit can be



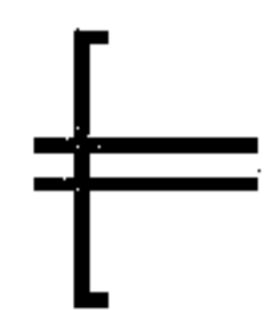
[0014] According to embodiments of the disclosure, the ratio between the first repeat unit and the second repeat unit of the polymer can be adjusted to achieve the desired characteristics of the polymer. For example, the ratio between the first repeat unit and the second repeat unit can be increased in order to enhance the electrical conductivity and the anion exchange capacity of the polymer. On the other hand, the ratio between the first repeat unit and the

second repeat unit can be decreased in order to enhance the solubility, the mechanical strength, and the solvent selectivity of the polymer. The ratio between the first repeat unit and the second repeat unit is between about 1:99 and 99:1, such as between about 10:90 and 90:10, between about 20:80 and 80:20, or between about 30:70 and 70:30.

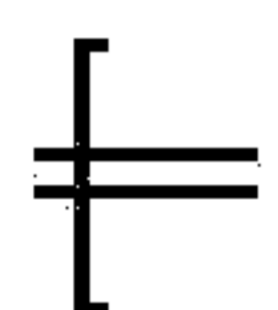
[0015] According to embodiments of the disclosure, the polymer of the disclosure can further include a third repeat unit, wherein the third repeat unit can be



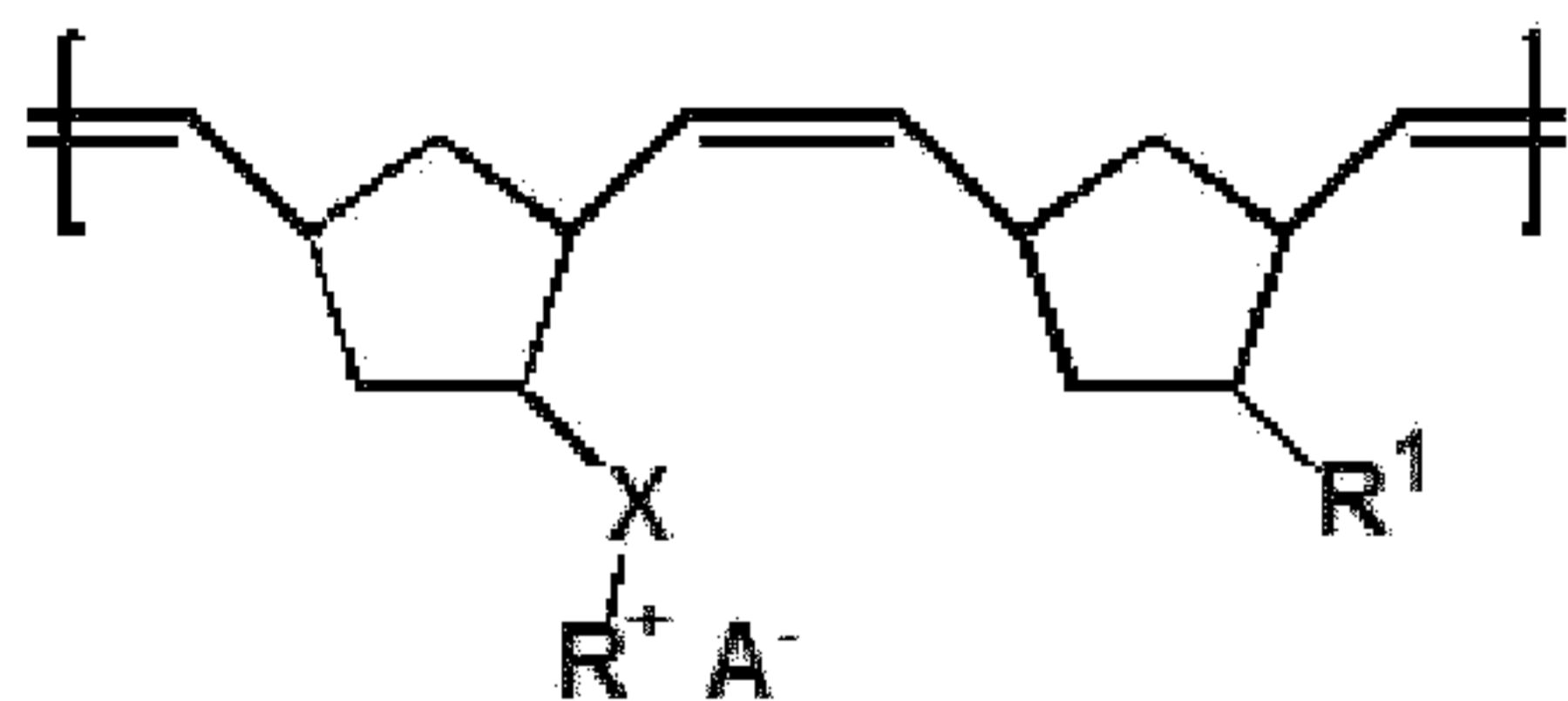
The portion represented by



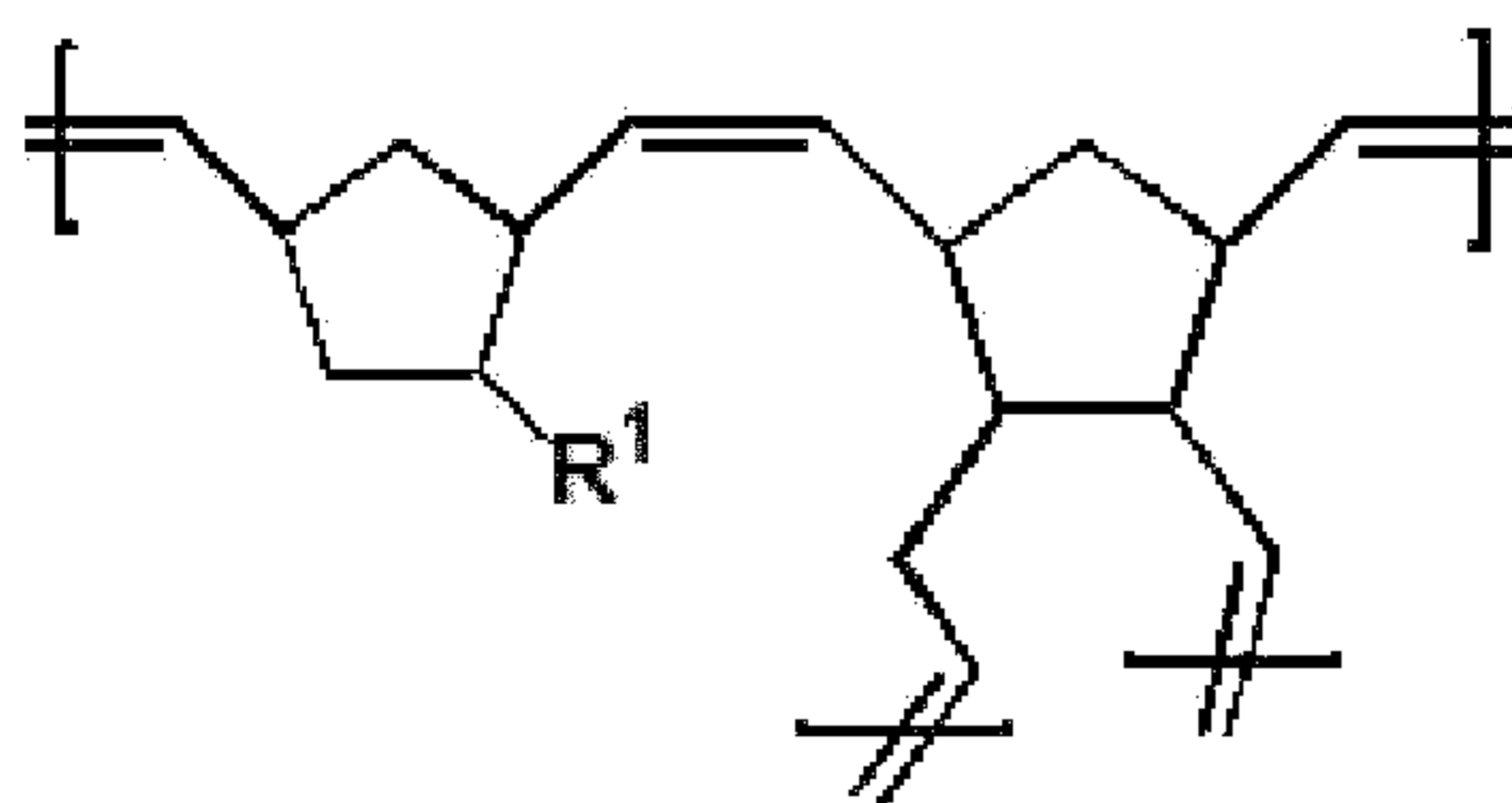
of the first repeat unit, the second repeat unit, or the third repeat unit is bonded to the portion represented by



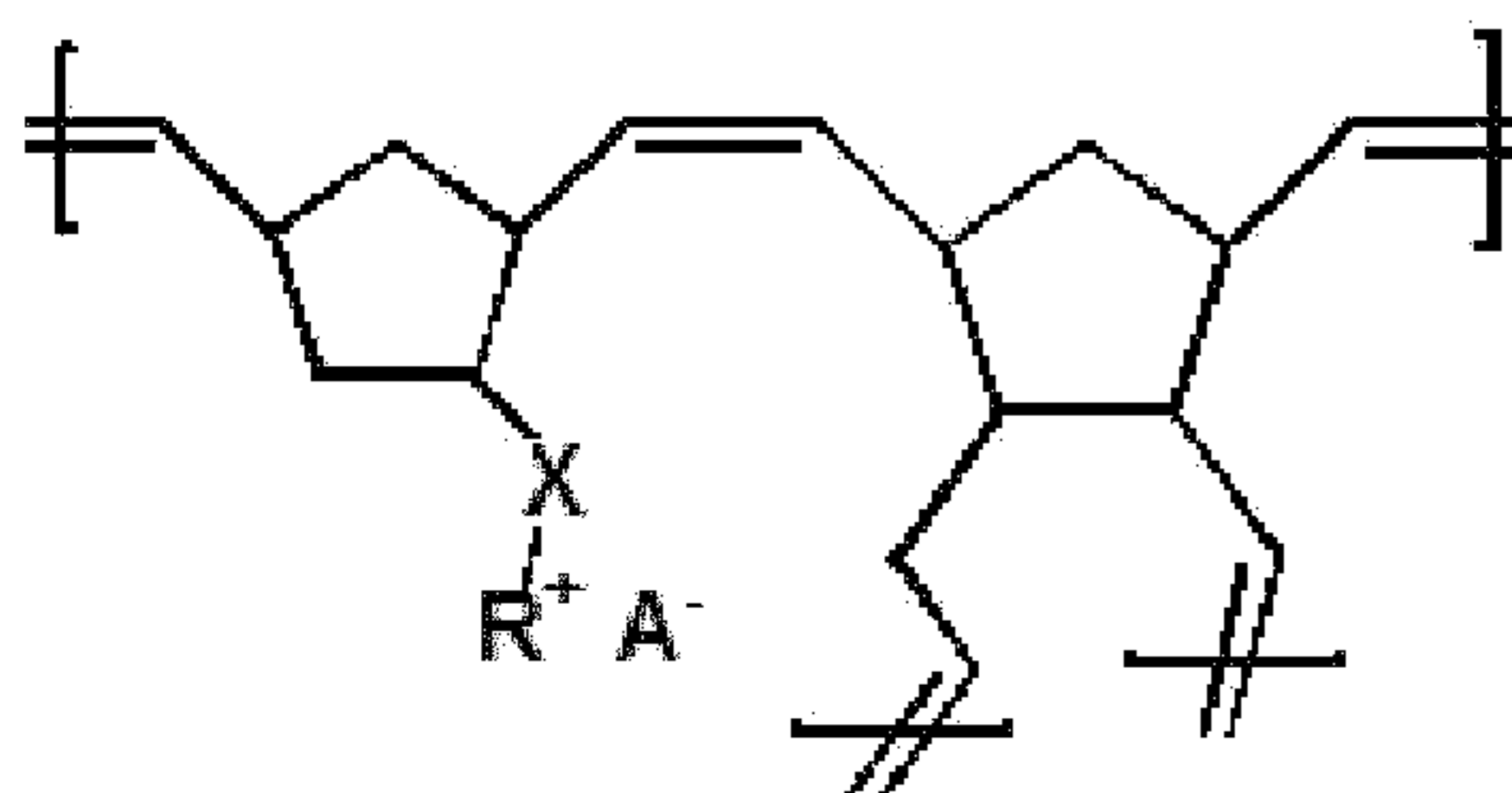
of the other first repeat unit, the other second repeat unit, or the other third repeat unit. In addition, the first repeat unit, the second repeat unit, and the third repeat unit can be arranged in a random fashion. For example, the polymer of the disclosure can have a moiety represented by



a moiety represented by



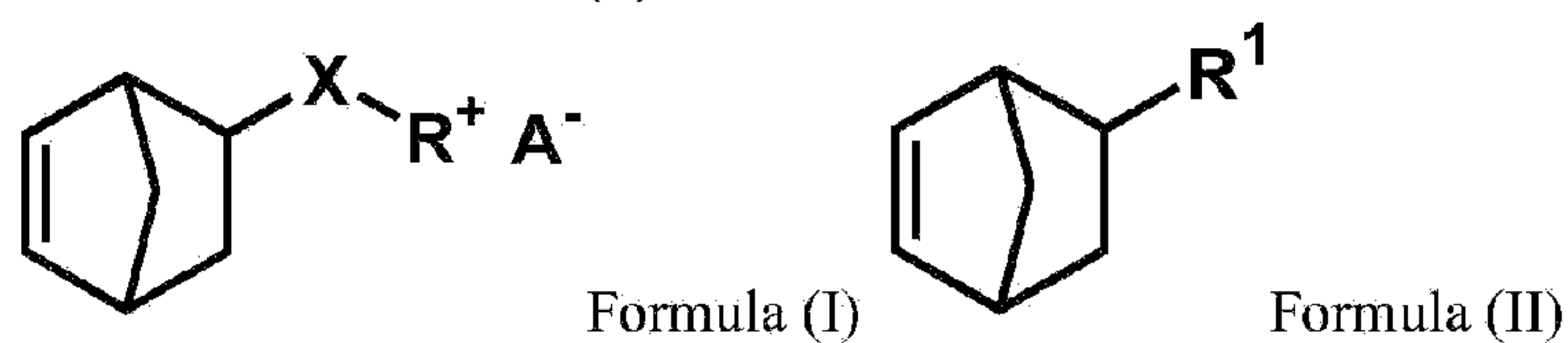
or a moiety represented by



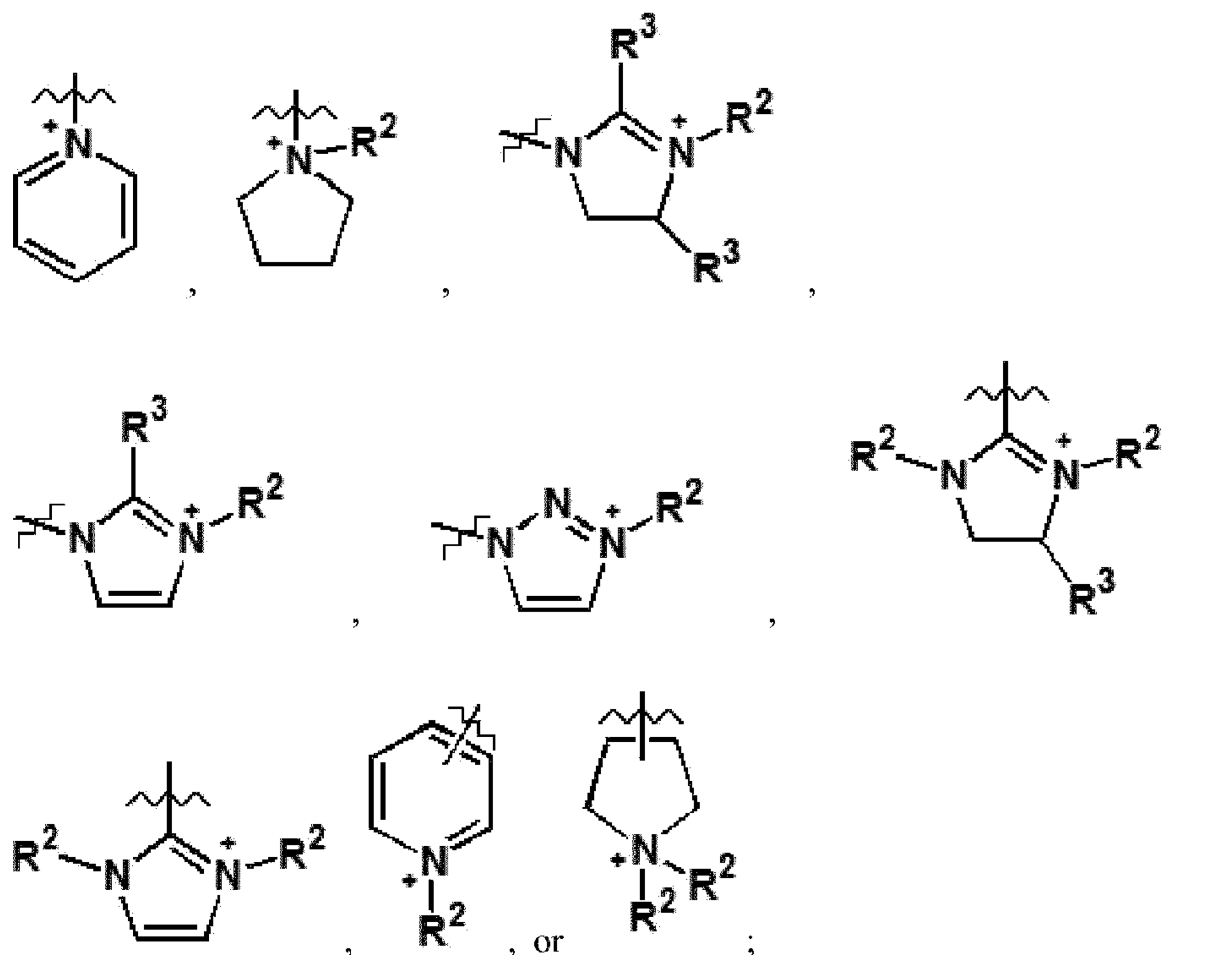
According to embodiments of the disclosure, the ratio between the third repeat unit and the

sum of the first repeat unit and the second repeat unit can be between about 0.1:100 and 5:100, such as between about 0.5:100 and 4:100, or between about 0.5:100 and 3:100. Due to the introduction of the third repeat unit, the polymer can have improved cross-linking degree and mechanical strength by adopting the third repeat unit. In addition, when the ratio between the third repeat unit and the sum of the first repeat unit and the second repeat unit is too high, the polymer would have too high a cross-linking degree and too high a molecular weight and cannot be redissolved in the subsequent process solvent.

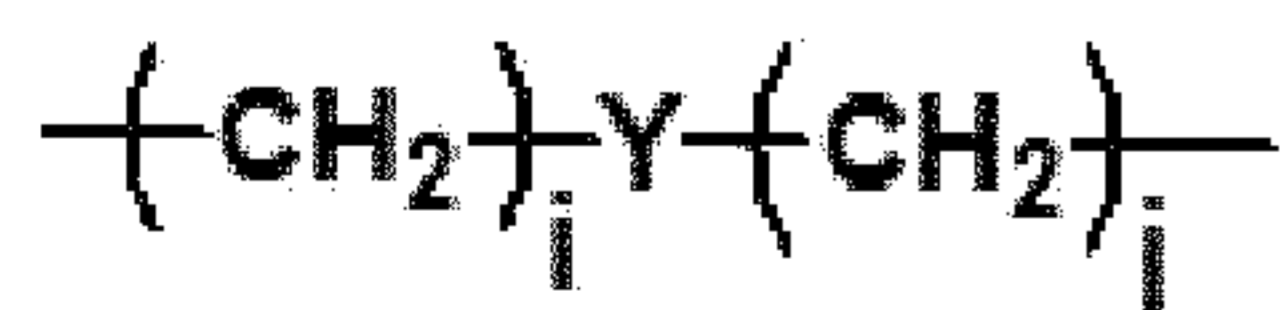
[0016] According to embodiments of the disclosure, the disclosure provides a method for preparing the aforementioned polymer. The method includes subjecting a composition to a polymerization, such as a ring opening metathesis polymerization (ROMP). The composition can include a first monomer having a structure of Formula (I) and a second monomer having a structure of Formula (II)



wherein, R^+ can be

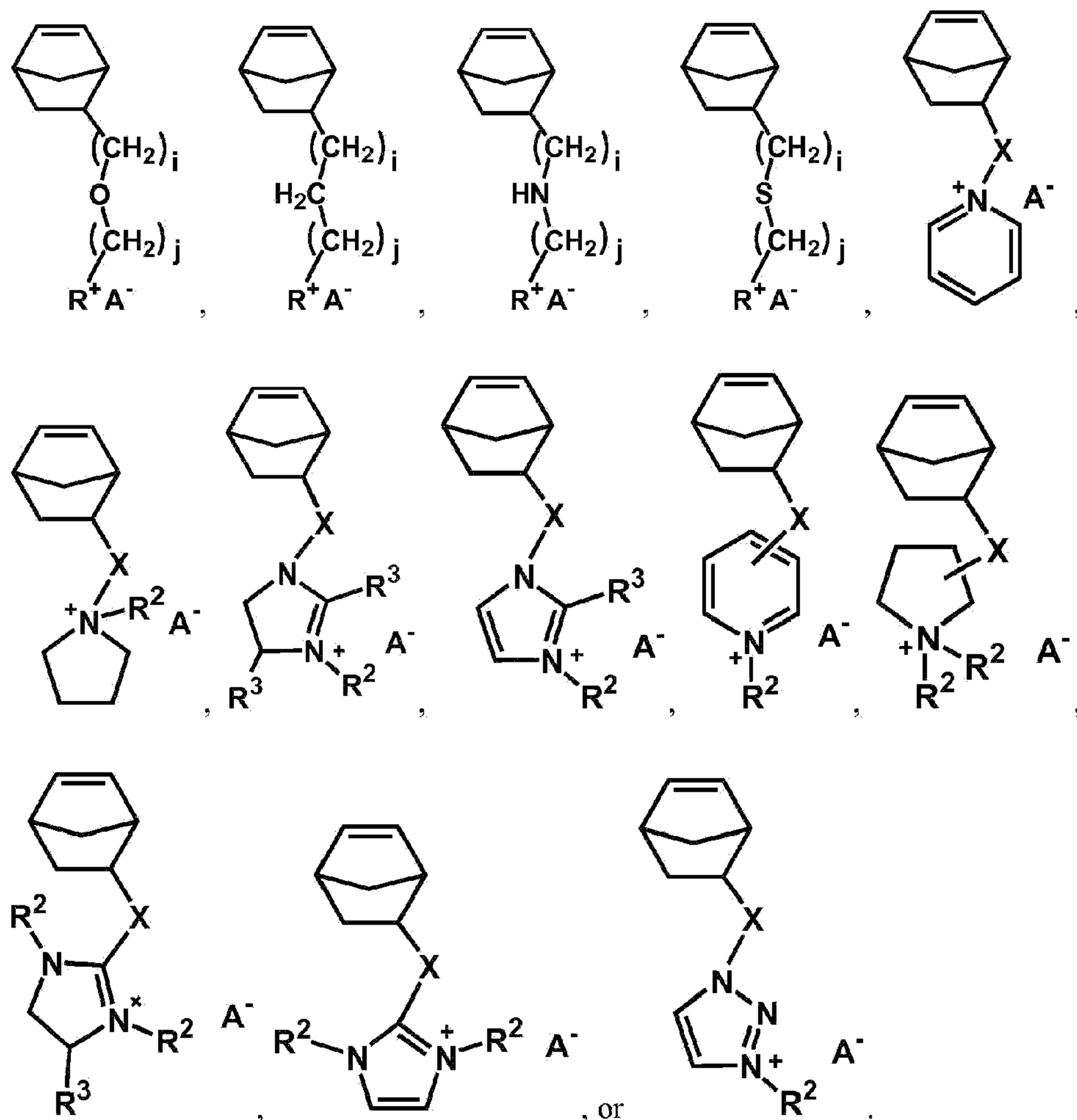


A^- can be F^- , Cl^- , Br^- , I^- , OH^- , HCO_3^- , HSO_4^- , SbF_6^- , BF_4^- , $H_2PO_4^-$, $H_2PO_3^-$, or $H_2PO_2^-$; X can be

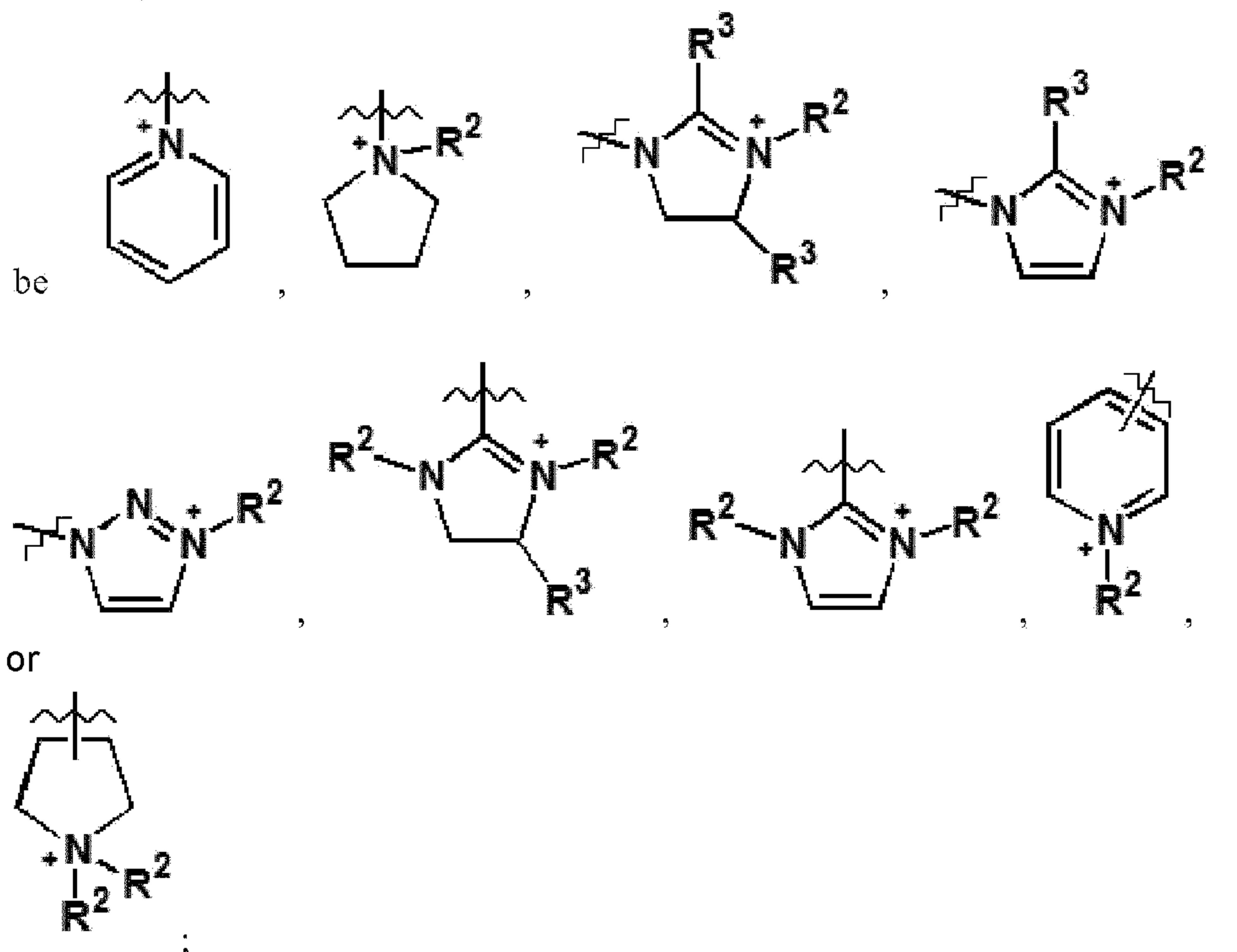


i and j can be independently 0, or an integer from 1 to 6, Y can be $-O-$, $-S-$, $-CH_2-$, or $-NH-$; R^1 can be independently C_{1-8} alkyl group; and, R^2 and R^3 can be independently hydrogen, or C_{1-8} alkyl group. In addition, a catalyst (such as the first generation or second generation Grubb's catalysts) can be further employed during the polymerization.

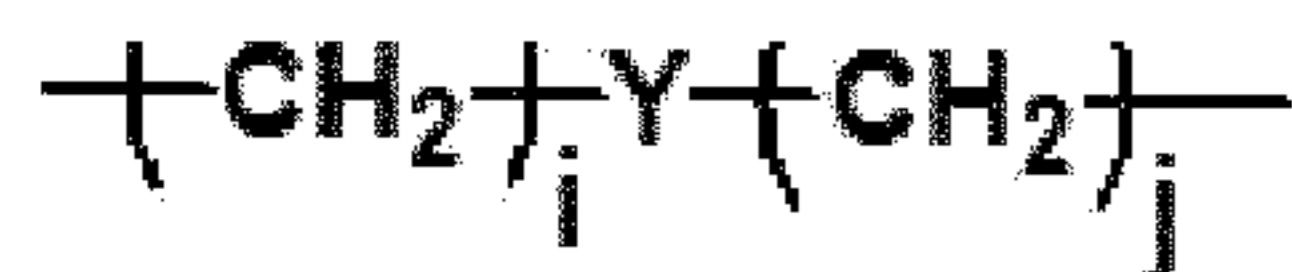
[0017] According to embodiments of the disclosure, the first monomer can be



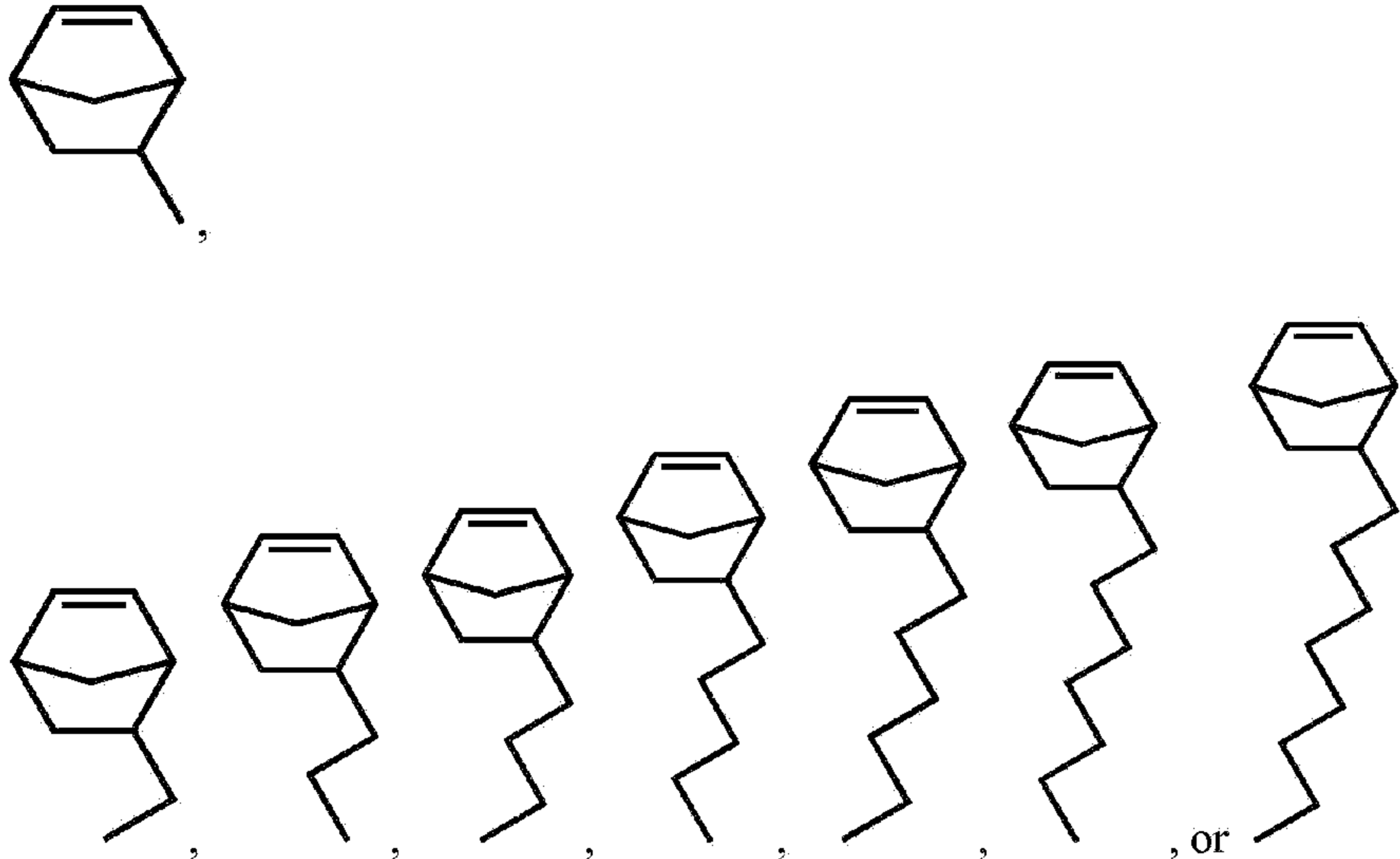
wherein, R⁺ can



A⁻ can be F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻, or H₂PO₂⁻; X can be

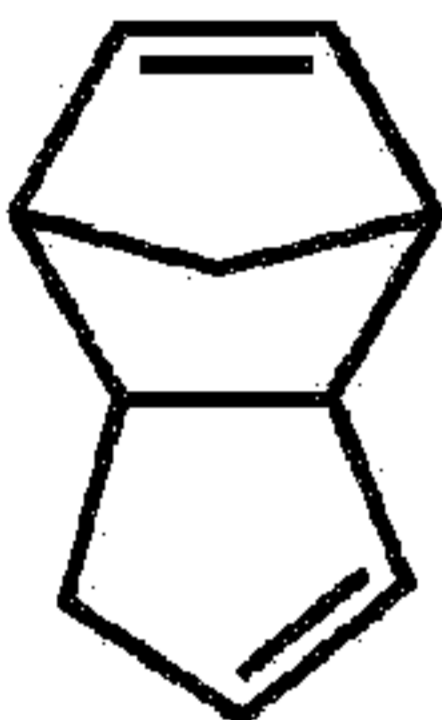


i and j can be independently 0, or an integer from 1 to 6, Y is $-\text{O}-$, $-\text{S}-$, $-\text{CH}_2-$, or $-\text{NH}-$; and, R^2 and R^3 are independently hydrogen, or C_{1-8} alkyl group (such as : methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, cyclohexyl, cyclopentyl, heptyl, or octyl). In addition, the second monomer can be



[0018] According to embodiments of the disclosure, the molar ratio between the first monomer and the second monomer is between about 1:99 and 99:1, such as between about 10:90 and 90:10, between about 20:80 and 80:20, or between about 30:70 and 70:30.

[0019] In addition, according to embodiments of the disclosure, the composition can further include a third monomer, wherein the third monomer can be

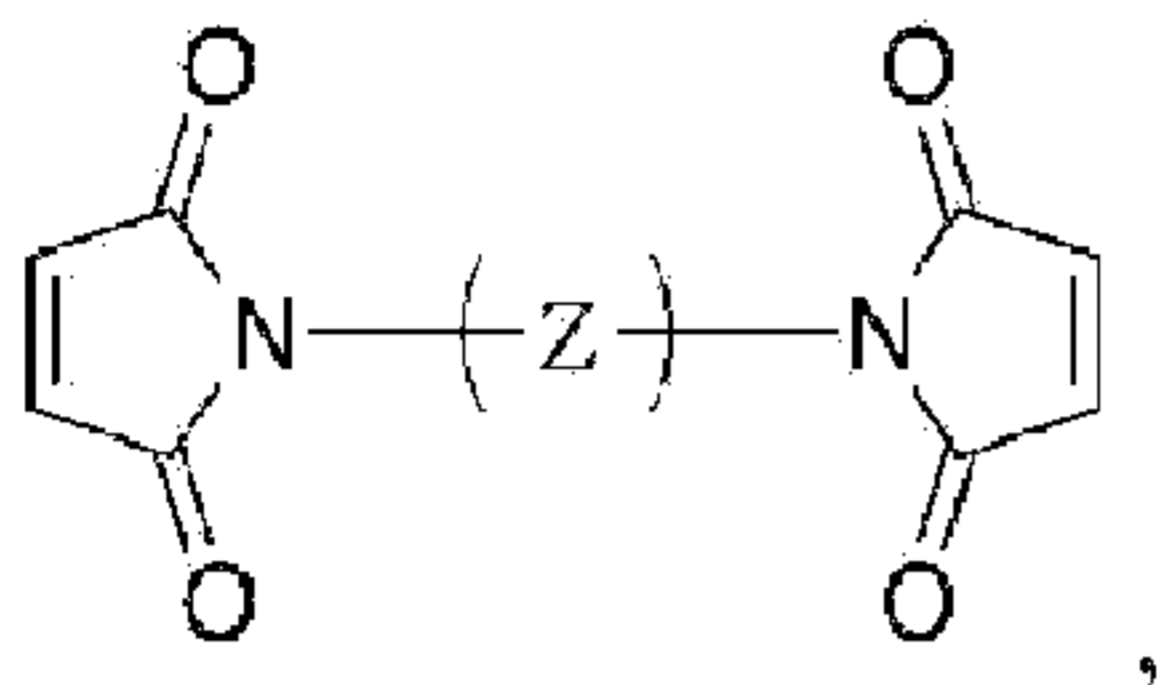


The molar ratio between the third monomer and the sum of the first monomer and the second monomer can be between about 0.1:100 and 5:100, such as between about 0.5:100 and 4:100, or between about 0.5:100 and 3:100.

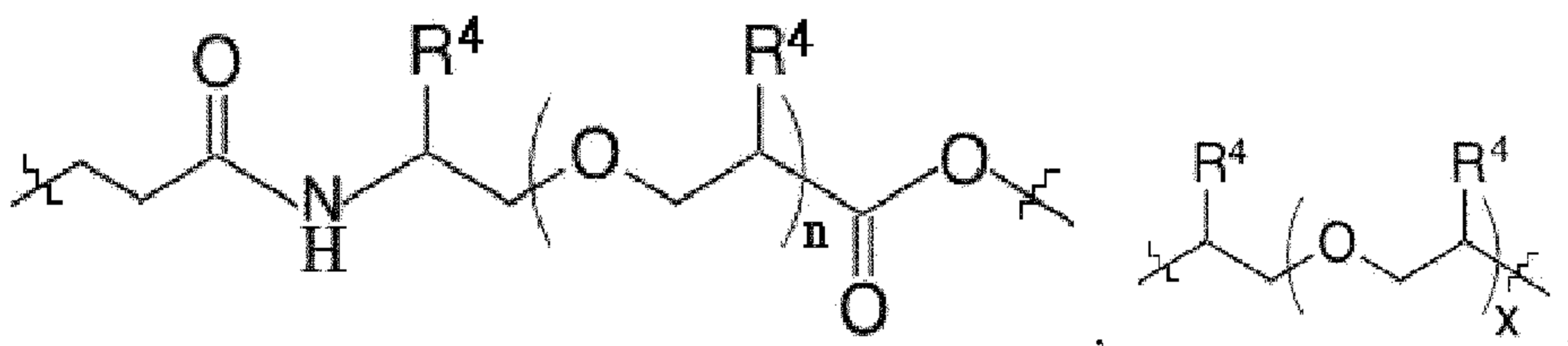
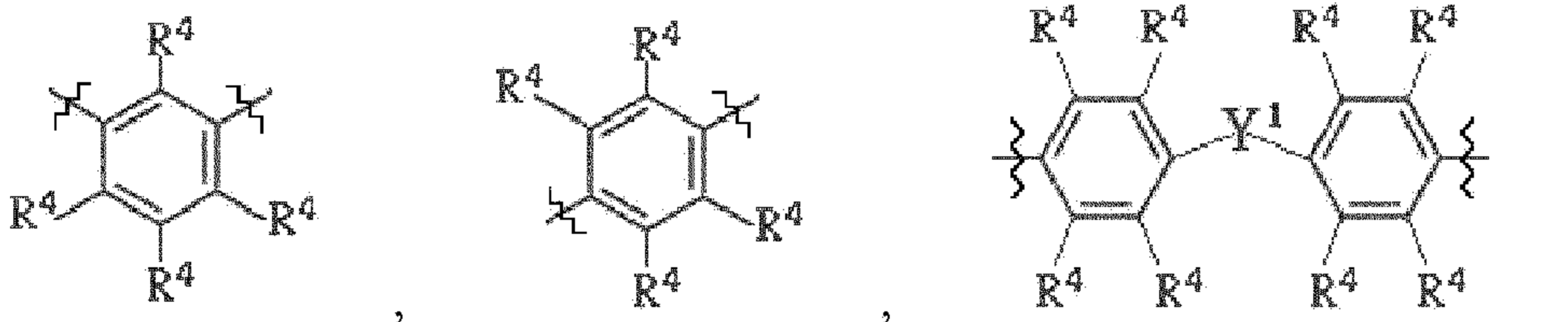
[0020] According to embodiments of the disclosure, the polymer of the disclosure can be used to prepare an ion exchange membrane. The method for preparing the ion exchange membrane includes the following steps. First, a composition is provided, wherein the composition includes the aforementioned polymer and a cross-linking agent. In addition, the composition can further include a solvent, and the composition has a solid content between about 5wt% and 50 wt%. In the composition, the cross-linking agent can have a weight percentage between about 1wt% and 30wt% (such as between about 5wt% and 30wt%, or between about 5wt% and 25wt%), based on the weight of the polymer. Next, the composition is subjected to a mixing and distributing process. Next, the composition is coated on a substrate

(such as a glass substrate) to form a coating. Next, the coating is baked to remove most of the solvent. Next, the coating formed on the substrate is baked in a high temperature oven to remove residual solvent. Finally, the coating is immersed in potassium hydroxide aqueous solution and deionized water for 1-3 hours sequentially. After drying, the ion exchange membrane of the disclosure is obtained.

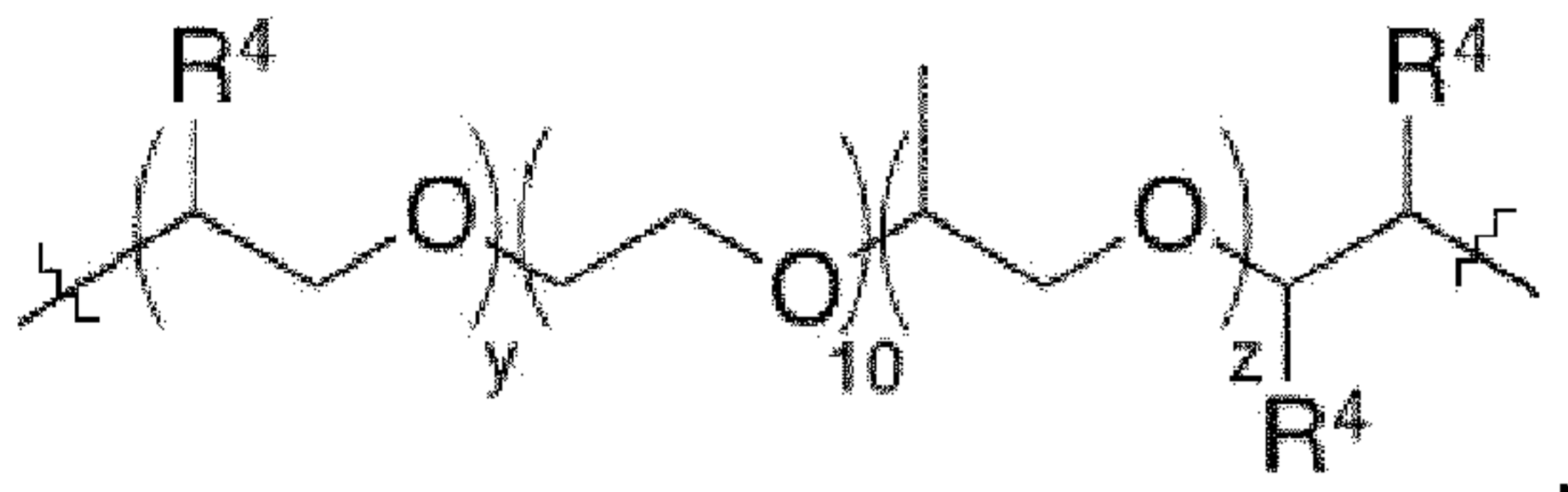
[0021] The cross-linking agent can be a compound having at least two maleimide groups. For example, the cross-linking agent can be a compound having two maleimide groups. According to embodiments of the disclosure, the compound having two maleimide groups can be



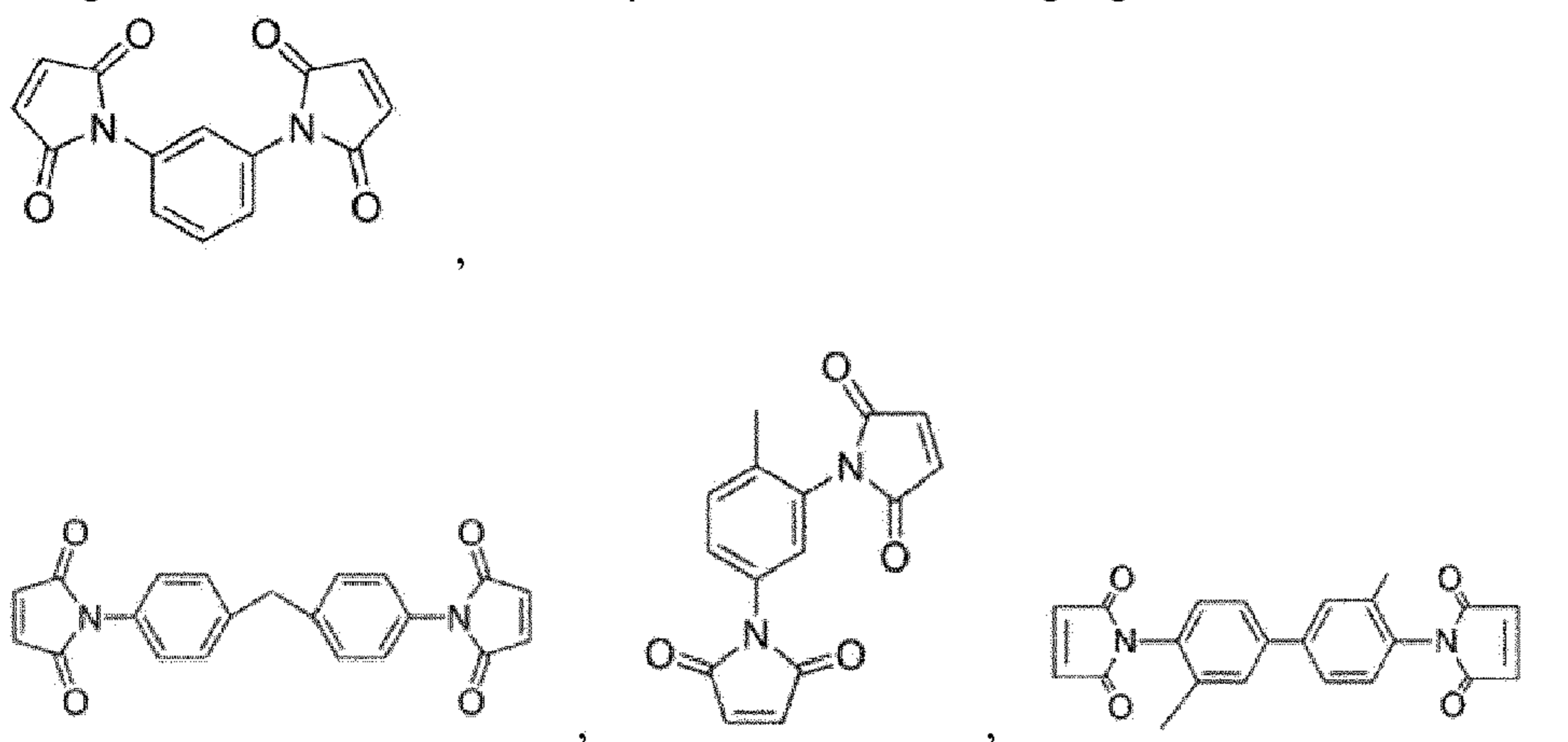
wherein Z can be

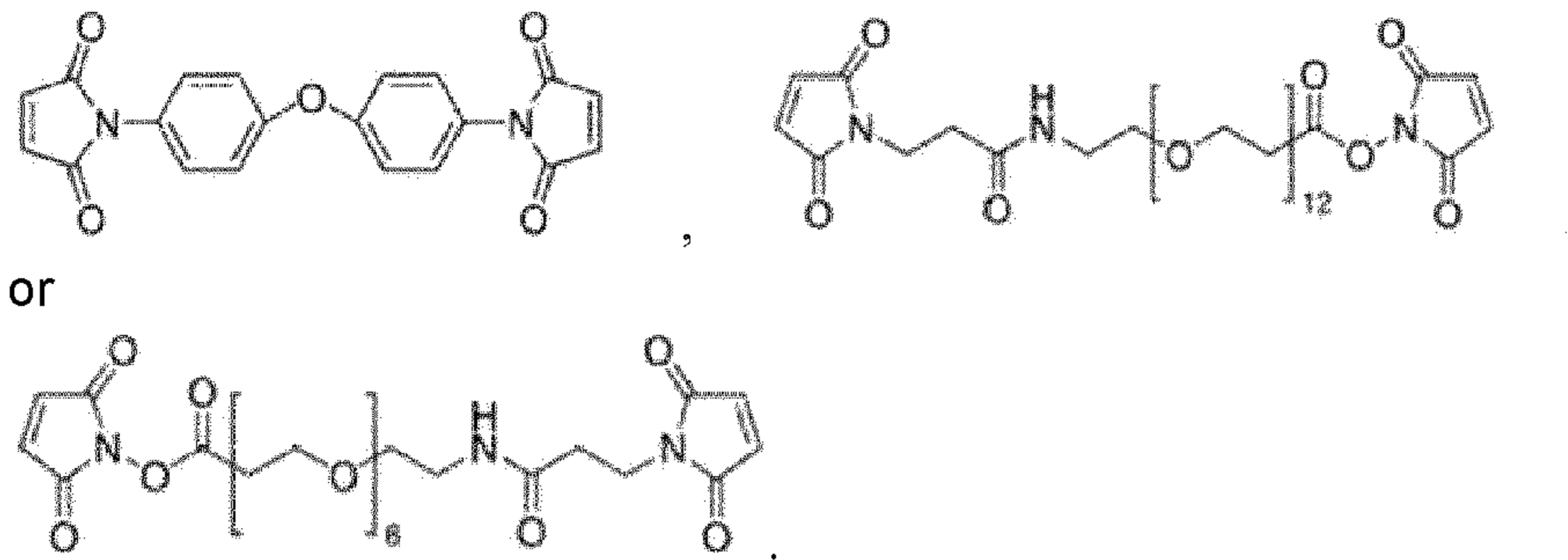


or

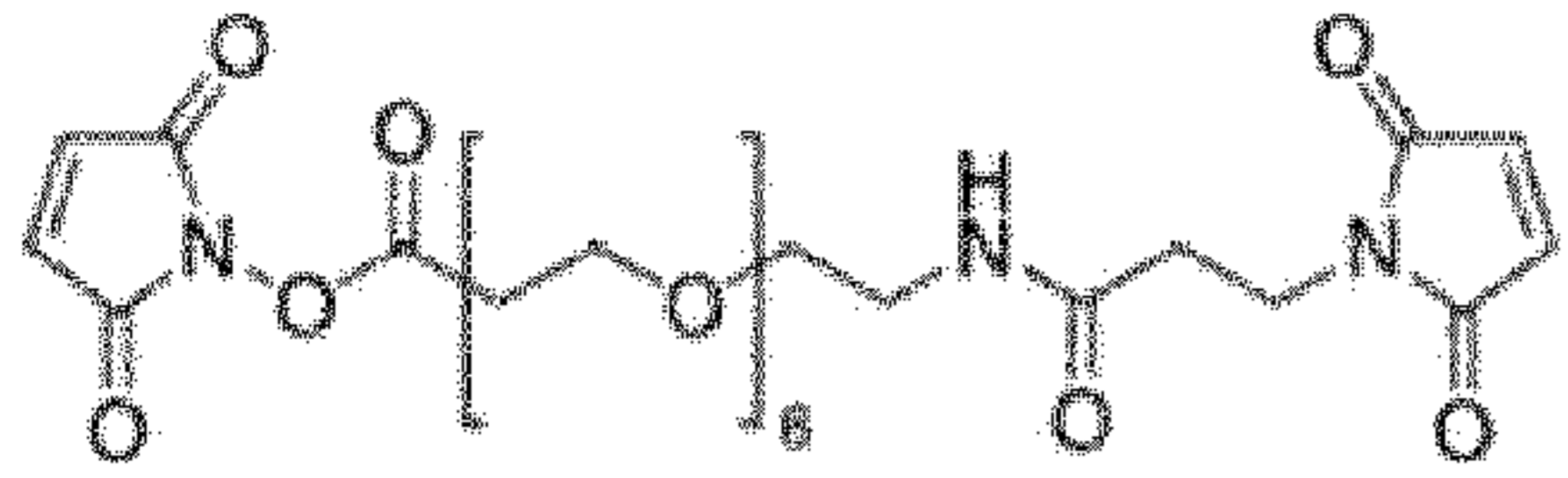


wherein Y¹ can be single bond, -O-, -S-, -CH₂-, or -NH-, R⁴ can be independently hydrogen, or C₁₋₄ alkyl group; n ≥ 1; x can be an integer from 1 to 12, y and z can be independently an integer from 1 to 5. For example, the cross-linking agent can be



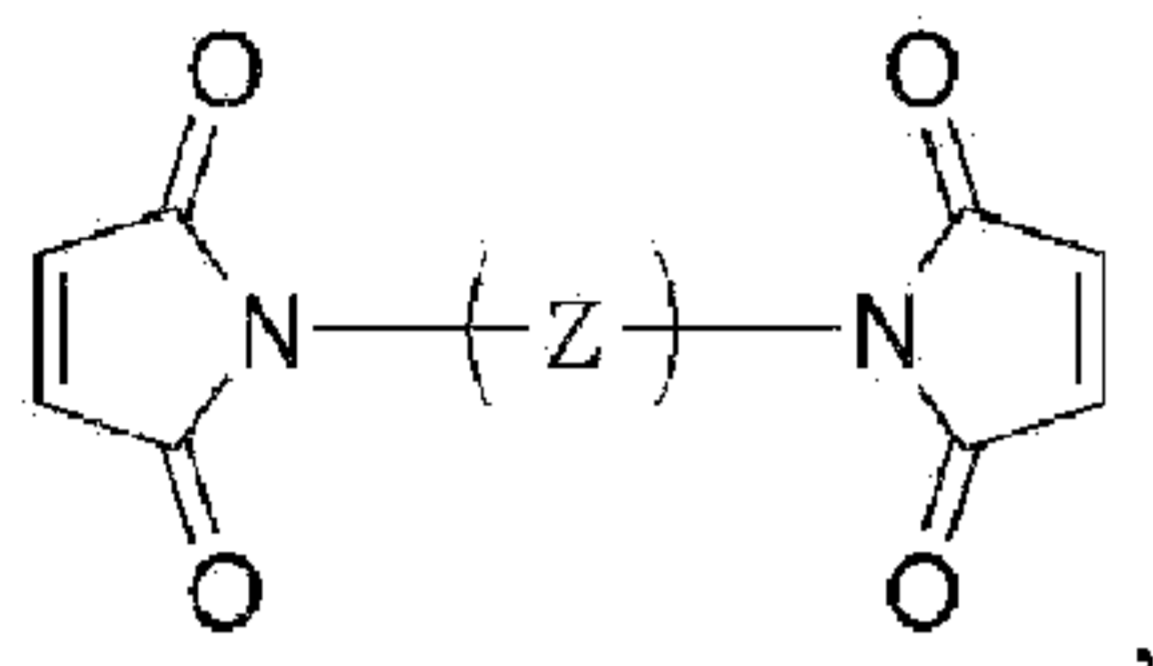


or

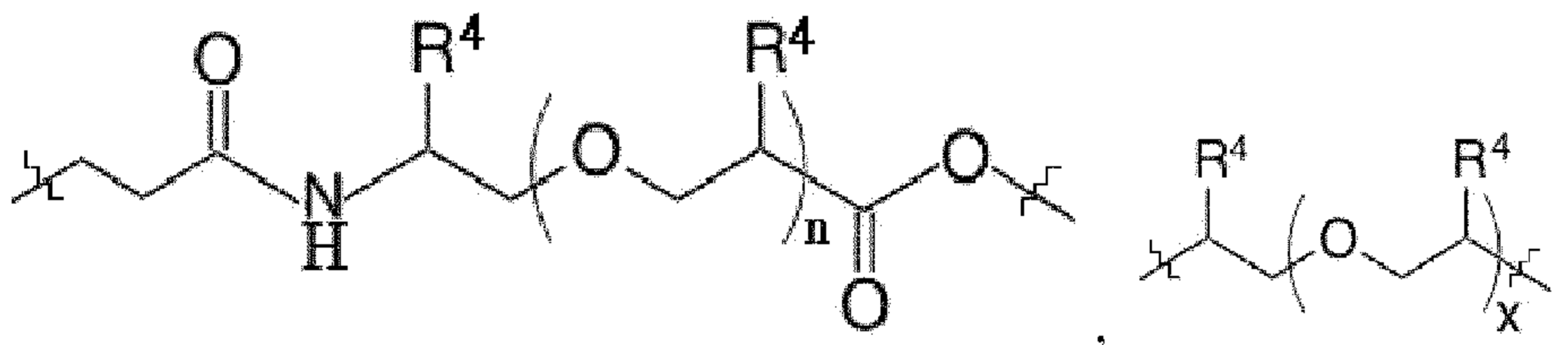
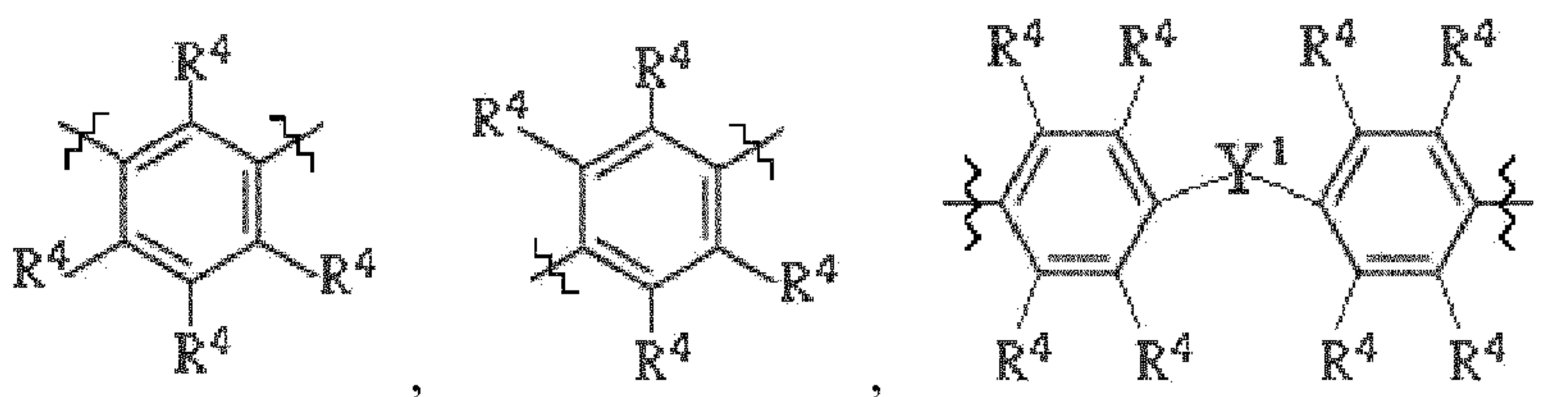


[0022] In addition, according to embodiments of the disclosure, the cross-linking agent can be a polymeric cross-linking agent having at least two maleimide groups. The polymeric cross-linking agent can be a reaction product of a compound

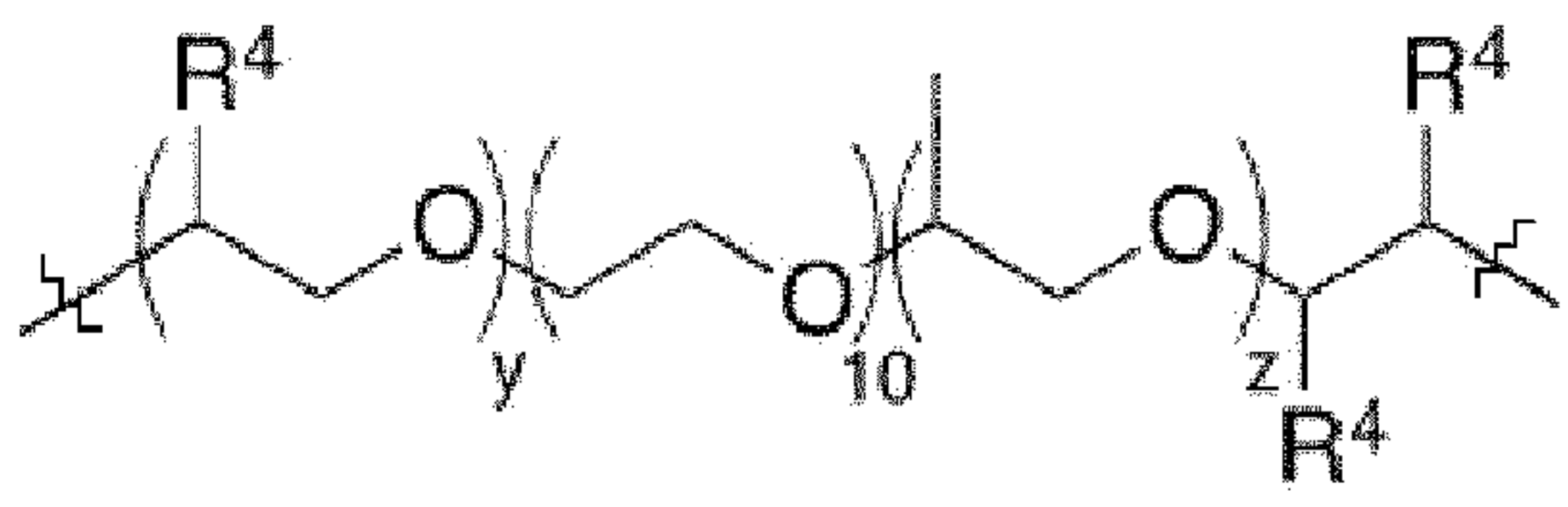
1. (a) and a compound (b). The compound (a) can be



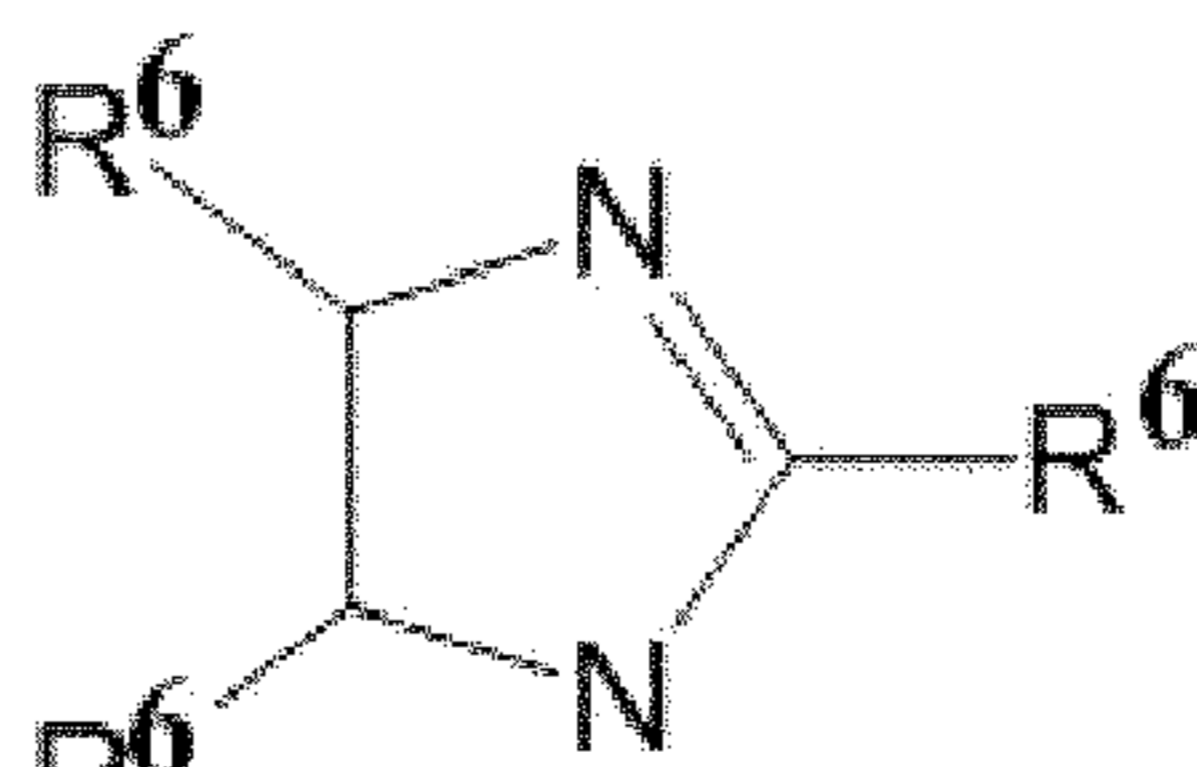
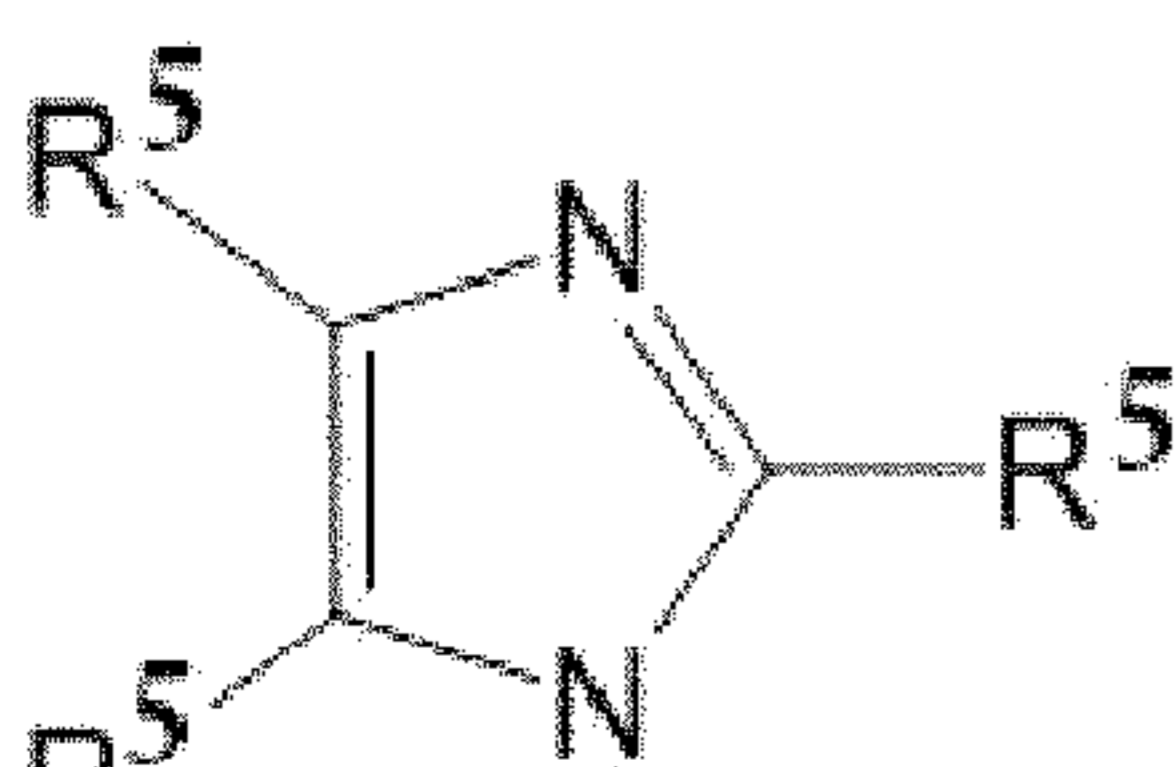
wherein Z can be

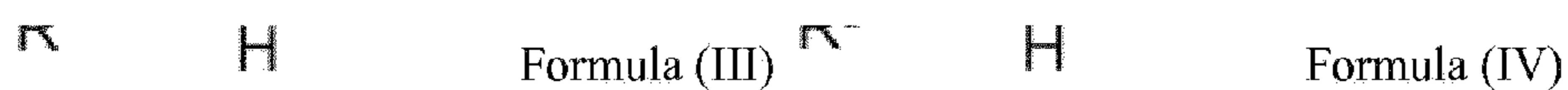


or

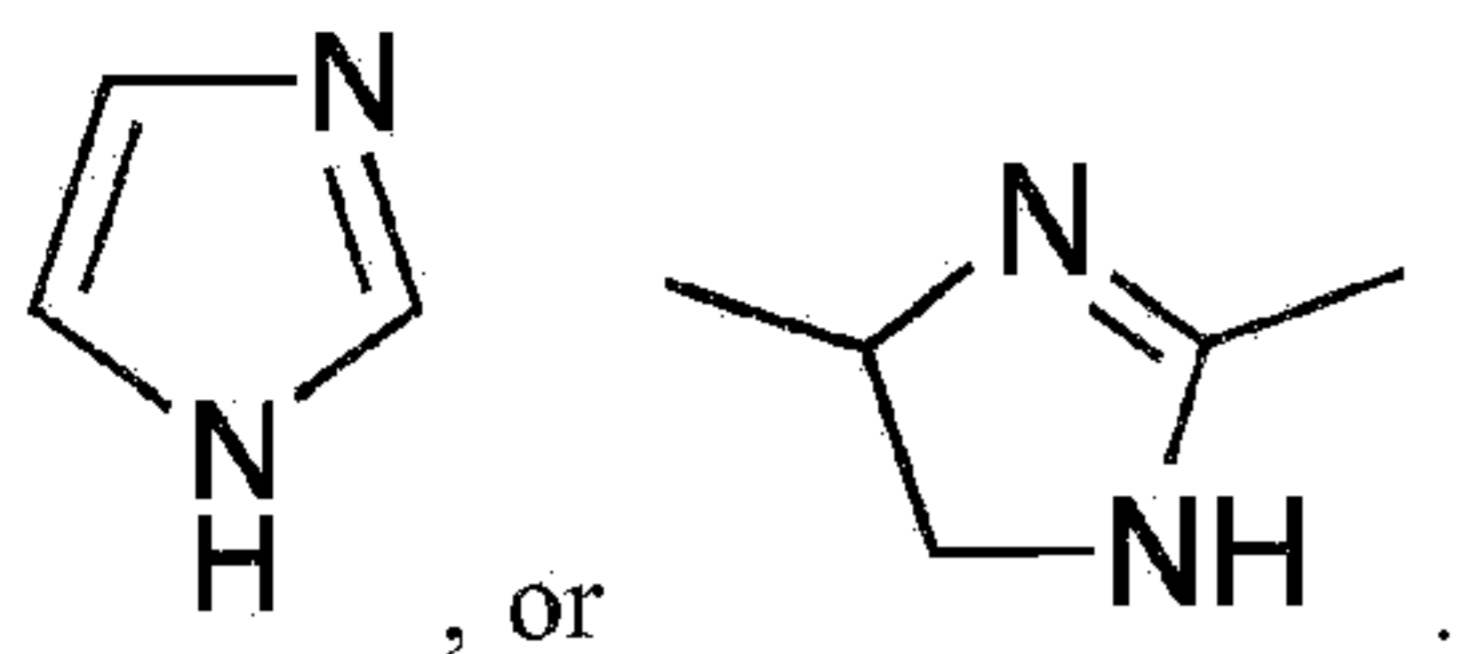


wherein Y^1 can be single bond, -O-, -S-, -CH₂-, or -NH-, R^4 can be independently hydrogen, or C₁₋₄ alkyl group; and, $n \geq 1$; x can be an integer from 1 to 12; and, y and z can be independently an integer from 1 to 5. The compound (b) can be a compound represented by Formula (III) or Formula (IV)





, wherein R⁵ is independently hydrogen, or C₁₋₄ alkyl group; and, R⁶ is independently hydrogen, or C₁₋₄ alkyl group. For example, the compound (b) can be



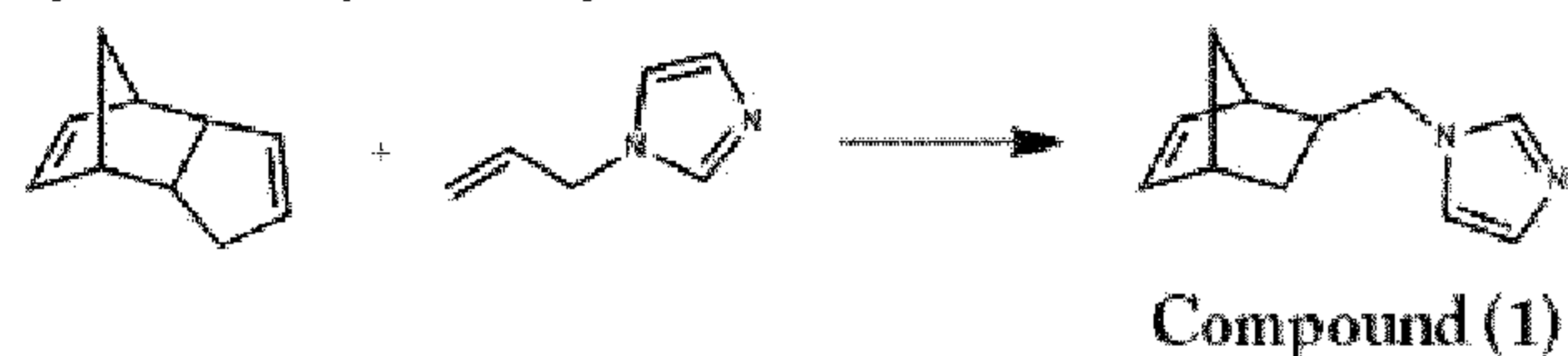
The polymeric cross-linking agent and the polymer can form an interpenetrating polymer network, thereby enhancing the mechanical strength and dimensional stability.

[0023] Below, exemplary embodiments will be described in detail so as to be easily realized by a person having ordinary knowledge in the art. The disclosure concept may be embodied in various forms without being limited to the exemplary embodiments set forth herein. Descriptions of well-known parts are omitted for clarity.

Preparation of monomer with cationic group

Preparation Example 1

[0024] 10ml of dicyclopentadiene (0.074 mmol) and 20.15ml of 1-allylimidazole (0.186 mmol) were added into a high-pressure reactor. After stirring at 180 °C for 8 hours, the result was purified by fractionation and column chromatography (using ethyl acetate (EA) and hexane (9:1) as the eluent), obtaining Compound (1) (colorless transparent viscous liquid). The synthesis pathway of the above reaction was as follows:



[0025] Compound (1) was analyzed by nuclear magnetic resonance (NMR) spectroscopy and the result is as follows: ¹H NMR (300 MHz, CDCl₃): δ 7.46 (d, J = 15.3, 1H), 6.98 (m, 2H), 6.12 (m, 2H), 3.79 (m, 2H), 2.66 (m, 3H), 1.89 (m, 1H), 1.33 (m, 2H), 0.62 (m, 1H).

[0026] Next, 0.5g of Compound (1) (2.87 mmol) and 0.268 ml of methyl iodide (4.30 mmol) were added into a reaction bottle. After stirring at room temperature (about 25 °C) for 8 hours and then removing residual methyl iodide by vacuum distillation, Compound (2) (yellow viscous liquid) was obtained. The synthesis pathway of the above reaction was as follows:

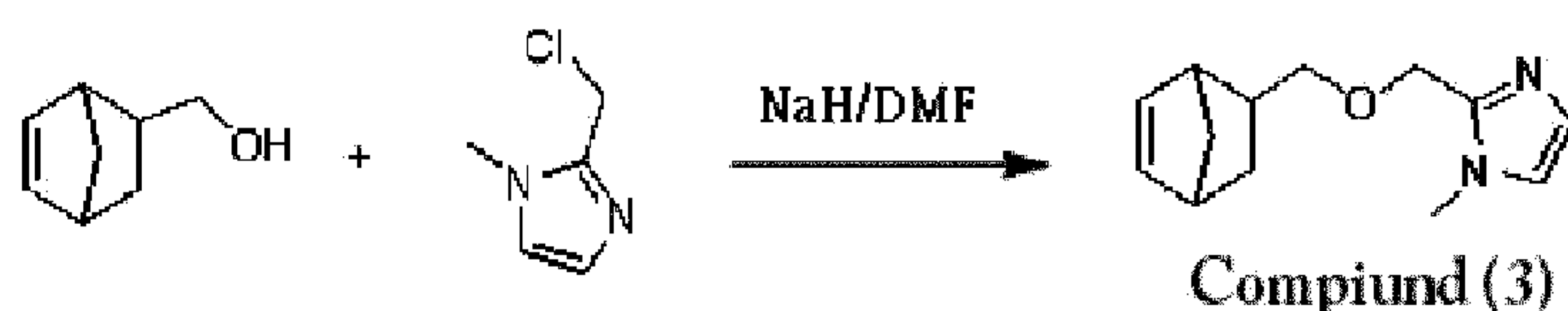




[0027] Compound (2) was analyzed by nuclear magnetic resonance (NMR) spectroscopy and the result is as follows: ^1H NMR (300 MHz, CDCl_3): δ 10.03 (d, $J = 12.0$ Hz, 1H), 7.42 (m, 2H), 6.21 (m, 2H), 4.19 (m, 5H), 2.74 (m, 3H), 1.99 (m, 1H), 1.41 (m, 2H), 0.67 (m, 1H)

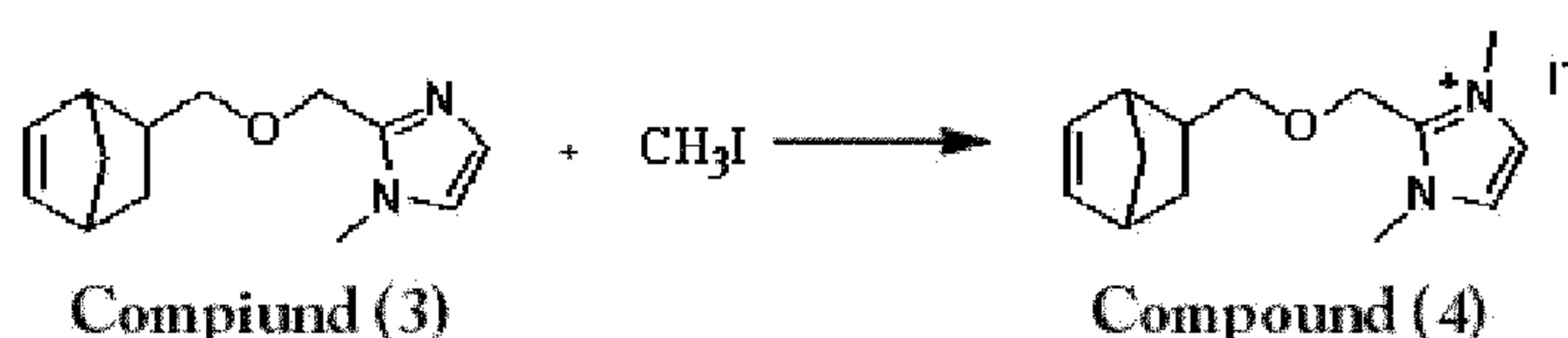
Preparation Example 2

[0028] 15ml of dimethylformamide (DMF) was added into a reaction bottle. Next, 1.7g of sodium hydride (NaH) (0.00427 mol) was added into the reaction bottle at 0°C . Next, 2.122g of 5-Norbornene-2-methanol (0.0171 mol) was added into the reaction bottle at 0°C . After stirring, 2g of 1-methyl-2-(chloromethyl) imidazole (0.0154 mol) was added into the reaction bottle. After stirring for 12 hours, water was added into the reaction bottle to quench the reaction, and then the result was extracted by dichloromethane. After concentration, the result was purified by fractionation, obtaining Compound (3). The synthesis pathway of the above reaction was as follows:



[0029] Compound (3) was analyzed by nuclear magnetic resonance (NMR) spectroscopy and the result is as follows: ^1H NMR (300 MHz, CDCl_3): δ 6.90 (s, 2H), 6.10-5.76 (m, 2H), 4.59-4.81 (m, 2H), 3.71 (s, 3H), 3.51-3.00(m, 2H), 2.86-2.69(m, 2H), 2.33(m, 1H), 1.84-1.66 (m, 1H), 1.41-1.10(m, 2H), 0.47-0.43(m, 1H)

[0030] Next, 2g of Compound (3) (9 mmol) was added into a reaction bottle and dissolved in dichloromethane. Next, 1 ml of methyl iodide (17 mmol) was added into the reaction bottle. After stirring at room temperature for 12 hours, residual methyl iodide and solvent were removed, obtaining Compound (4) (yellow viscous liquid). The synthesis pathway of the above reaction was as follows:



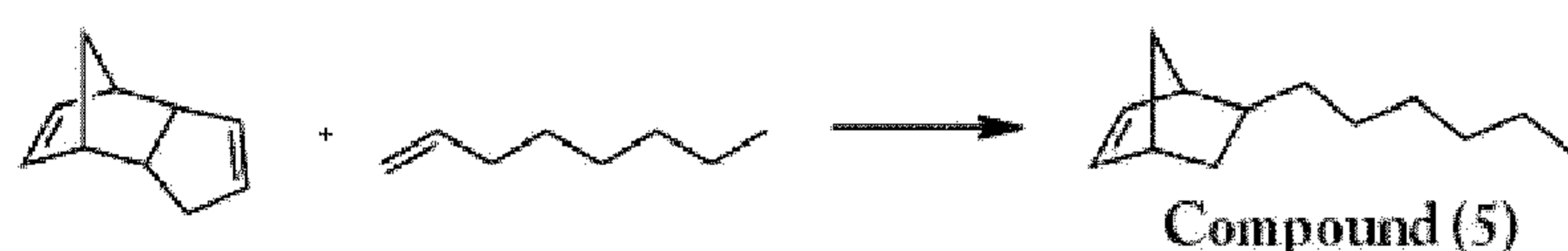
[0031] Compound (4) was analyzed by nuclear magnetic resonance (NMR) spectroscopy and the result is as follows: ^1H NMR (300 MHz, CDCl_3): δ 7.45 (s, 2H), 6.18-5.84(m, 2H), 4.90(s, 2H), 3.98(s, 6H), 3.68-3.20(m, 2H), 2.35(m, 1H), 1.86-1.78(m, 1H), 1.46-1.14(m, 4H), 0.52-

0.51(m, 1H)

Preparation of monomer with non-ionic group

Preparation Example 3

[0032] 13.4ml of dicyclopentadiene (0.1 mmol) and 36ml of 1-octene (0.23 mmol) were added into a high-pressure reactor. After stirring at 240°C for 12 hours, the result was filtered through neutral alumina to remove the yellow suspension. Next, the result was purified by fractionation, obtaining Compound (5) (colorless transparent viscous liquid). The synthesis pathway of the above reaction was as follows:

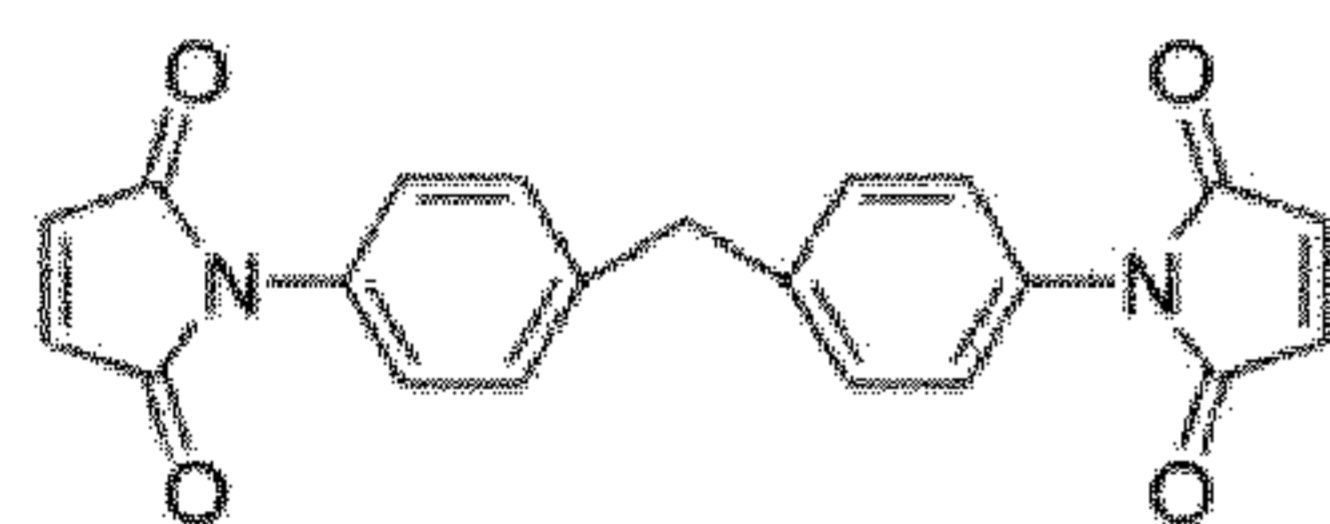


[0033] Compound (5) was analyzed by nuclear magnetic resonance (NMR) spectroscopy and the result is as follows: ^1H NMR (300 MHz, CDCl_3): δ 6.08 (m, 1H, endo), 6.04 (m, 1H, exo), 5.90 (m, 1H, endo), 2.67-2.77 (m, 2H), 2.48 (m, 1H, exo), 1.97 (m, 1H, endo), 1.80 (m, 1H, endo), 1.14-1.38 (m, 11H), 0.82-0.90(m, 3H), 0.43-0.50(m, 1H, endo)

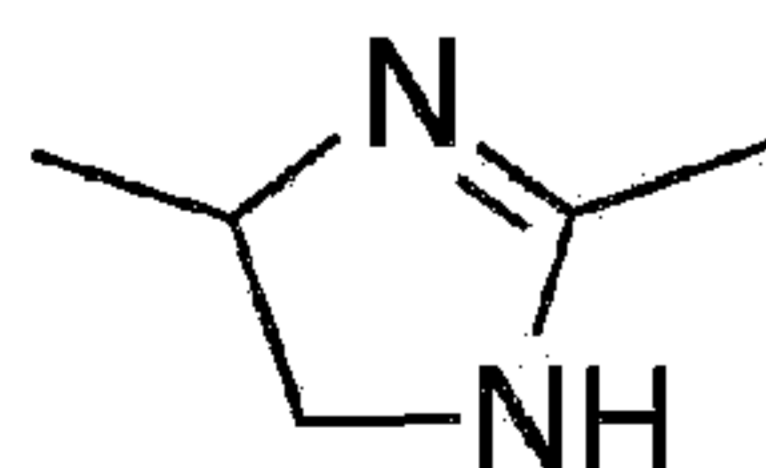
Preparation of cross-linking agent

Preparation Example 4

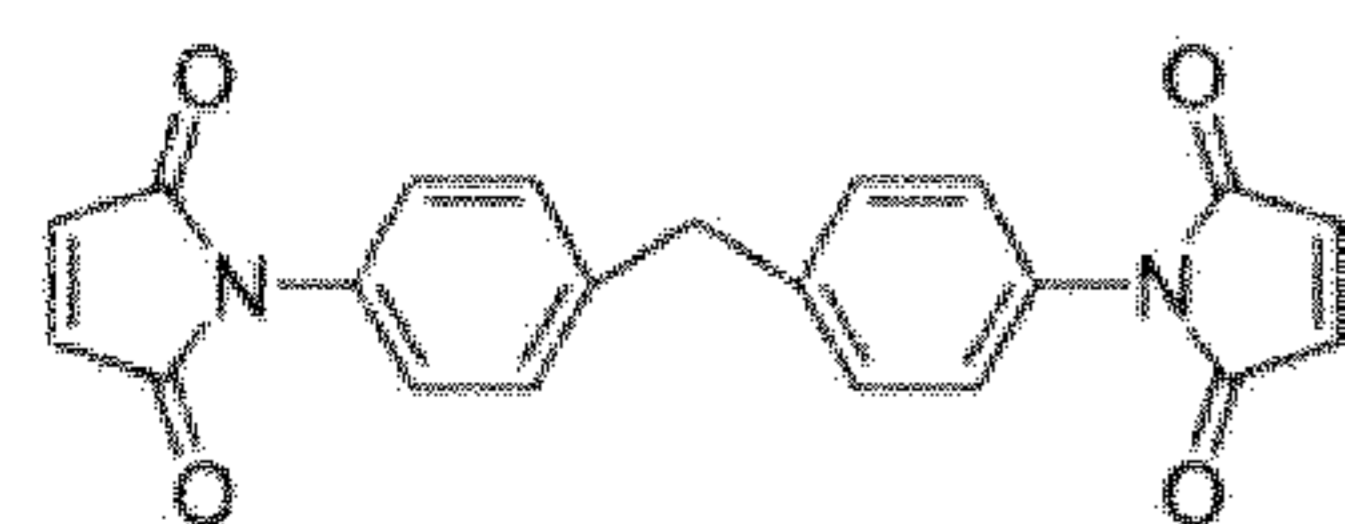
[0034] 2.73g of



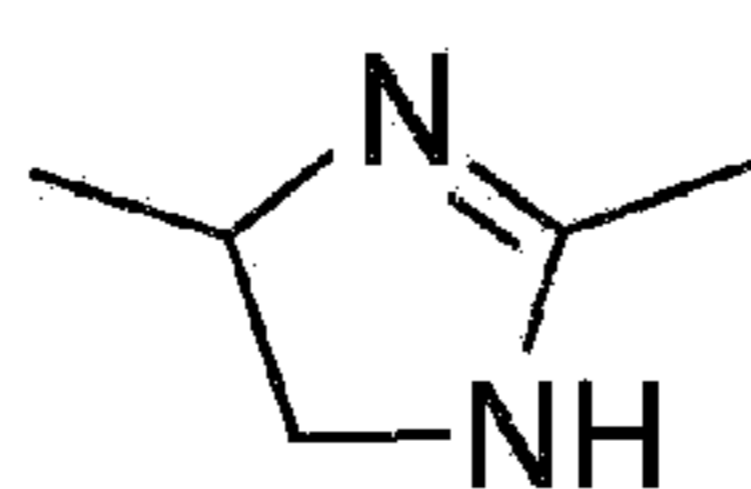
and 0.37g of



were added into a reaction bottle, wherein the molar ratio of the



and

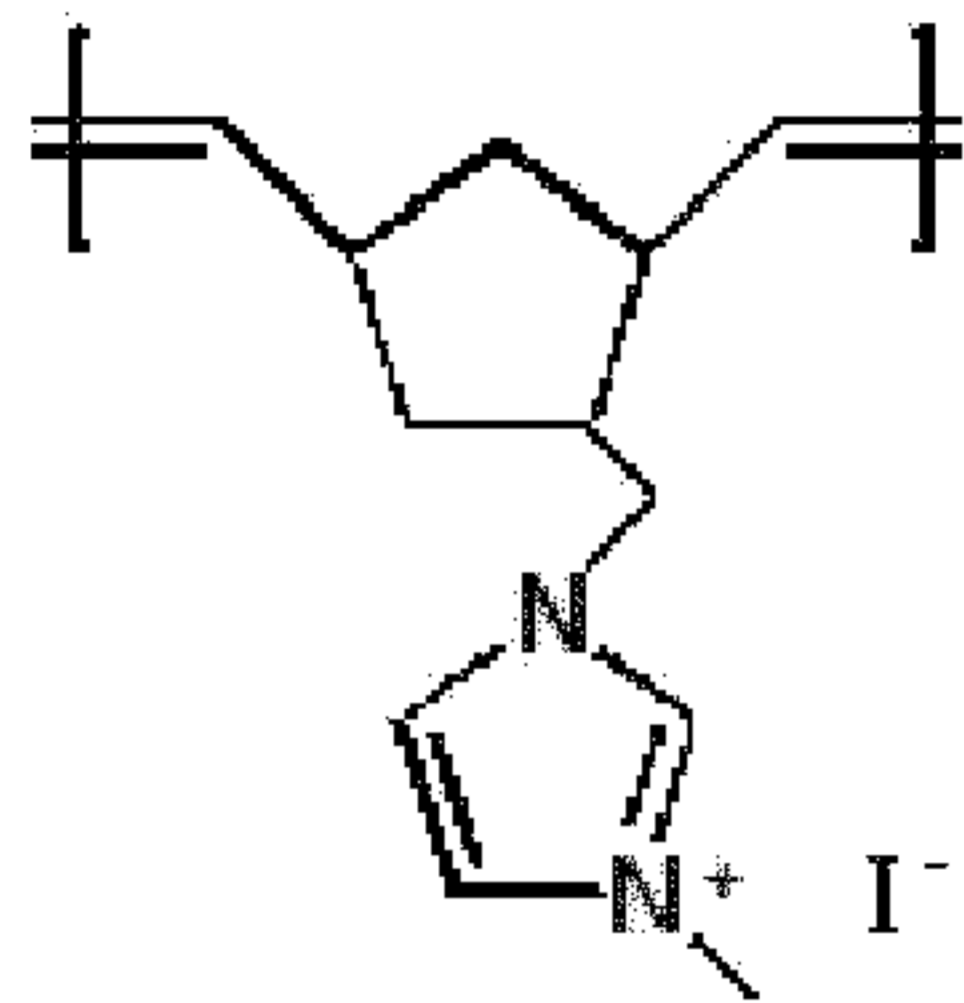


was 2:1). Next, 97g of dimethylacetamide (DMAc) was added into the reaction bottle. After stirring at 100-150°C for 5-10 hours, Polymeric cross-linking agent (1) was obtained.

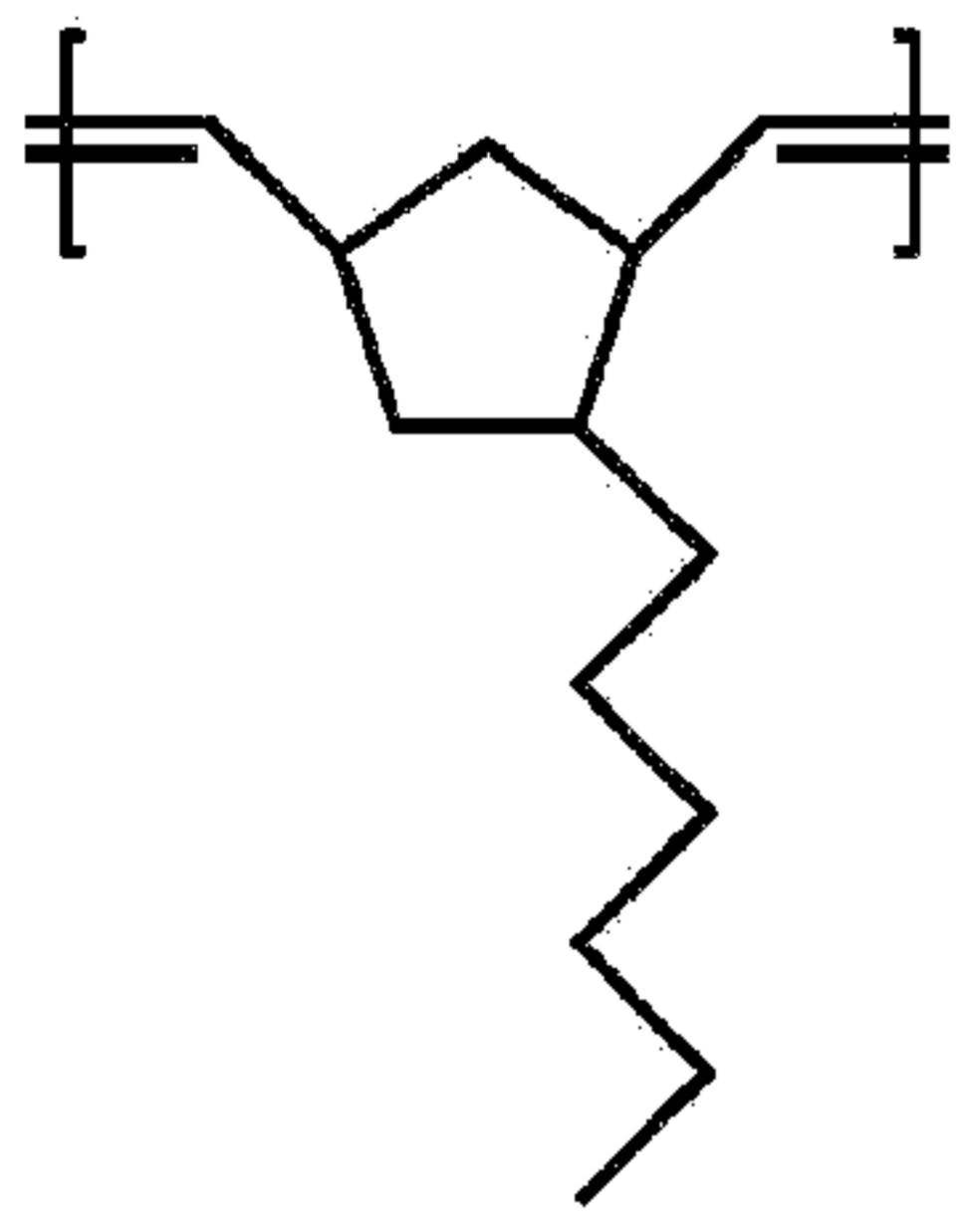
Preparation of polymer

Example 1

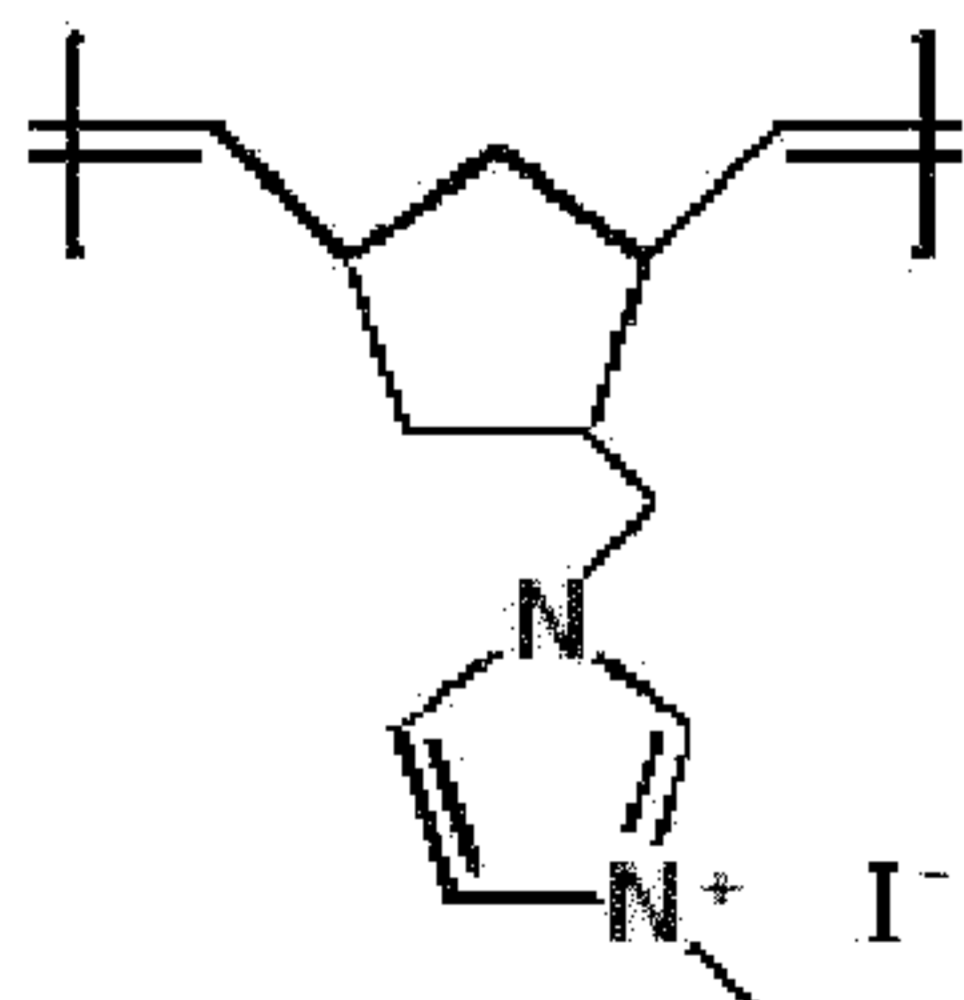
[0035] 3.08g of Compound (2) (9.74 mmole) and 0.19g of Compound (5) (1.08 mmole) were added into a reaction bottle under a nitrogen atmosphere, wherein the molar ratio of Compound (2) and Compound (5) was about 9:1. Next, 30 ml of dichloromethane was added into the reaction bottle. Next, Grubbs's solution (9.2mg, dissolved in 6ml of dichloromethane) was slowly added into the reaction bottle at 30 °C. After stirring for 4 hours, the result was slowly added into 250 ml of ethyl ether. After stirring for about 30 minutes and concentration, the result was washed with 100ml of acetone, and then the solid was collected. After drying, Polymer (1) (having a repeat unit represented by



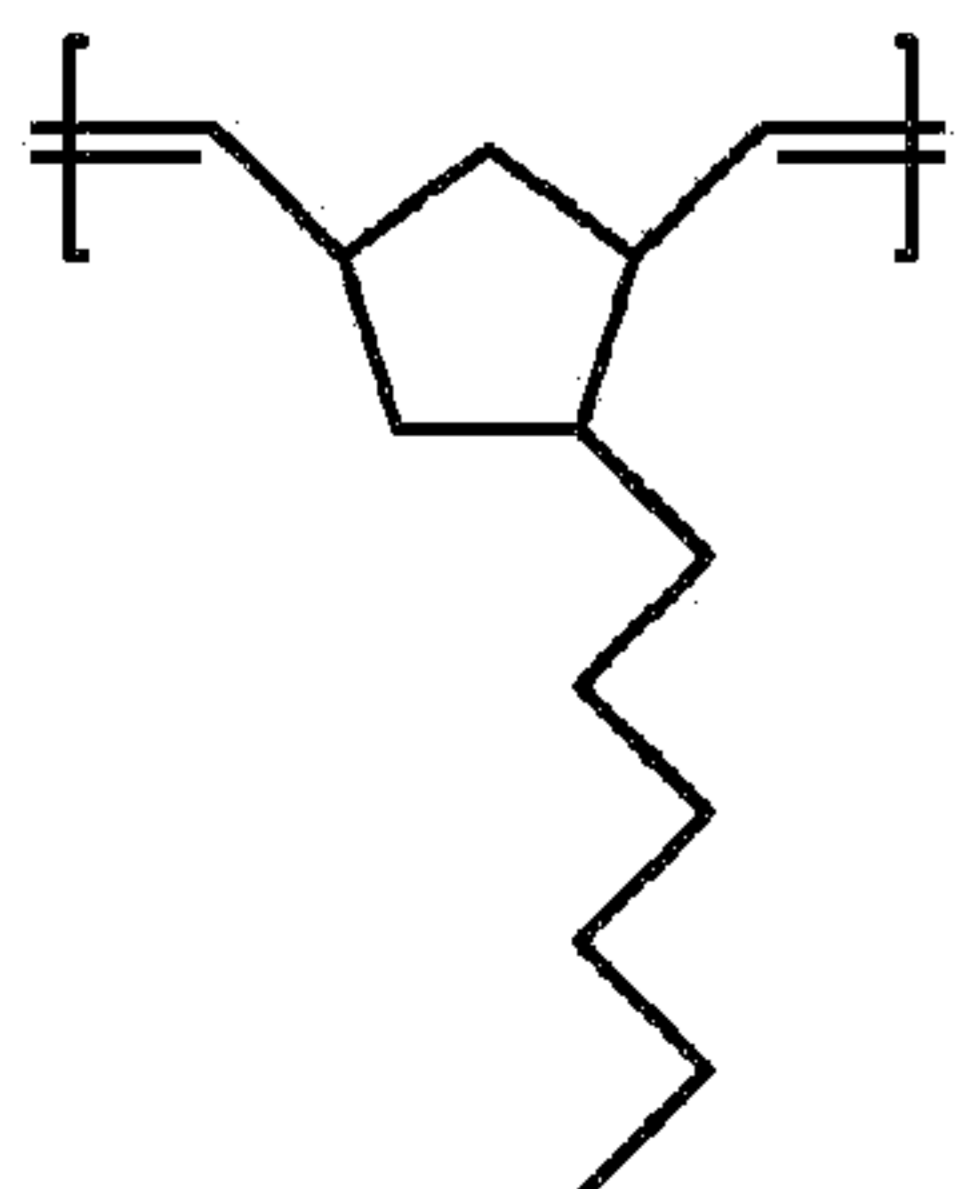
and a repeat unit represented by



wherein the ratio of the repeat unit represented by



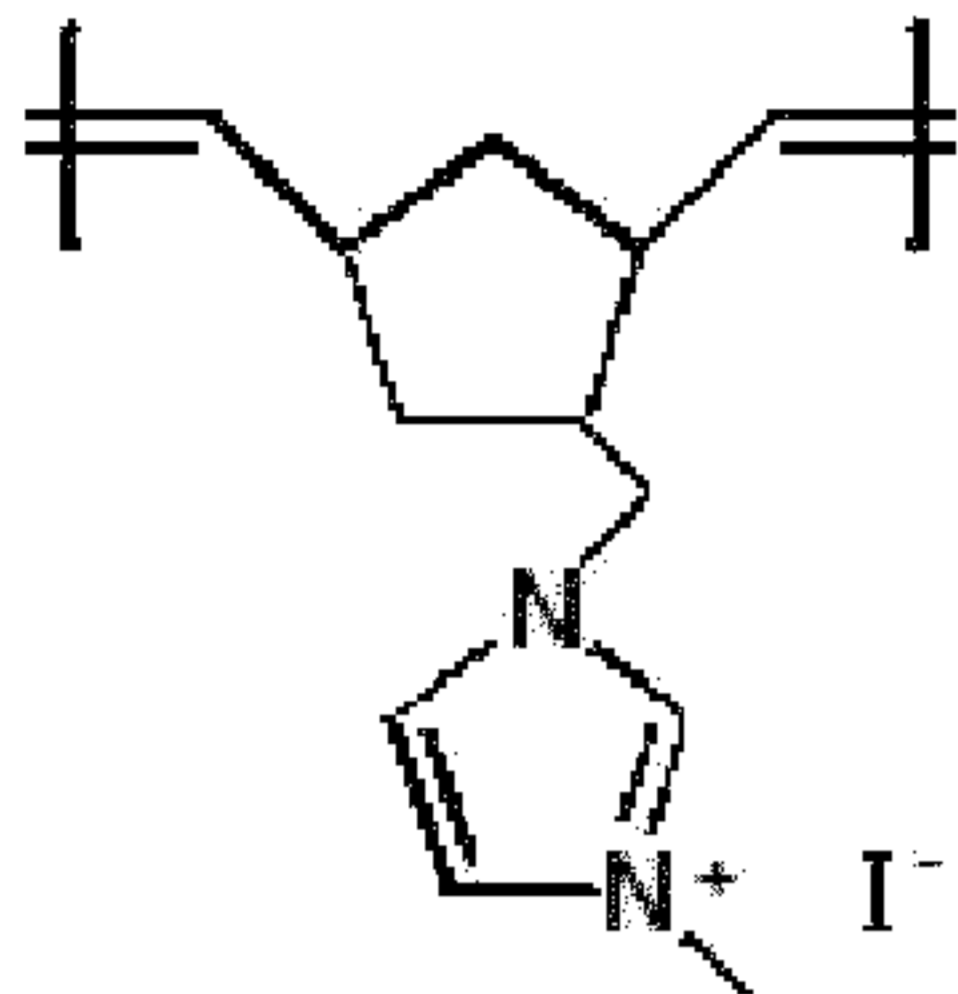
and the repeat unit represented by



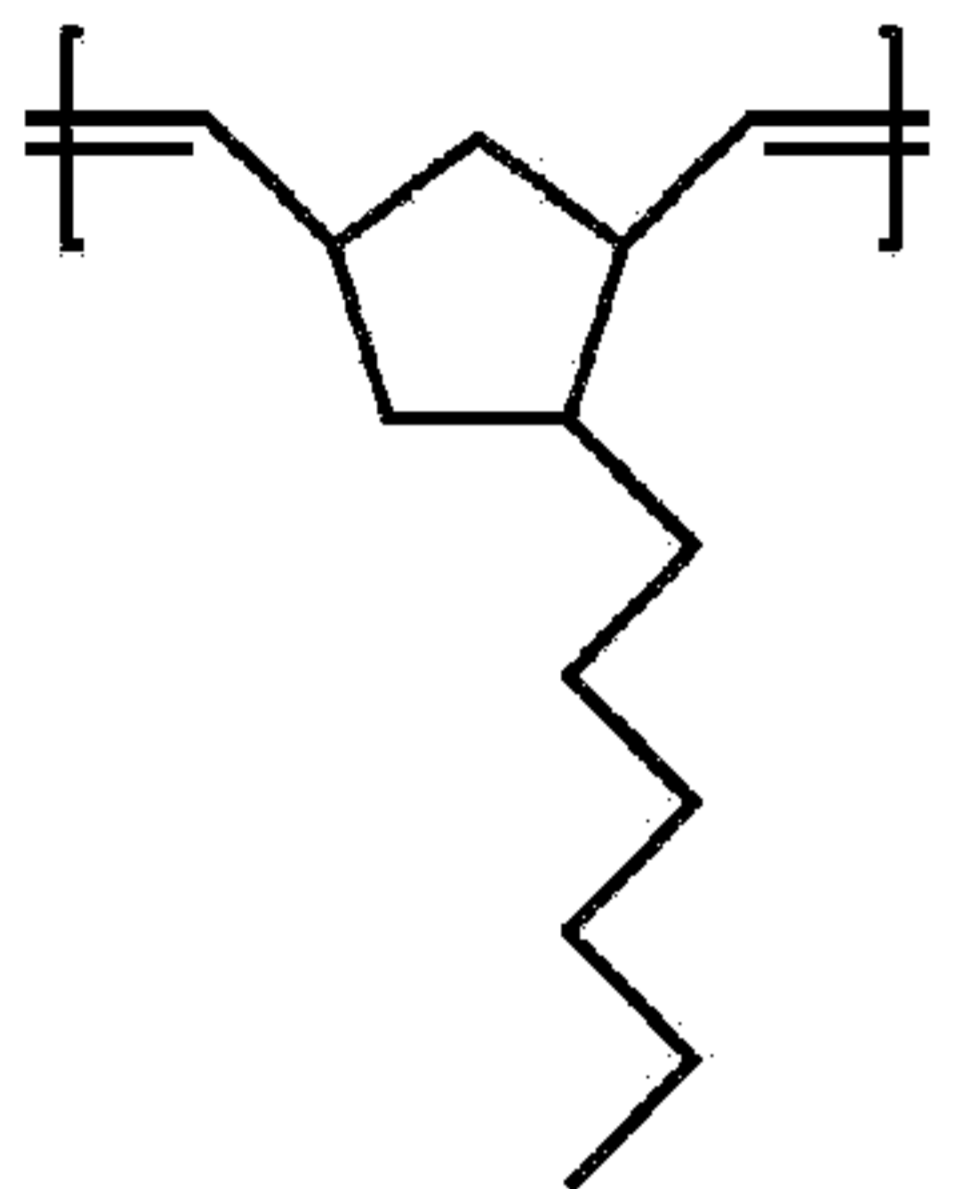
was about 9:1) was obtained. After measurement, the number average molecular weight (M_n) of Polymer (1) is about 110,000, and the polydispersity index (PDI) of Polymer (1) is about 1.4.

Example 2

[0036] Example 2 was performed in the same manner as in Example 1 except that the molar ratio of Compound (2) and Compound (5) was about 8:2, obtaining Polymer (2) (the ratio of the repeat unit represented by



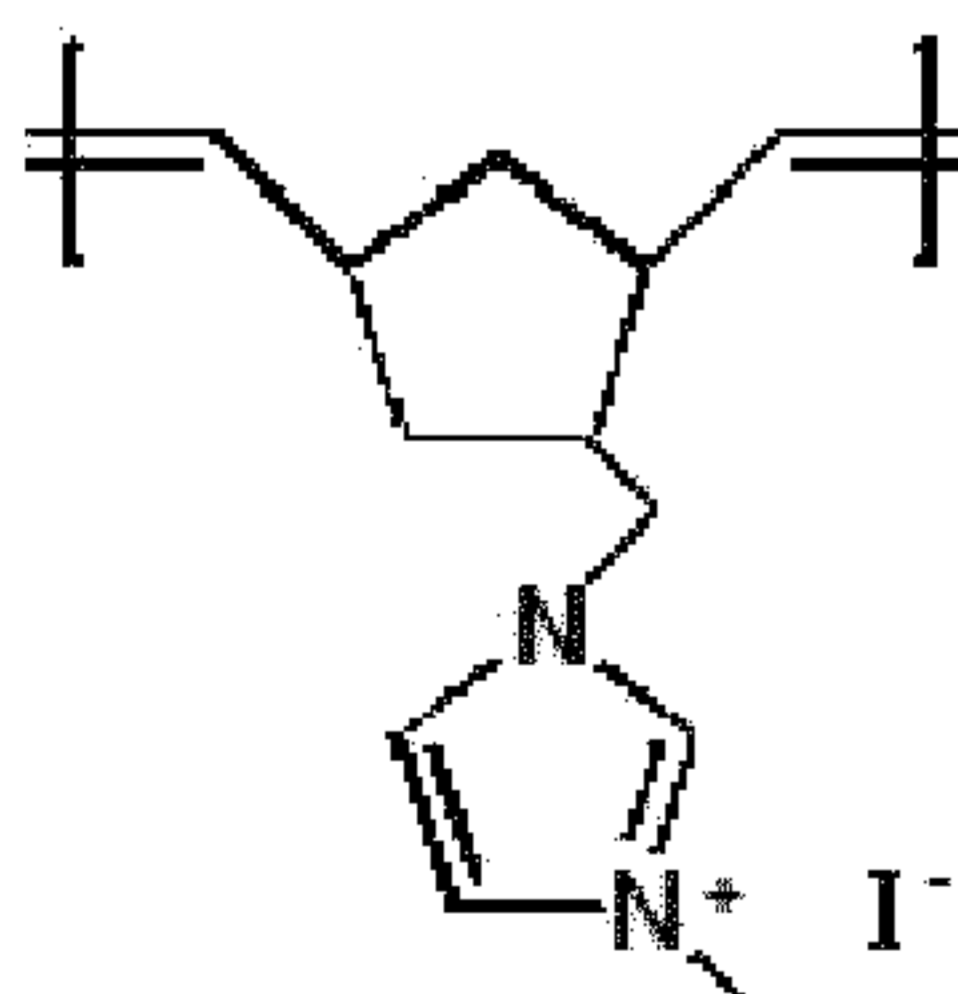
and the repeat unit represented by



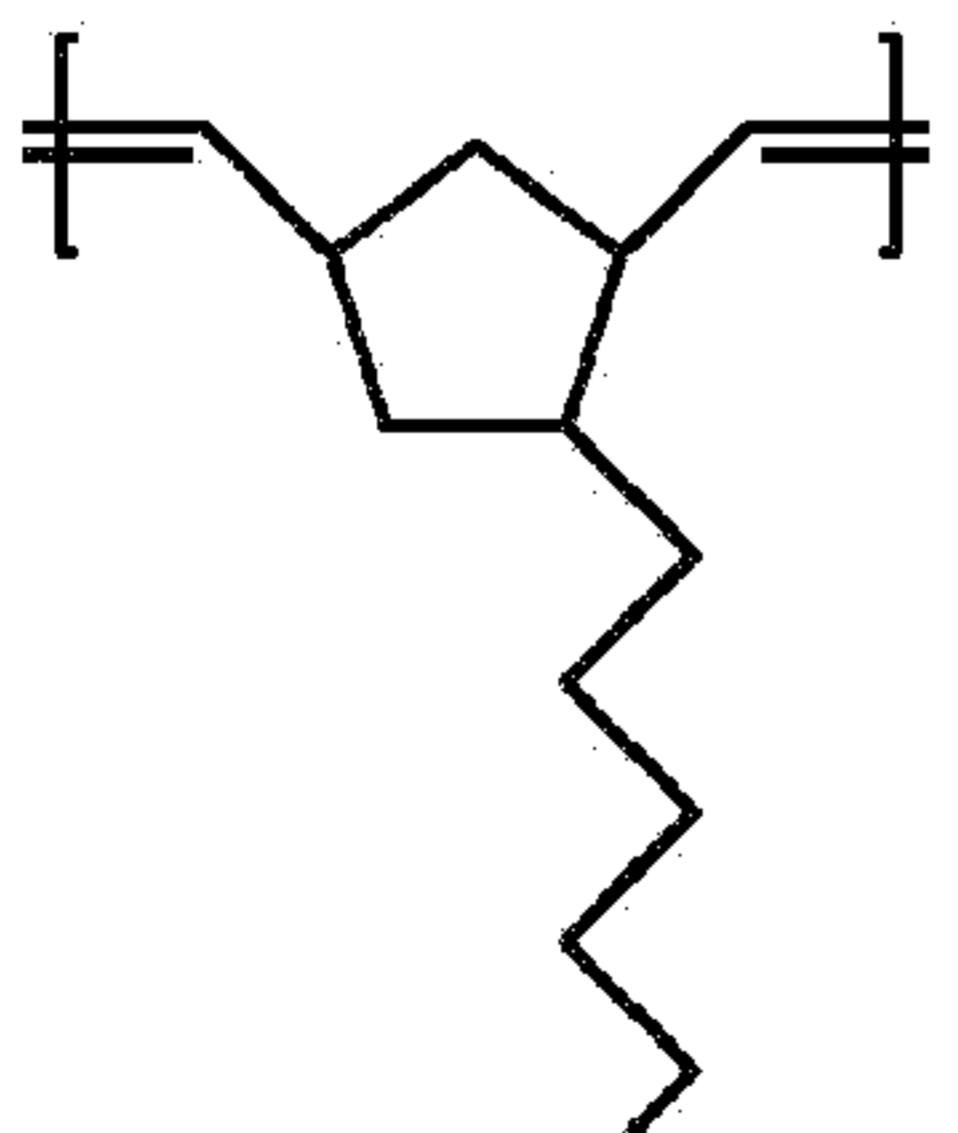
was about 8:2).

Example 3

[0037] Example 3 was performed in the same manner as in Example 1 except that the molar ratio of Compound (2) and Compound (5) was about 7:3, obtaining Polymer (3) (the ratio of the repeat unit represented by



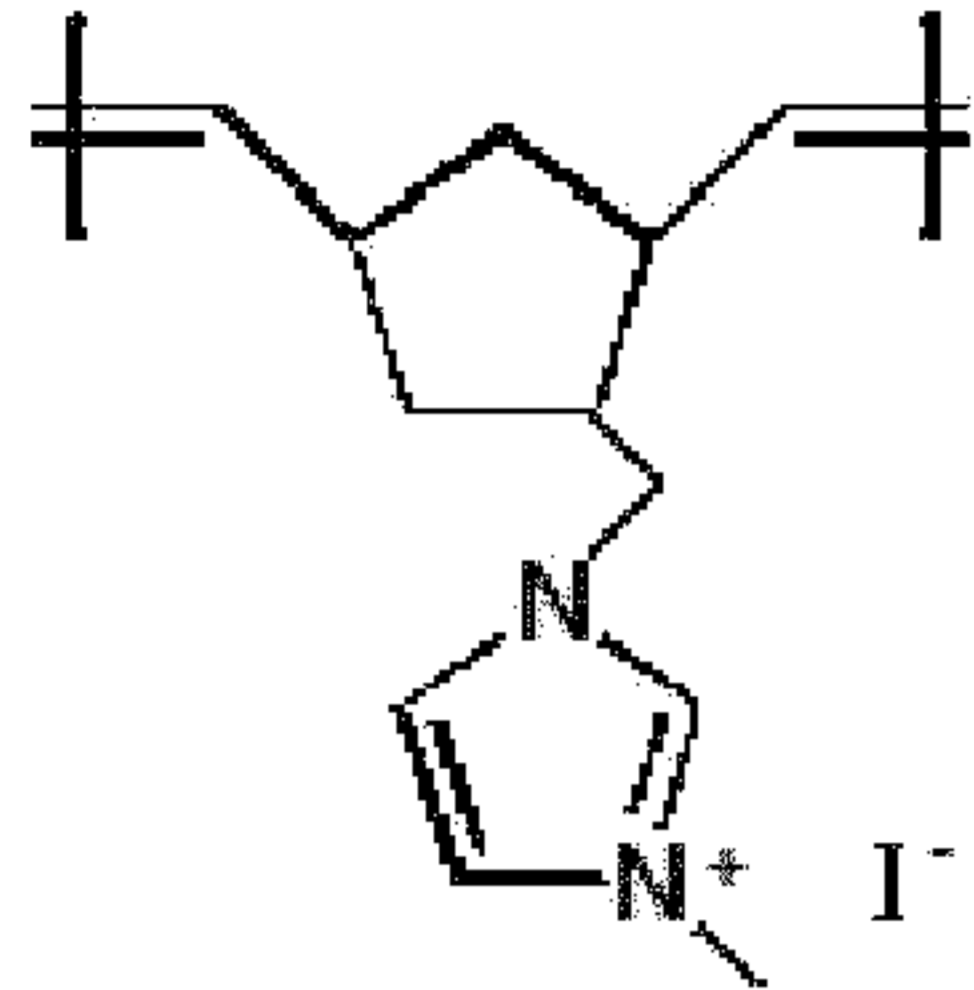
and the repeat unit represented by



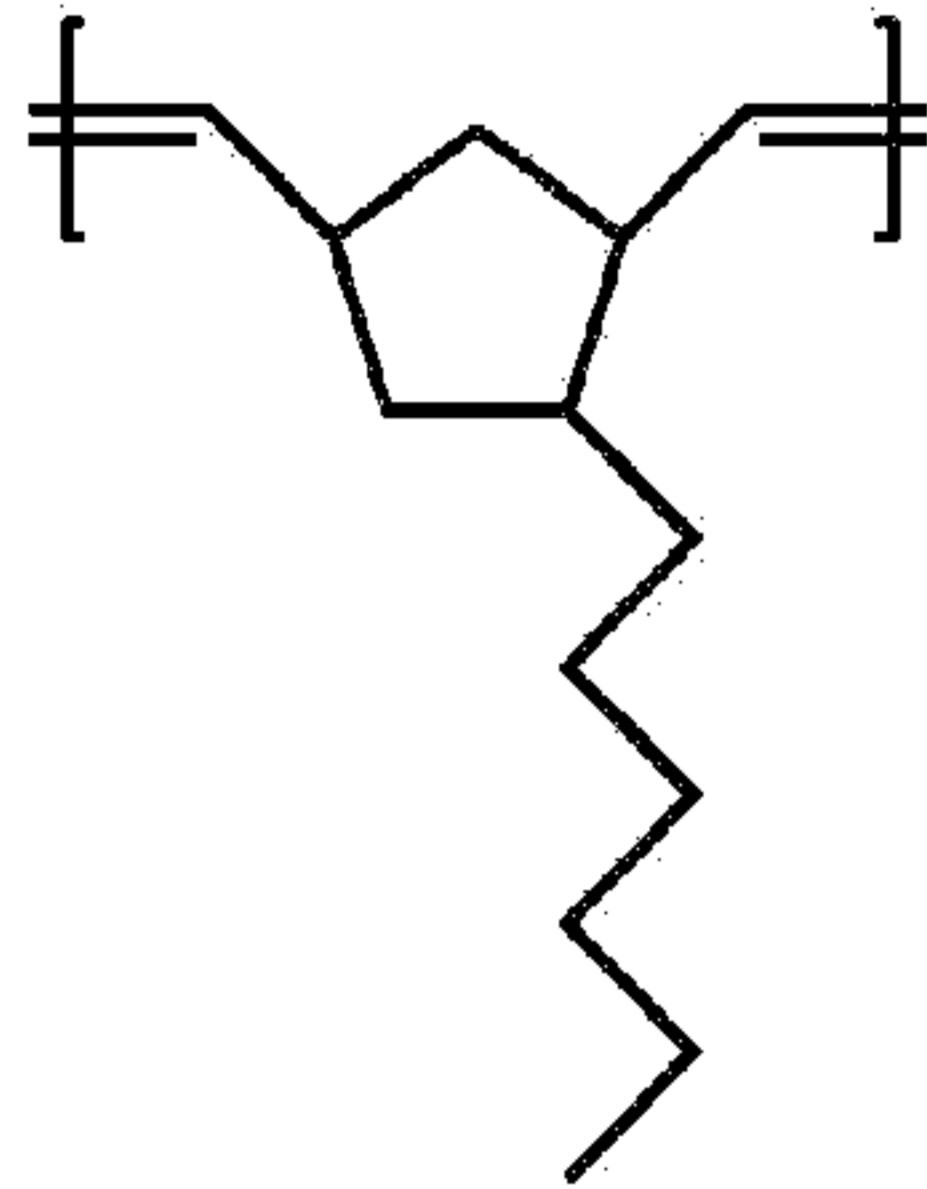
was about 7:3).

Example 4

[0038] Example 4 was performed in the same manner as in Example 1 except that the molar ratio of Compound (2) and Compound (5) was about 4:6, obtaining Polymer (4) (the ratio of the repeat unit represented by



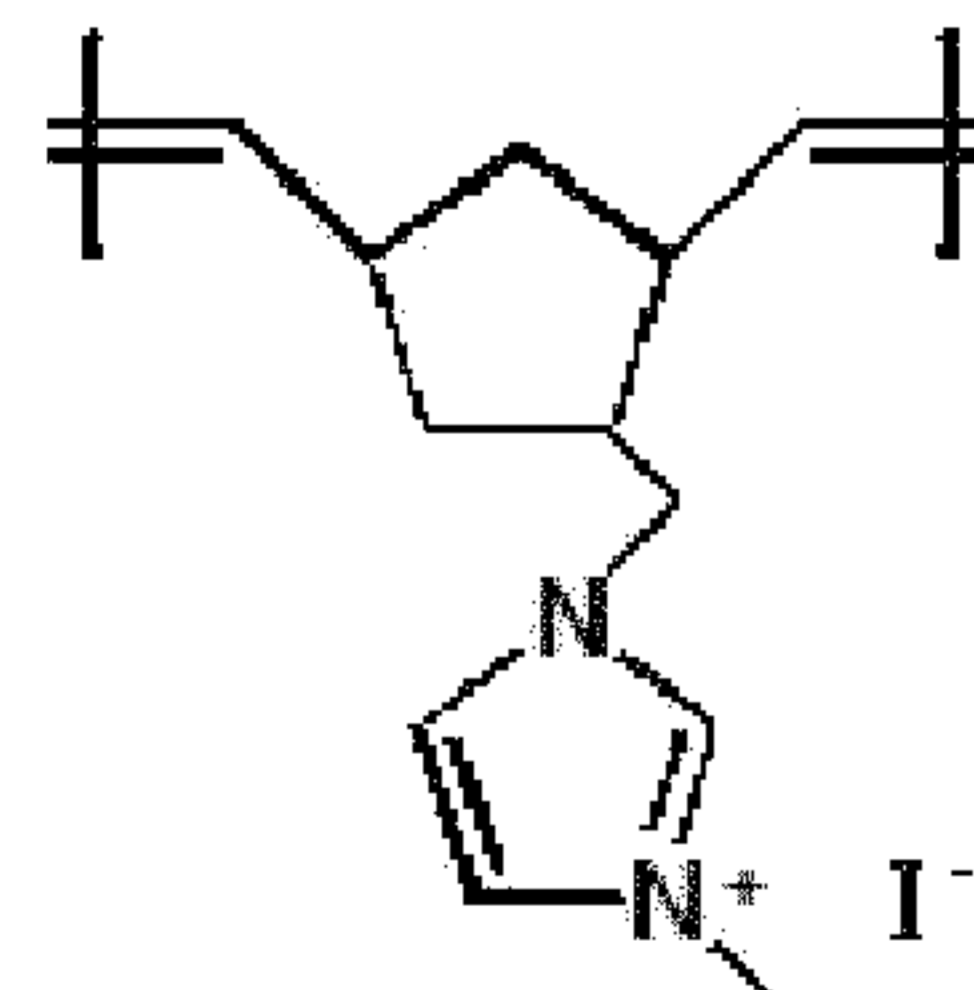
and the repeat unit represented by



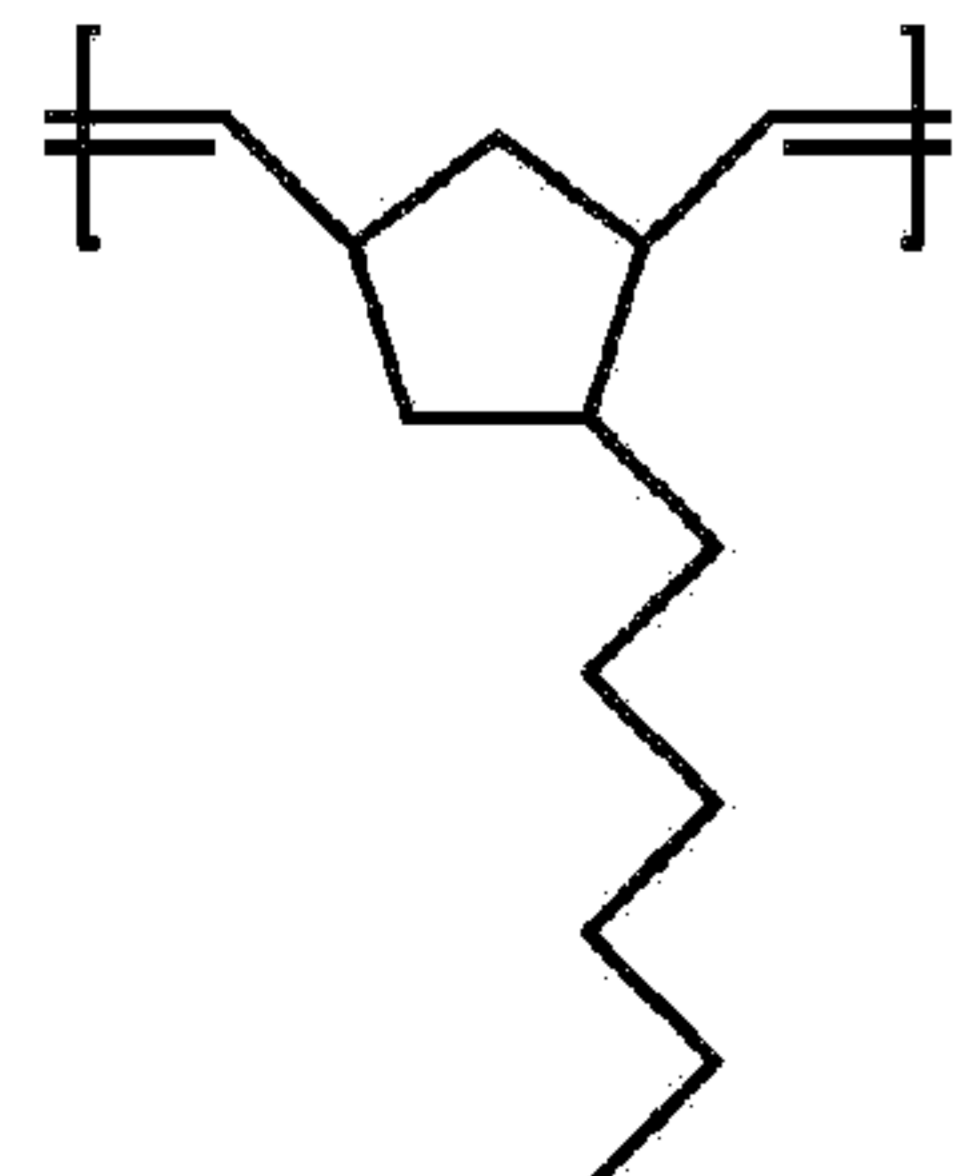
was about 4:6).

Example 5

[0039] Example 5 was performed in the same manner as in Example 1 except that the molar ratio of Compound (2) and Compound (5) was about 2:8, obtaining Polymer (5) (the ratio of the repeat unit represented by



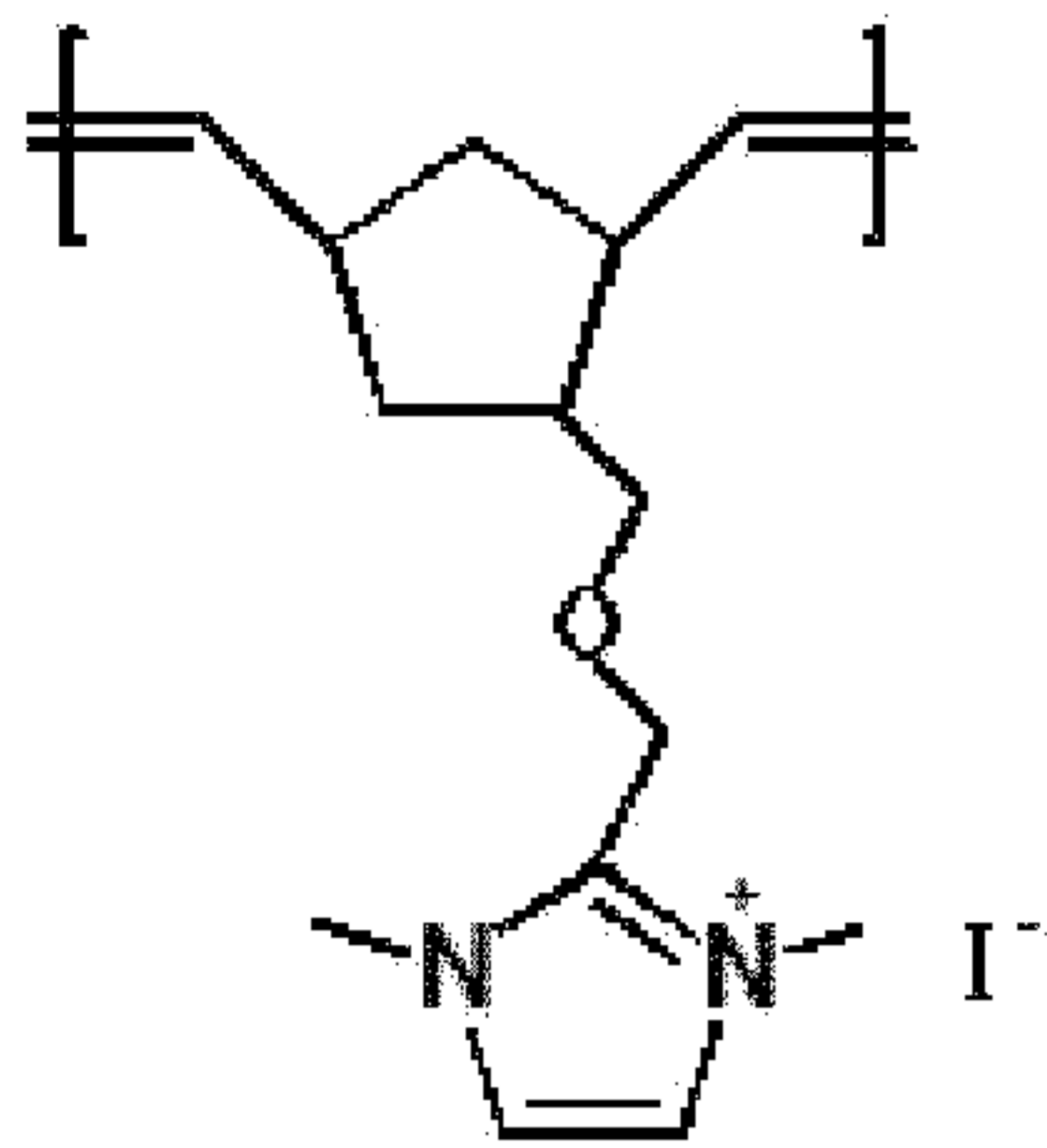
and the repeat unit represented by



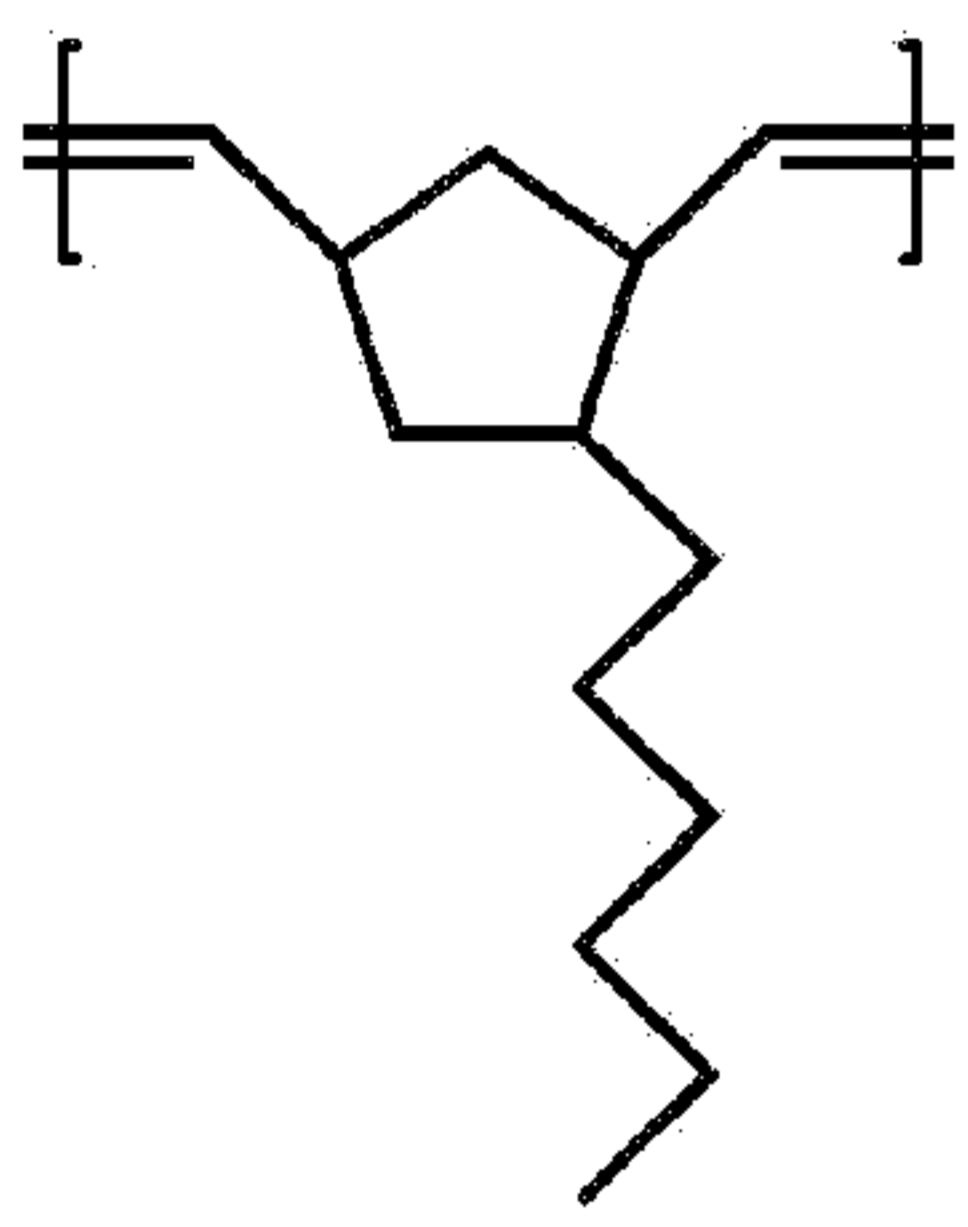
was about 2:8).

Example 6

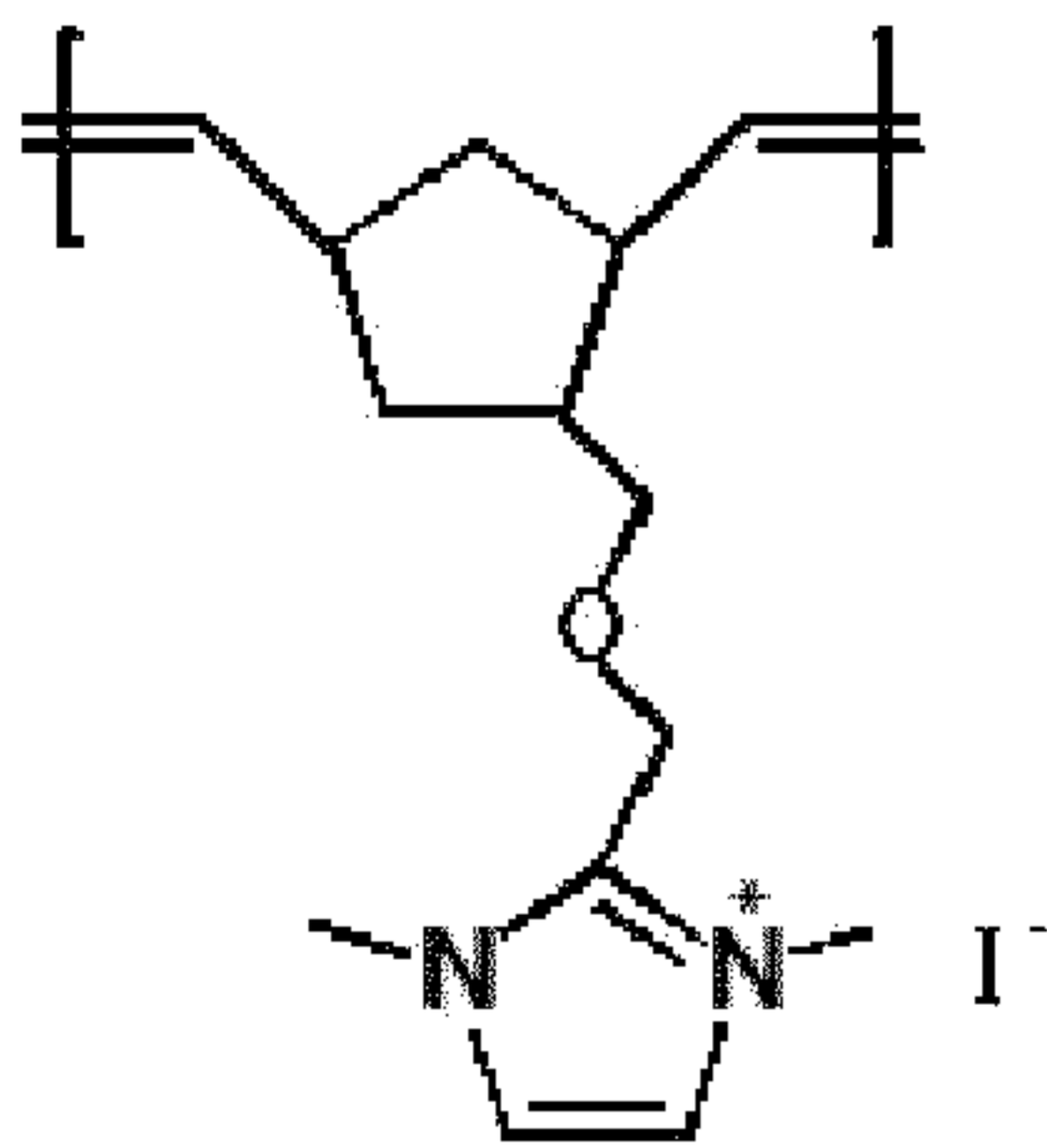
[0040] 3.53g of Compound (4) (9.74 mmole) and 0.19g of Compound (5) (1.08 mmole) were added into a reaction bottle under a nitrogen atmosphere, wherein the molar ratio of Compound (4) and Compound (5) was about 9:1. Next, 30 ml of dichloromethane was added into the reaction bottle. Next, Grubbs's solution (9.2mg, dissolved in 6ml of dichloromethane) was slowly added into the reaction bottle at 30 °C. After stirring for 4 hours, the result was slowly added into 250 ml of ethyl ether. After stirring for about 30 minutes and concentration, the result was washed with 100ml of acetone, and then the solid was collected. After drying, Polymer (6) (having a repeat unit represented by



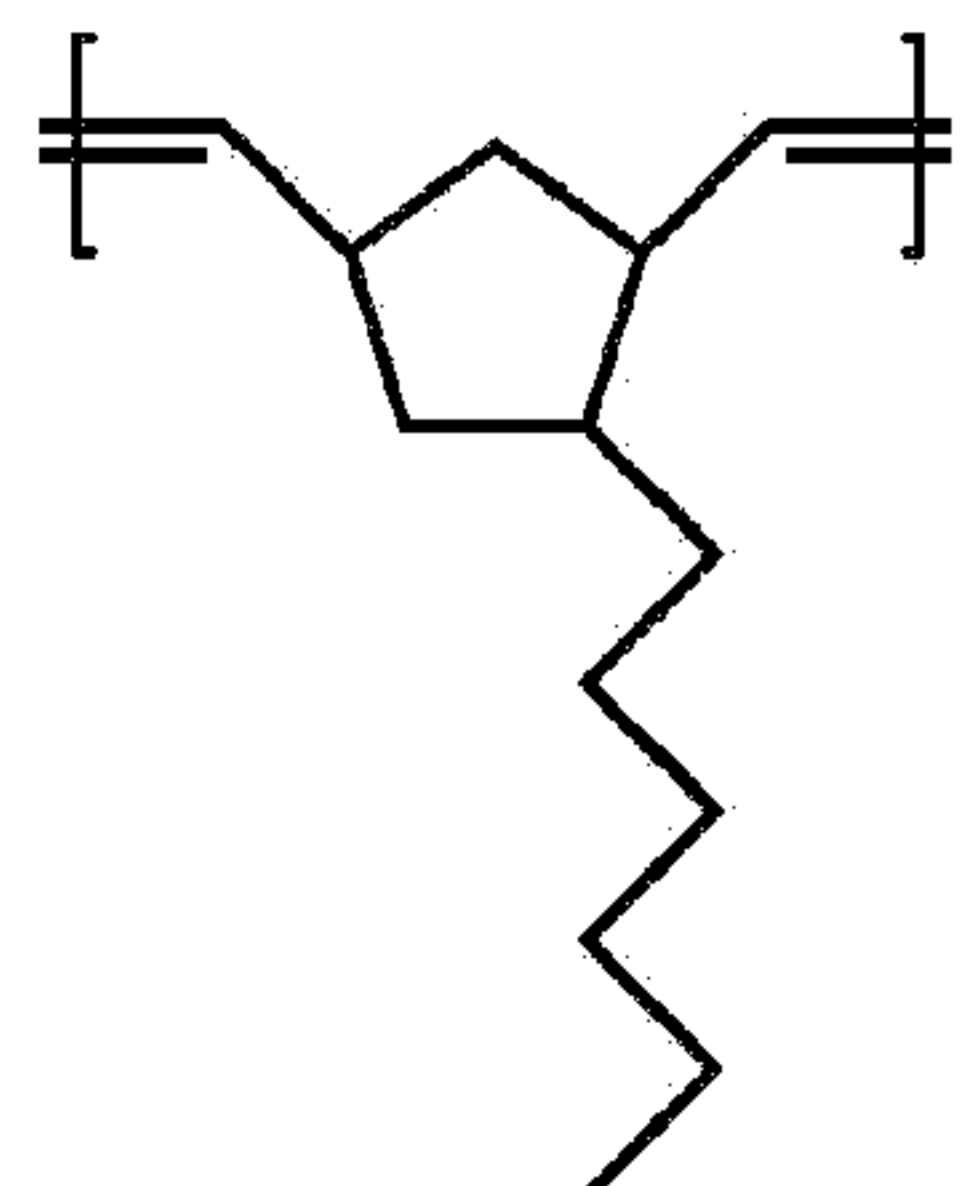
and a repeat unit represented by



wherein the ratio of the repeat unit represented by



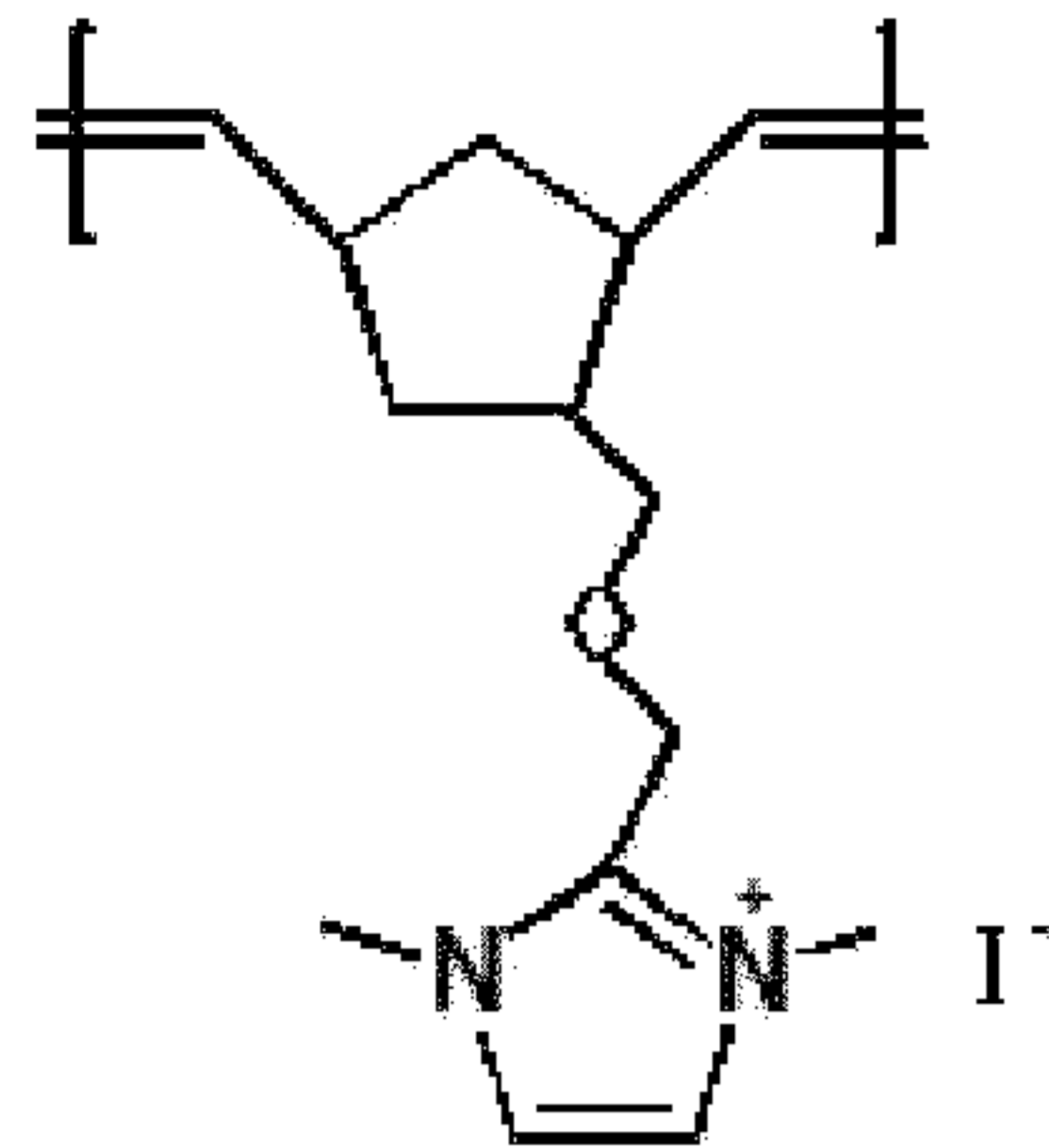
and the repeat unit represented by



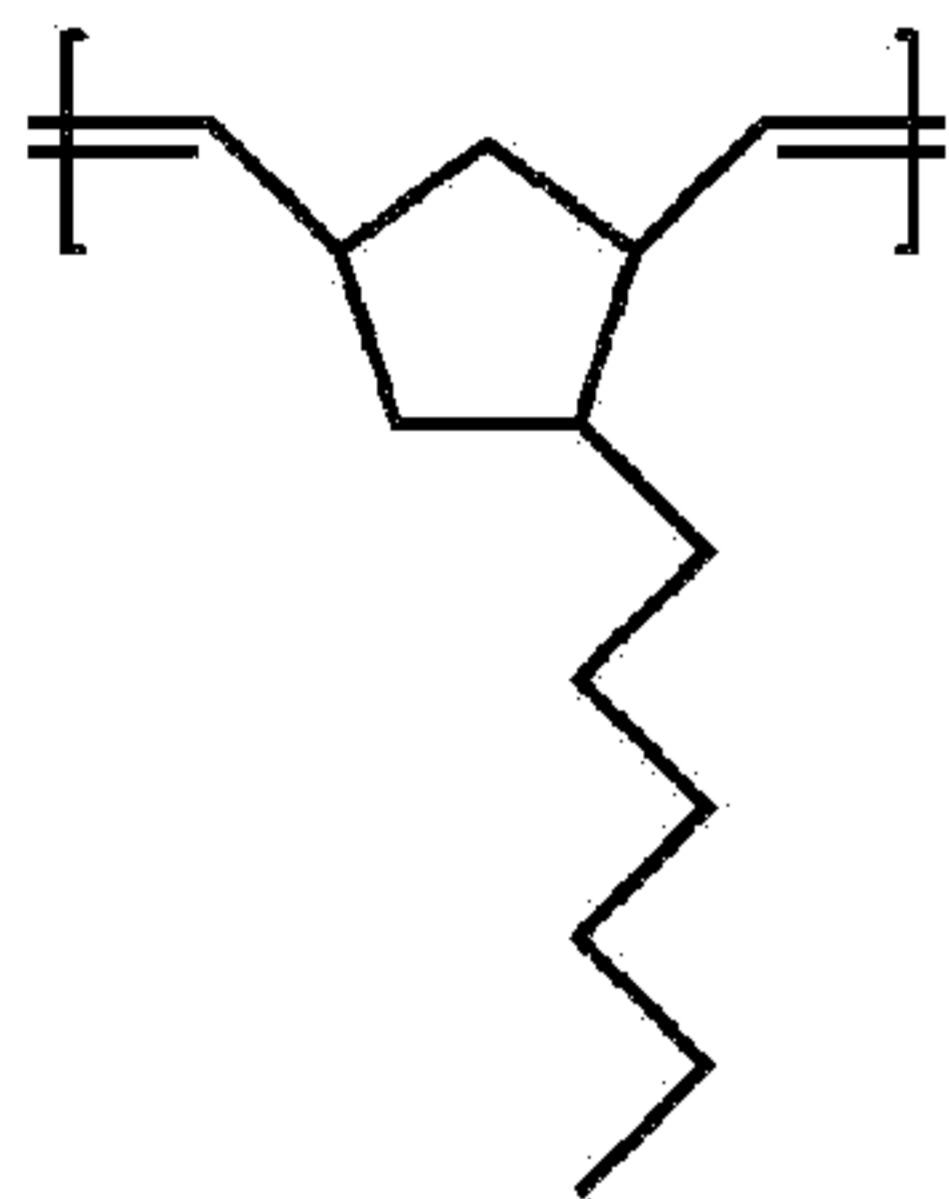
was about 9:1) was obtained.

Example 7

[0041] Example 7 was performed in the same manner as in Example 6 except that the molar ratio of Compound (4) and Compound (5) was about 6:4, obtaining Polymer (7) (the ratio of the repeat unit represented by



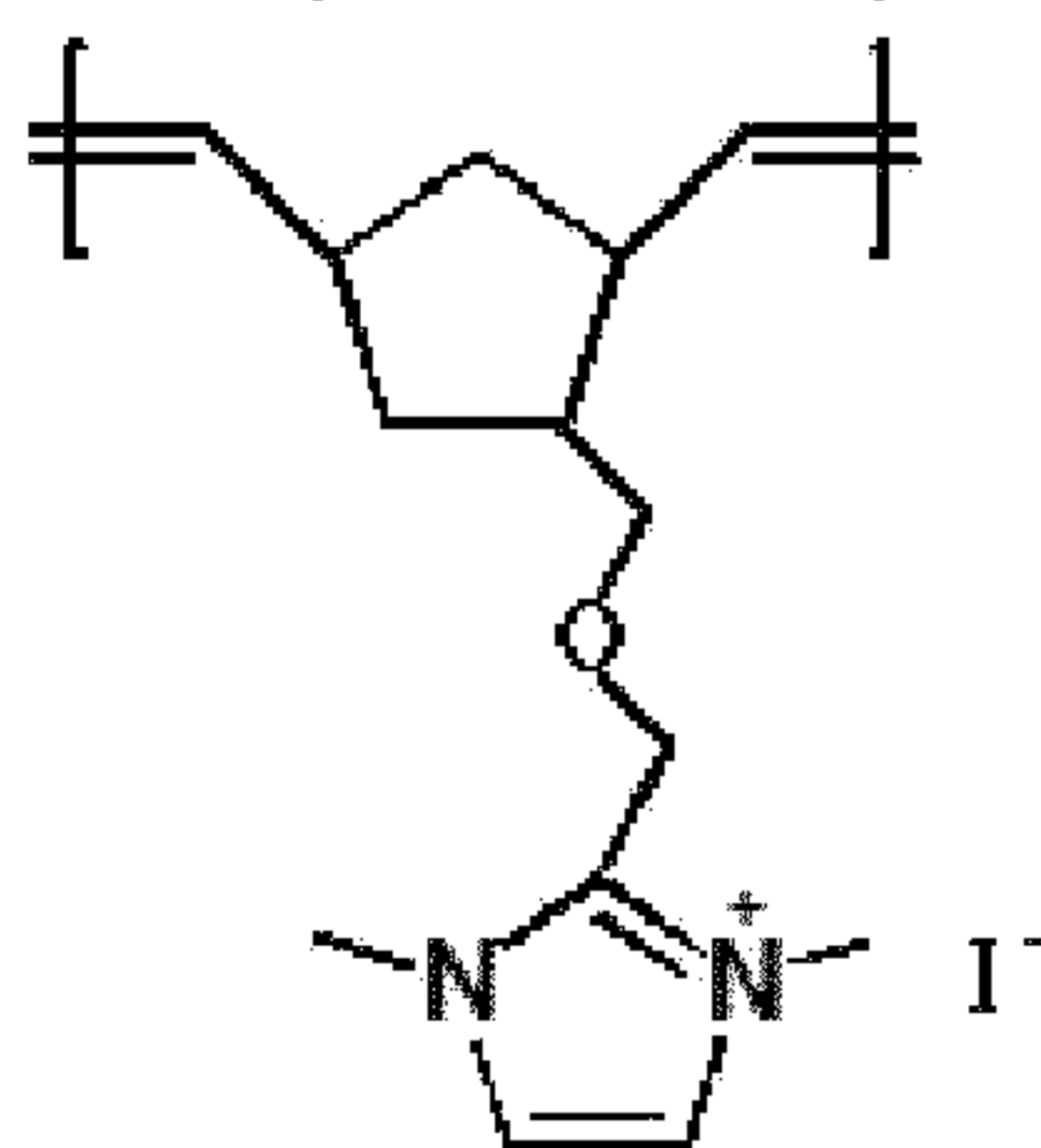
and the repeat unit represented by



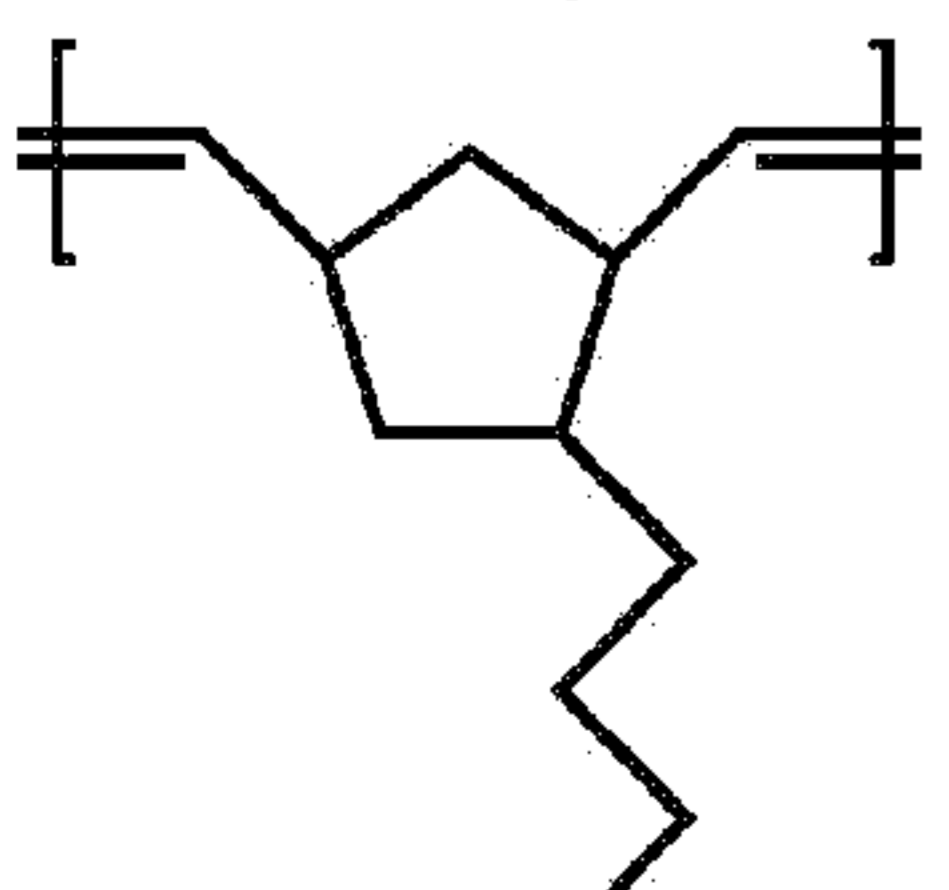
was about 6:4).


Example 8

[0042] Example 8 was performed in the same manner as in Example 6 except that the molar ratio of Compound (4) and Compound (5) was about 3:7, obtaining Polymer (8) (the ratio of the repeat unit represented by



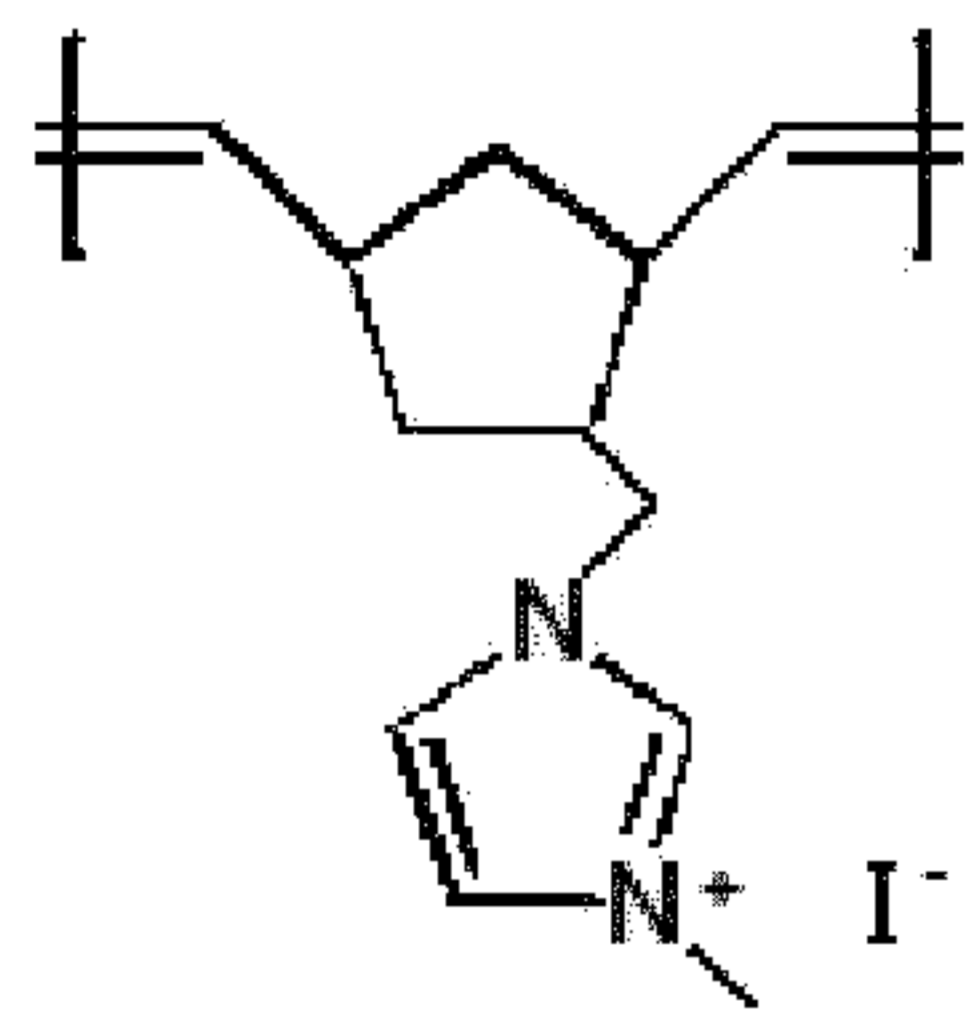
and the repeat unit represented by



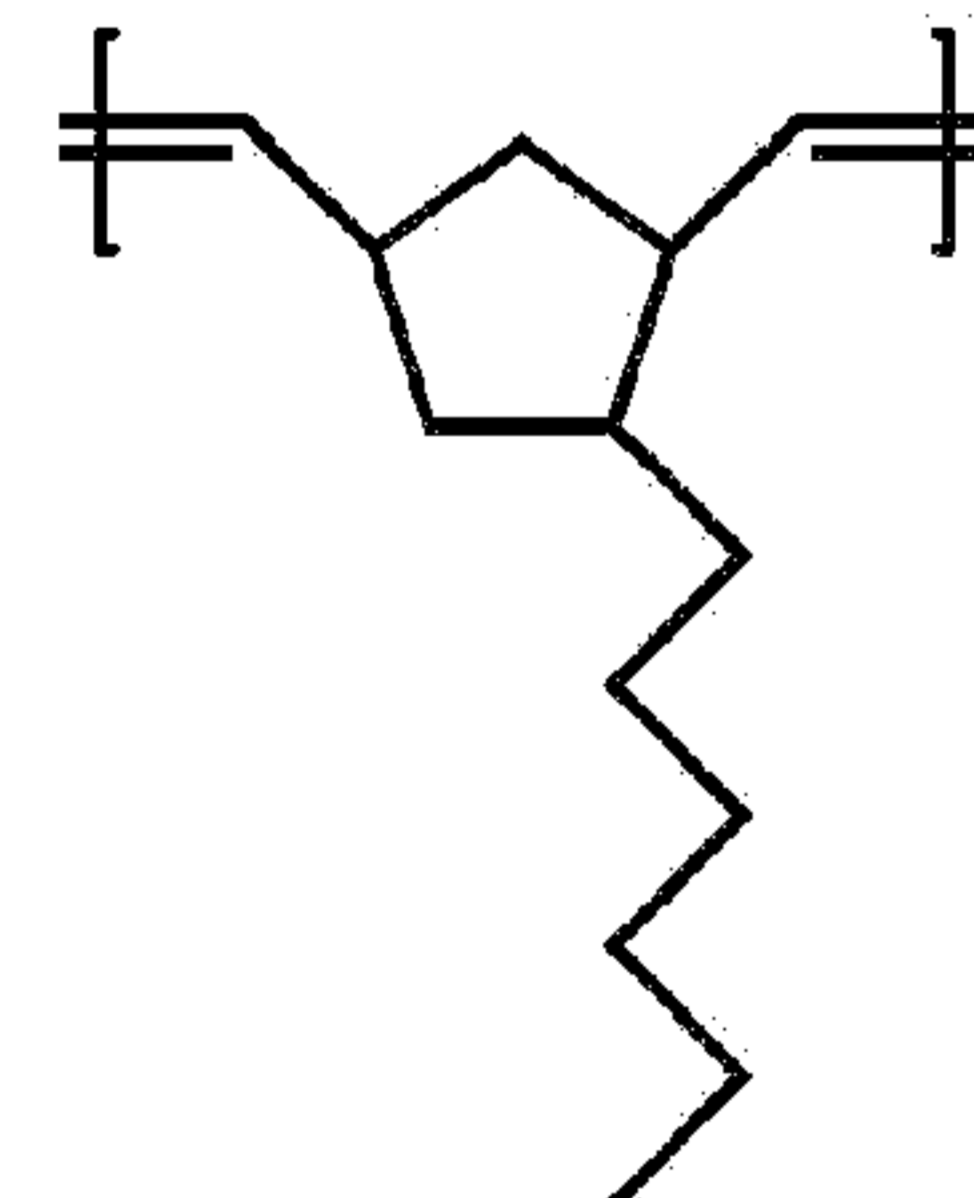

was about 3:7).

Example 9

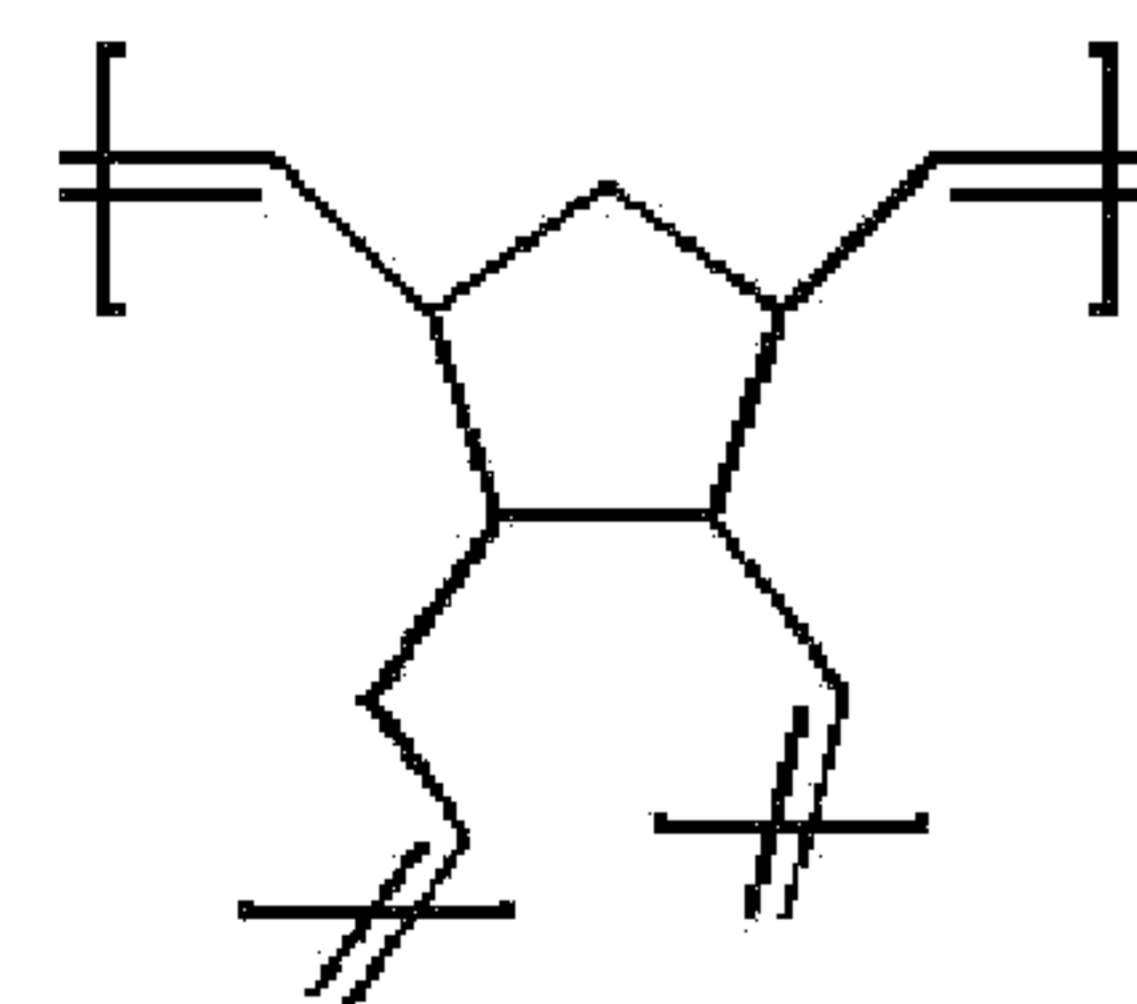
[0043] 3.08g of Compound (2) (9.74 mmole), 0.19g of Compound (5) (1.08 mmole), and 12mg of dicyclopentadiene (0.097 mmole) were added into a reaction bottle under a nitrogen atmosphere, wherein the molar ratio of Compound (2), Compound (5), and dicyclopentadiene was about 9:1:0.09. Next, 30 ml of dichloromethane was added into the reaction bottle. Next, Grubbs's solution (9.2mg, dissolved in 6ml of dichloromethane) was slowly added into the reaction bottle at 30 °C. After stirring for 4 hours, the result was slowly added into 250 ml of ethyl ether. After stirring for about 30 minutes and concentration, the result was washed with 100ml of acetone, and then the solid was collected. After drying, Polymer (9) (having a repeat unit represented by



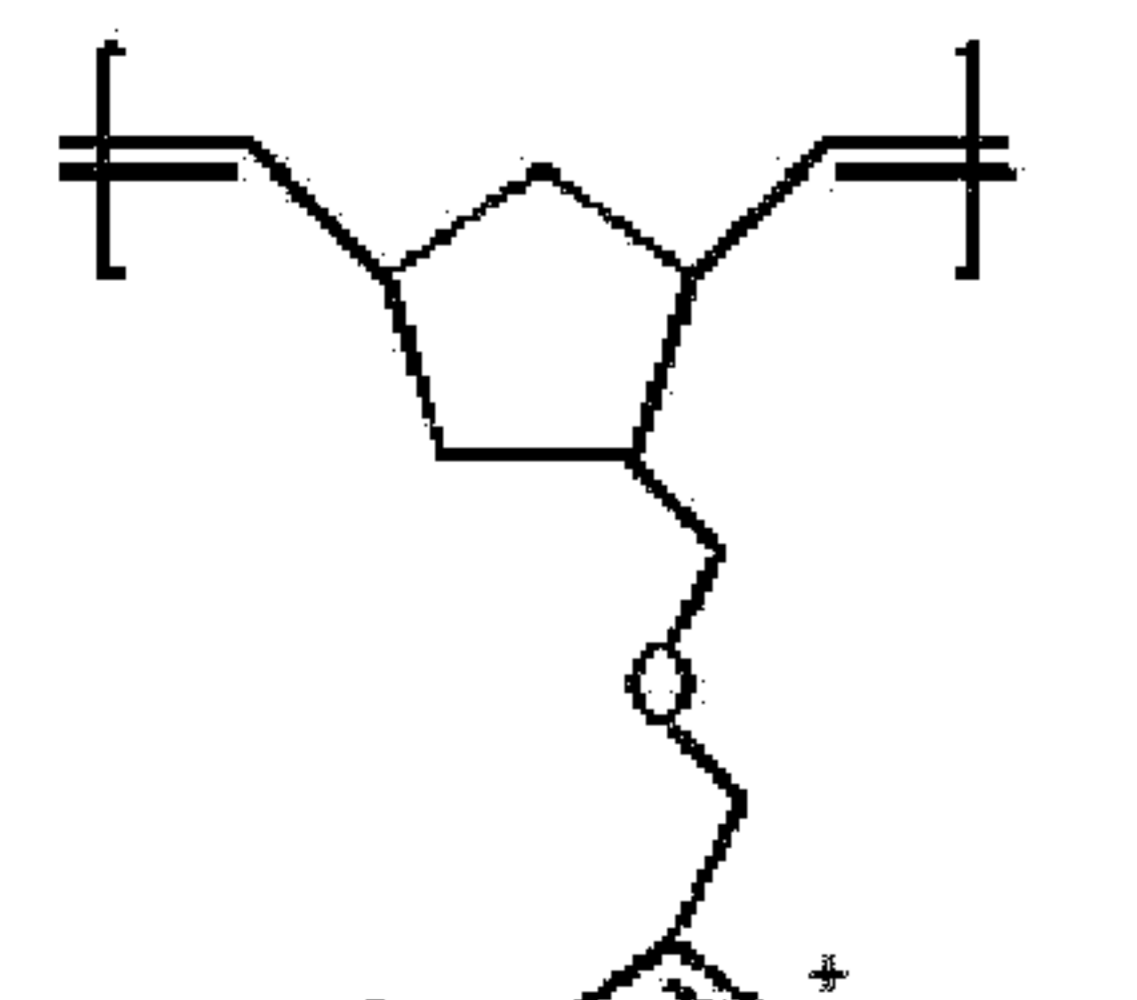
a repeat unit represented by



and a repeat unit represented by

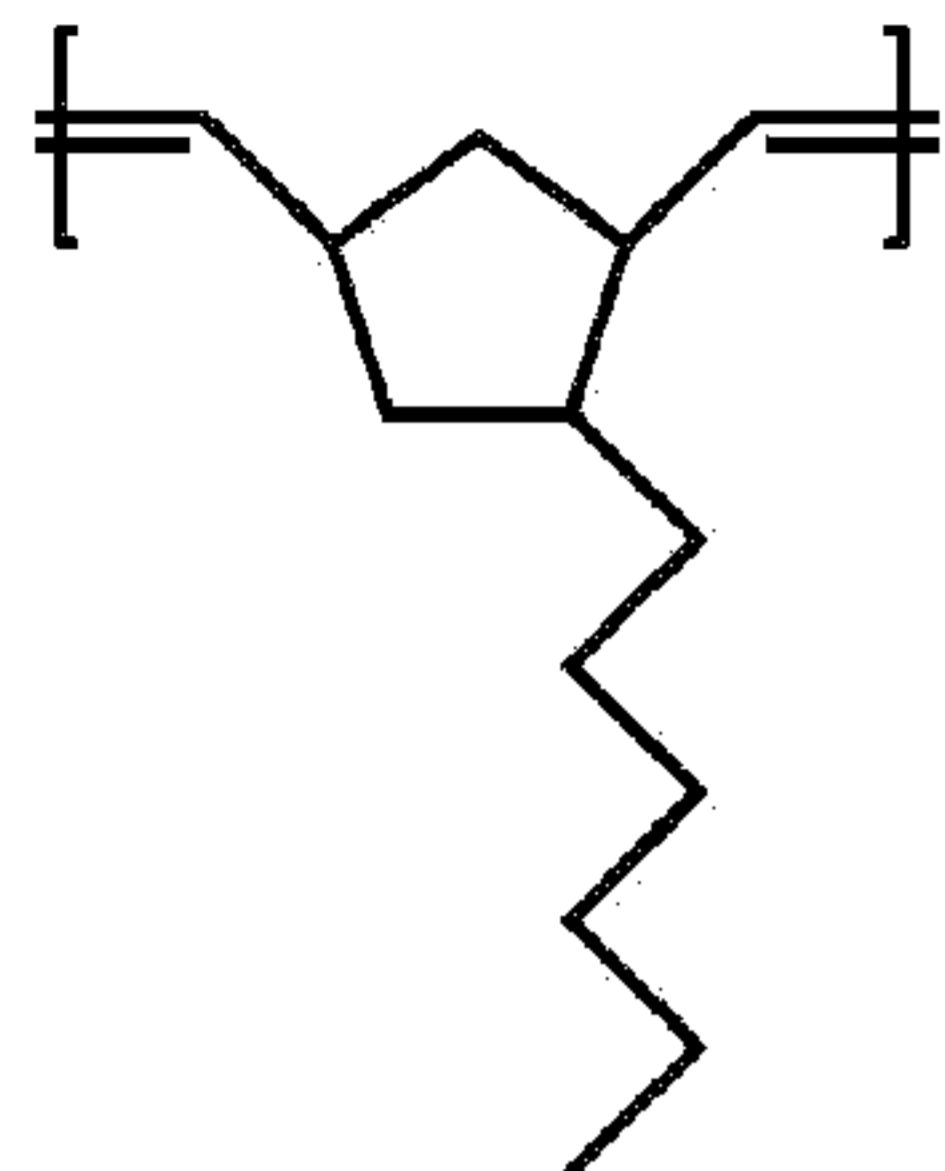


wherein the ratio of the repeat unit represented by

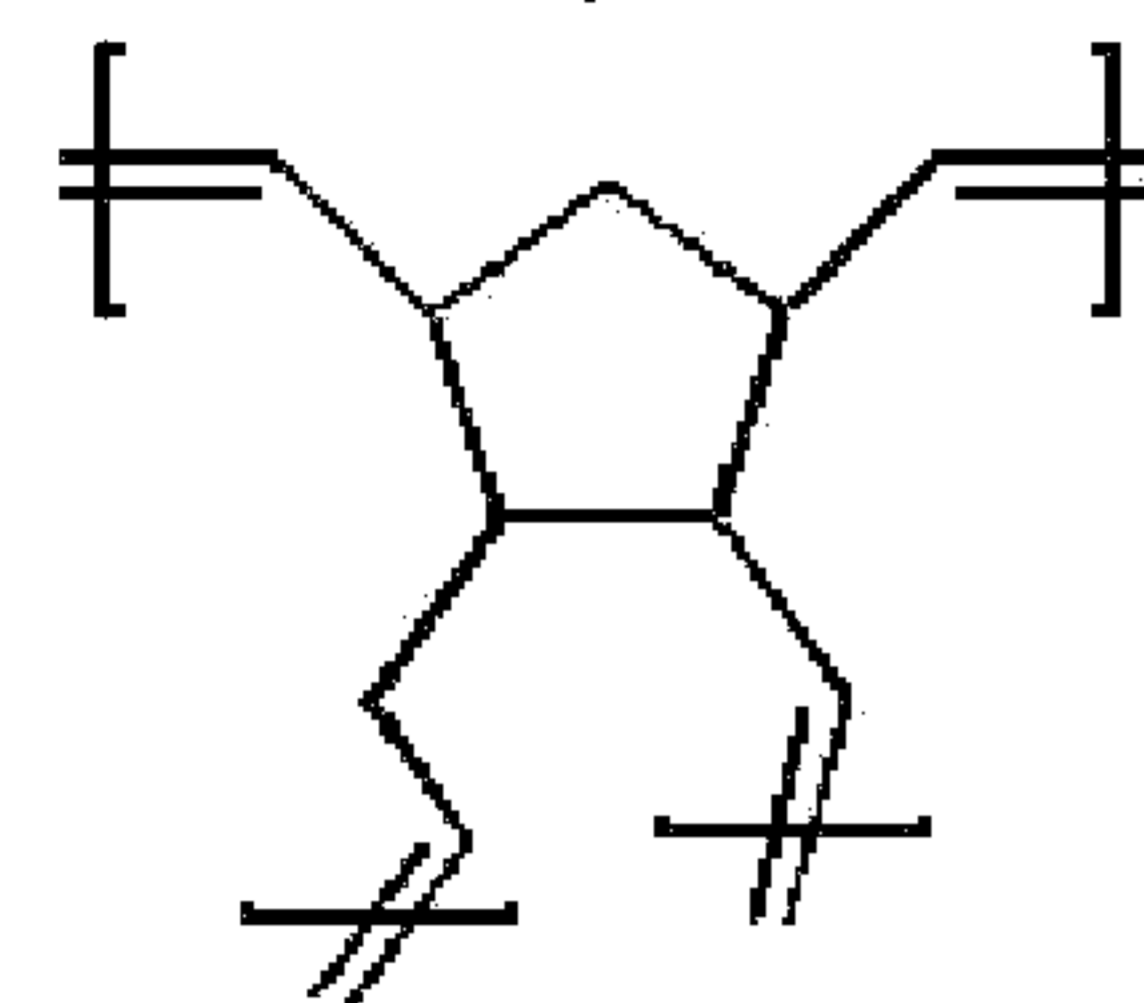




the repeat unit represented by



and the repeat unit represented by



was about 9:1:0.09) was obtained.

Preparation of anion exchange membrane

Example 10

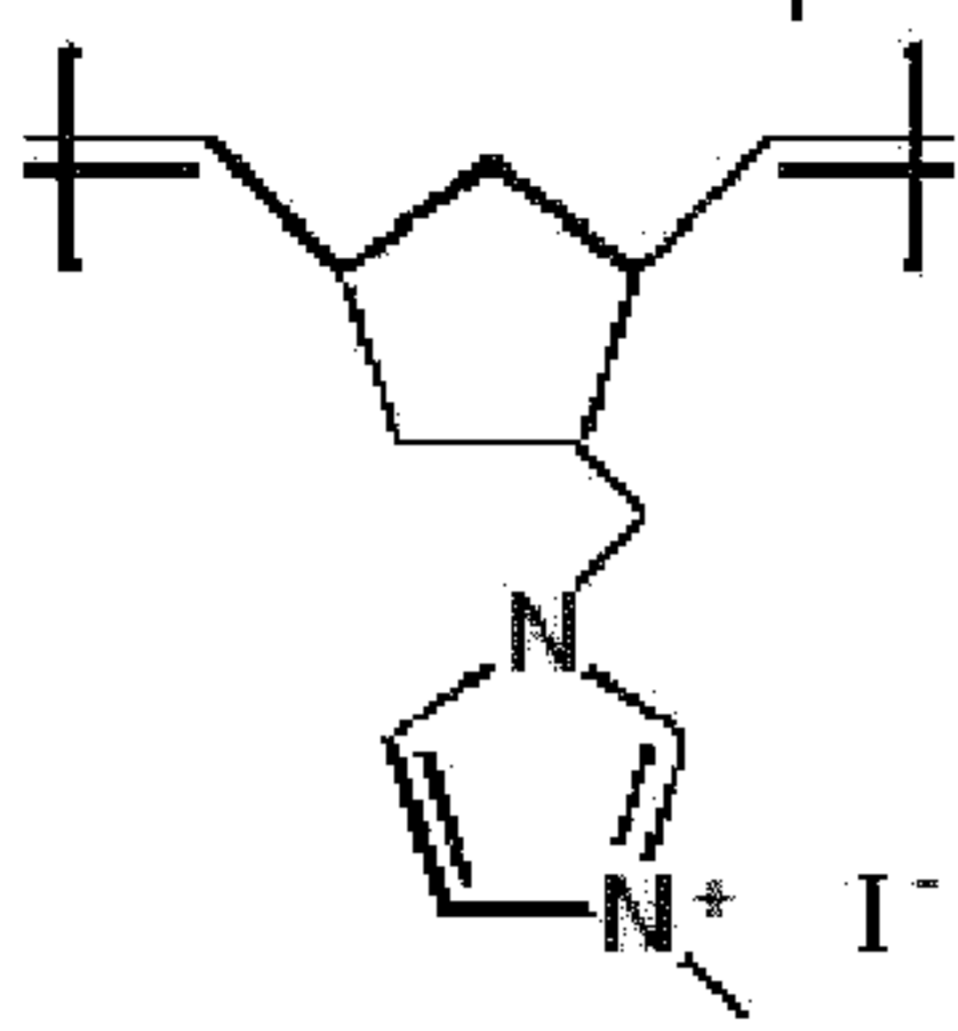
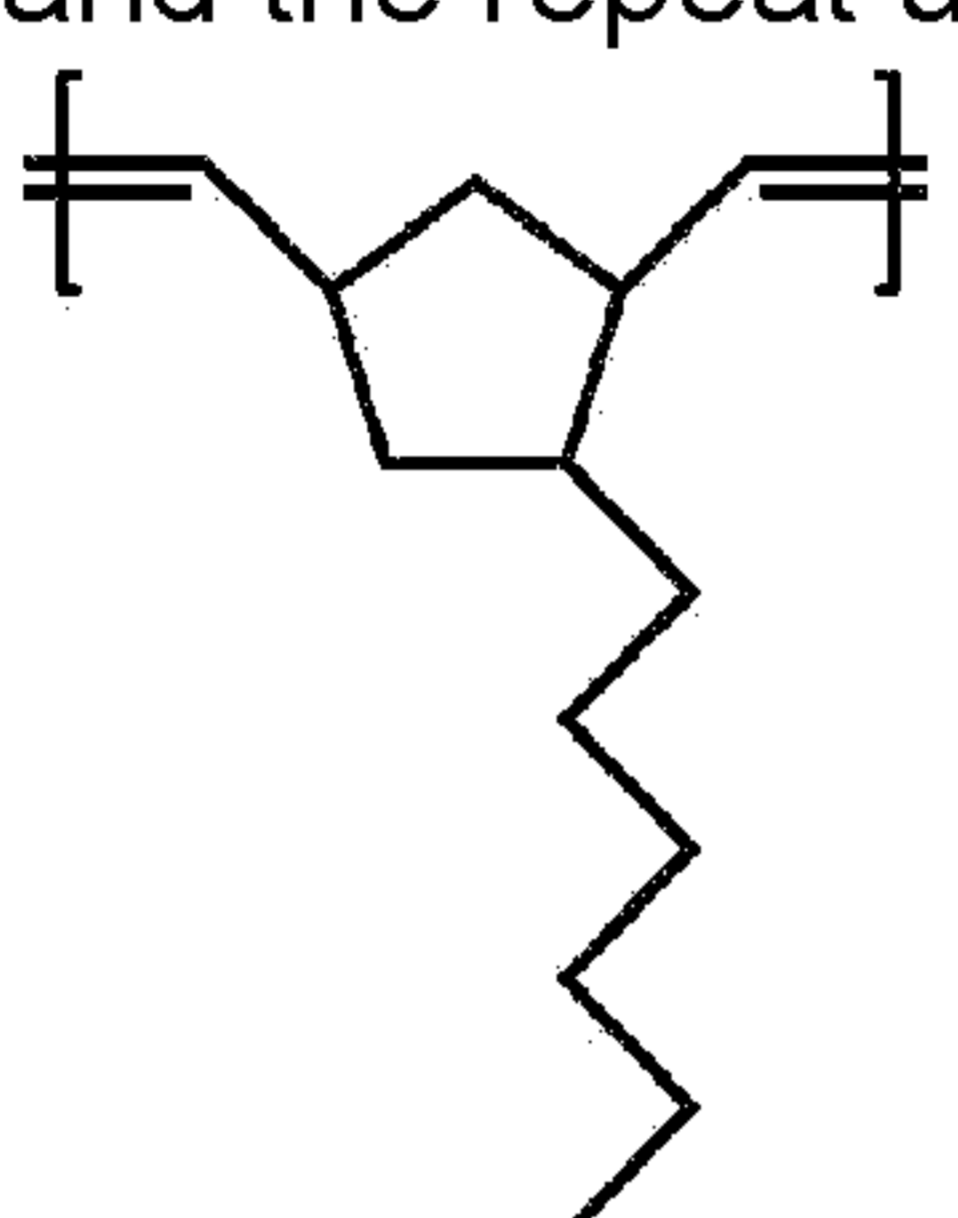
[0044] 100 parts by weight of polymer (1) (prepared from Example 1) was added into a reaction bottle, and dissolved in 667 parts by weight of dimethylacetamide (DMAc). Next, 10 parts by weight of polymeric cross-linking agent (1) (prepared from Preparation Example 4) was added into the reaction bottle. Next, the result was mixed and distributed via a high speed homogenizer, and then defoamed, obtaining a solution. Next, the solution was coated on a glass substrate via spin coating, forming a coating. Next, the coating was baked at 40-150°C to remove most of the solvent. Next, the coating was baked at 120-200°C for 1-6 hours to remove residual solvent. Next, the coating was immersed in potassium hydroxide aqueous solution at room temperature for 1.5 hours and deionized water at room temperature for 1.5 hours sequentially to ensure no solvent remained in the coating. After drying, Anion exchange membrane (1) was obtained. Next, the ionic conductivity of Anion exchange membrane (1) was measured, and the result is shown in Table 1.

Example 11-14

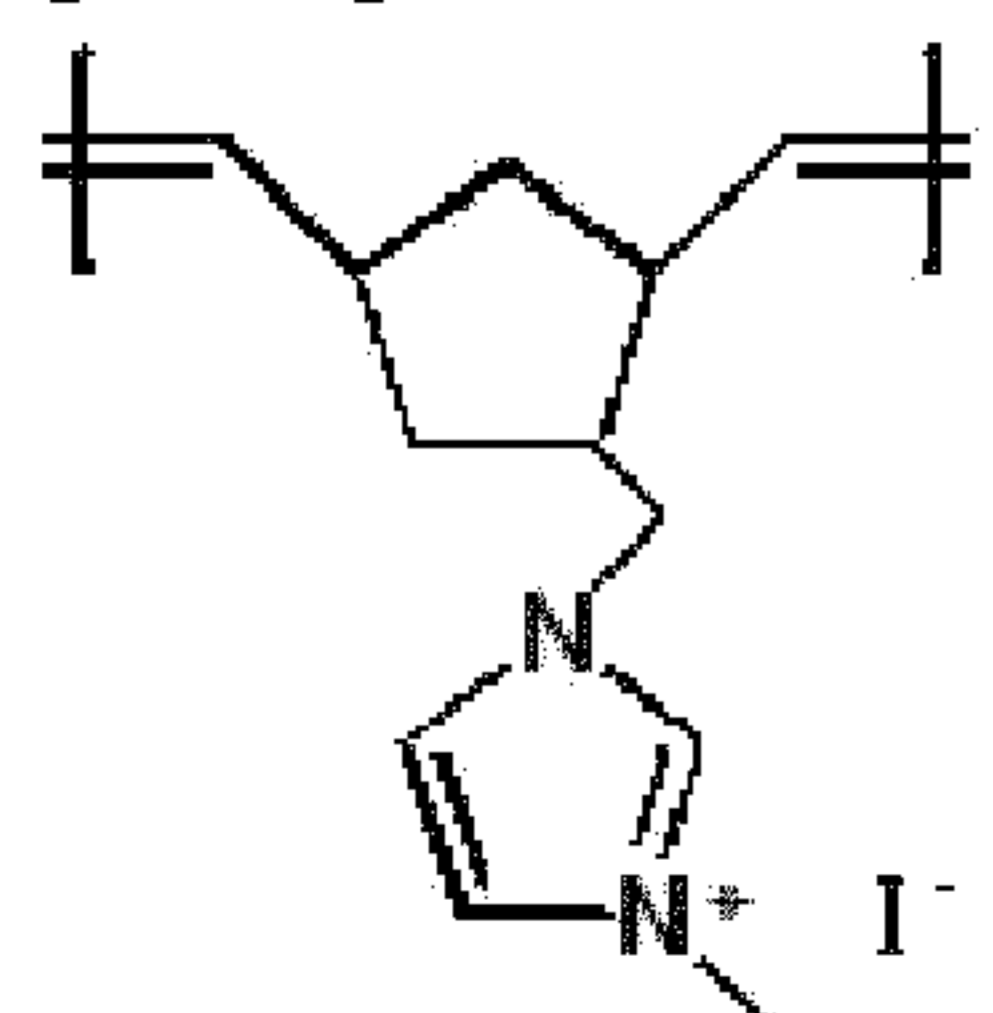
[0045] Examples 11-14 were performed in the same manner as in Example 10 except that Polymers (2)-(5) were substituted for Polymer (1) respectively, obtaining Anion exchange

membranes (2)-(5). Next, the ionic conductivity of Anion exchange membranes (2)-(5) were measured, and the results are shown in Table 1. Furthermore, the tensile strength and anti-rupture strength of Anion exchange membrane (3) were measured according to ASTM D882-02, and the result is shown in Table 2.

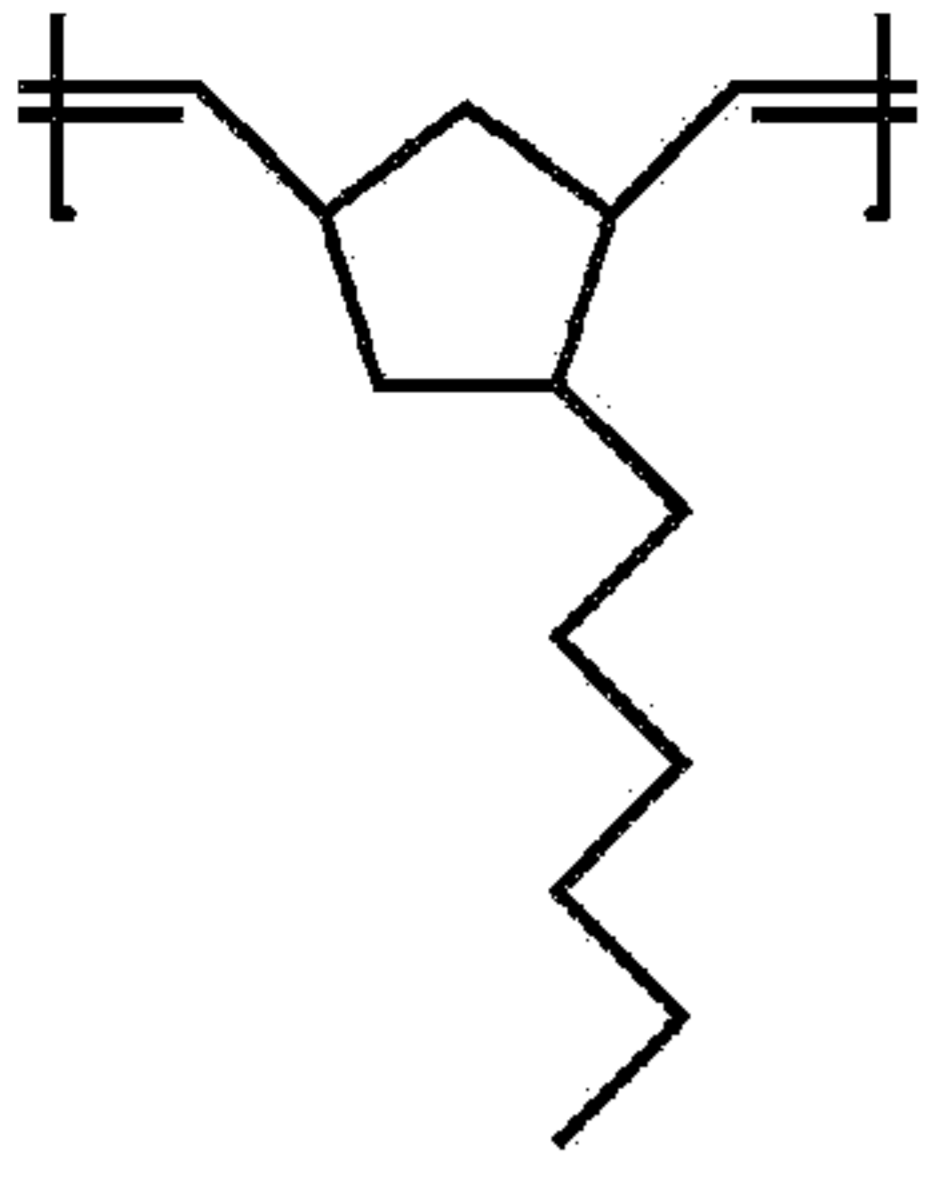
Table 1

	ratio of the repeat unit represented by  and the repeat unit represented by 	ionic conductivity (S/cm)
Anion exchange membrane (1)	9:1	0.13
Anion exchange membrane (2)	8:2	--
Anion exchange membrane (3)	7:3	0.06
Anion exchange membrane (4)	4:6	0.05
Anion exchange membrane (5)	2:8	0.005

[0046] As shown in Table 1, with the increase of the ratio of the repeat unit represented by



and the repeat unit represented by



the ionic conductivity of the anion exchange membrane is improved.

Example 15

[0047] Example 15 was performed in the same manner as in Example 12 except that 7 parts by weight of Polymeric cross-linking agent (1) was substituted for 10 parts by weight of Polymeric cross-linking agent (1), obtaining Anion exchange membrane (6). Next, the tensile strength and anti-rupture strength of Anion exchange membrane (6) were measured according to ASTM D882-02, and the result is shown in Table 2.

Example 16

[0048] Example 16 was performed in the same manner as in Example 12 except that 20 parts by weight of Polymeric cross-linking agent (1) was substituted for 10 parts by weight of Polymeric cross-linking agent (1), obtaining Anion exchange membrane (7). Next, the tensile strength and anti-rupture strength of Anion exchange membrane (7) were measured according to ASTM D882-02, and the result is shown in Table 2.

Example 17

[0049] Example 17 was performed in the same manner as in Example 12 except that 25 parts by weight of Polymeric cross-linking agent (1) was substituted for 10 parts by weight of Polymeric cross-linking agent (1), obtaining Anion exchange membrane (8). Next, the tensile strength and anti-rupture strength of Anion exchange membrane (8) were measured according to ASTM D882-02, and the result is shown in Table 2.

Table 2

	polymeric cross-linking agent (parts by weight)	tensile strength (MPa)	anti-rupture strength (MPa)
Anion exchange membrane (3)	10	25.59	36.57
Anion exchange membrane (6)	7	32.51	44.35

	polymeric cross-linking agent (parts by weight)	tensile strength (MPa)	anti-rupture strength (MPa)
Anion exchange membrane (7)	20	30.19	45.77
Anion exchange membrane (8)	25	35.22	47.32

[0050] As shown in Table 2, with the increase of the concentration of the polymeric cross-linking agent, the mechanical strength (such as tensile strength and anti-rupture strength) is improved. Therefore, according to Tables 1 and 2, the anion exchange membrane of the disclosure exhibits superior ionic conductivity and mechanical strength.

Example 18

[0051] 100 parts by weight of polymer (6) (prepared from Example 6) was added into a reaction bottle, and dissolved in 667 parts by weight of dimethylacetamide (DMAc). Next, 10 parts by weight of Polymeric cross-linking agent (1) (prepared from Preparation Example 4) was added into the reaction bottle. Next, the result was mixed and distributed via a high speed homogenizer, and then defoamed, obtaining a solution. Next, the solution was coated on a glass substrate via spin coating, forming a coating. Next, the coating was baked at 40-150°C to remove most of the solvent. Next, the coating was baked at 120-200°C for 1-6 hours to remove residual solvent. Next, the coating was immersed in potassium hydroxide aqueous solution at room temperature for 1.5 hours and deionized water at room temperature for 1.5 hours sequentially to ensure no solvent remained in the coating. After drying, Anion exchange membrane (9) was obtained. Next, the ionic conductivity and dimensional stability of Anion exchange membrane (9) was measured, and the result is shown in Table 3.

Examples 19-20

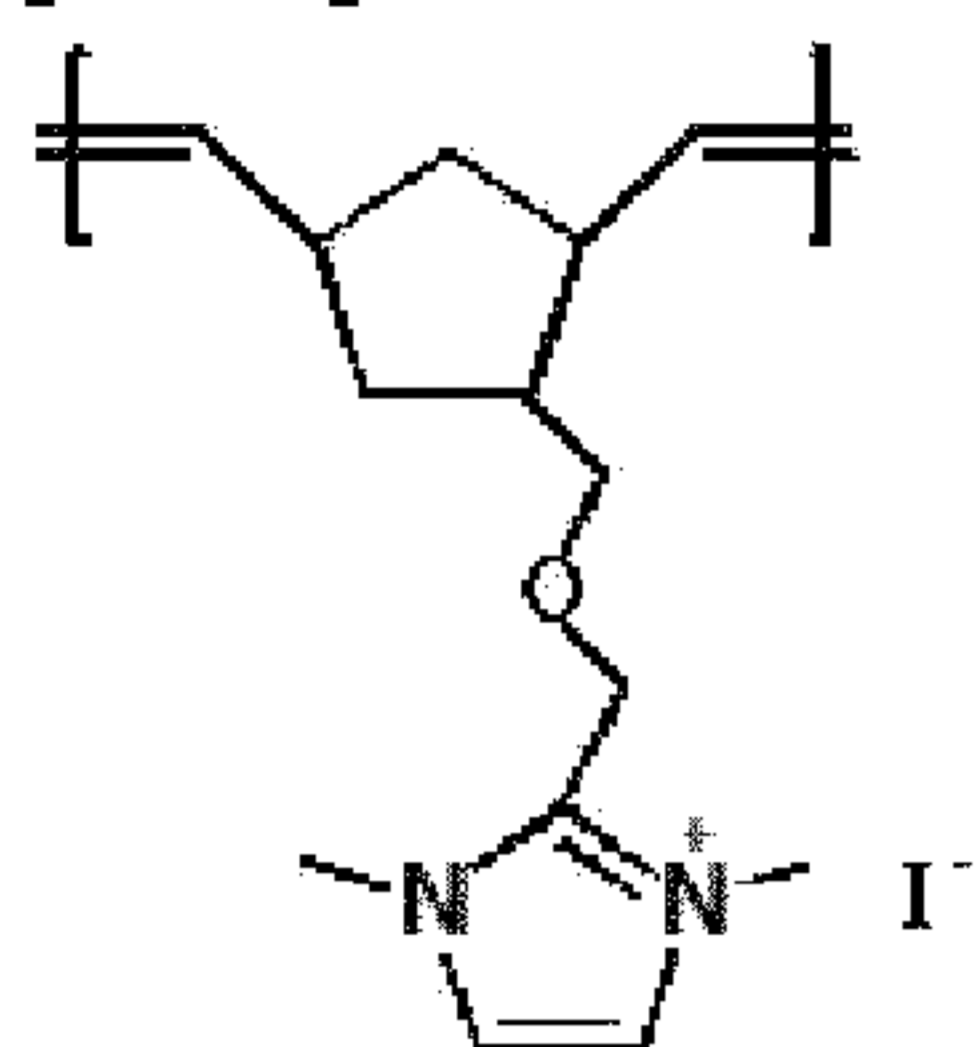
[0052] Examples 19-20 were performed in the same manner as in Example 18 except that Polymers (7) and (8) were substituted for Polymer (6) respectively, obtaining Anion exchange membranes (10) and (11). Next, the ionic conductivity and dimensional stability of Anion exchange membranes (10) and (11) were measured, and the results are shown in Table 3.

Table 3

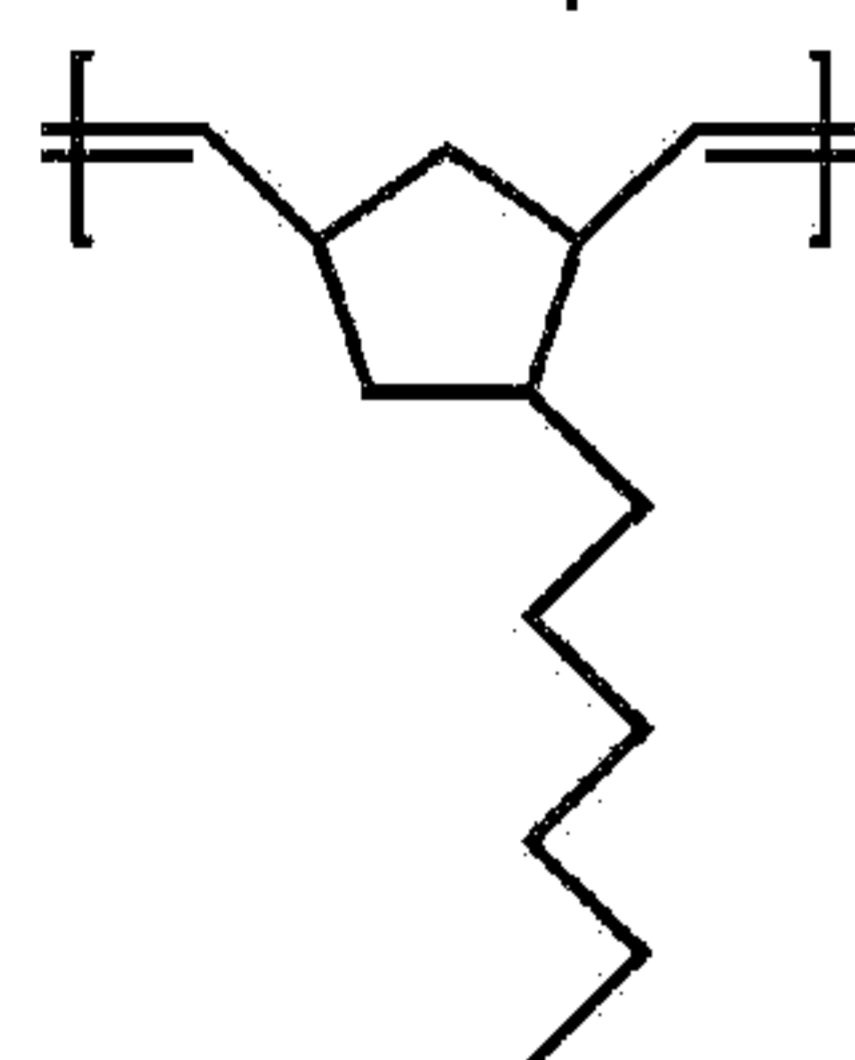
	ionic conductivity (S/cm)	dimensional shrinkage (%) (measured at 25°C)		dimensional shrinkage (%) (measured at 80°C)	
		area	thickness	area	thickness
anion exchange membrane (9)	0.09	20	9	24	31

	ionic conductivity (S/cm)	dimensional shrinkage (%) (measured at 25°C)		dimensional shrinkage (%) (measured at 80°C)	
		area	thickness	area	thickness
anion exchange membrane (10)	0.02	0	13	0	4
anion exchange membrane (11)	0.004	15	6	4.5	21

[0053] As shown in Table 3, with the increase of the ratio of the repeat unit represented by



and the repeat unit represented by



the ionic conductivity of the anion exchange membrane is improved. In addition, the anion exchange membrane of the disclosure also exhibits high dimensional stability.

[0054] Accordingly, due to the introduction of stably cationic group, the polymer of the disclosure exhibits high ionic conductivity. Furthermore, due to the introduction of non-ionic group simultaneously, the polymer of the disclosure also exhibits high solubility, mechanical strength, and solvent selectivity.

REFERENCES CITED IN THE DESCRIPTION

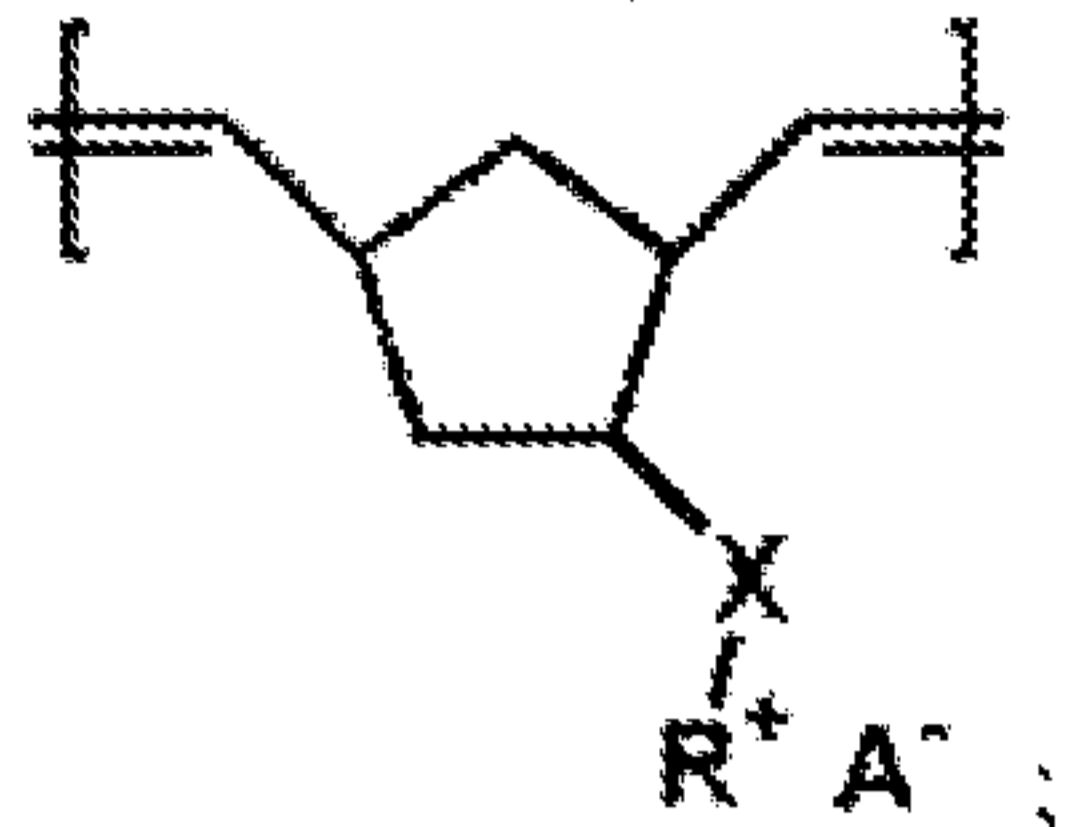
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Patent documents cited in the description

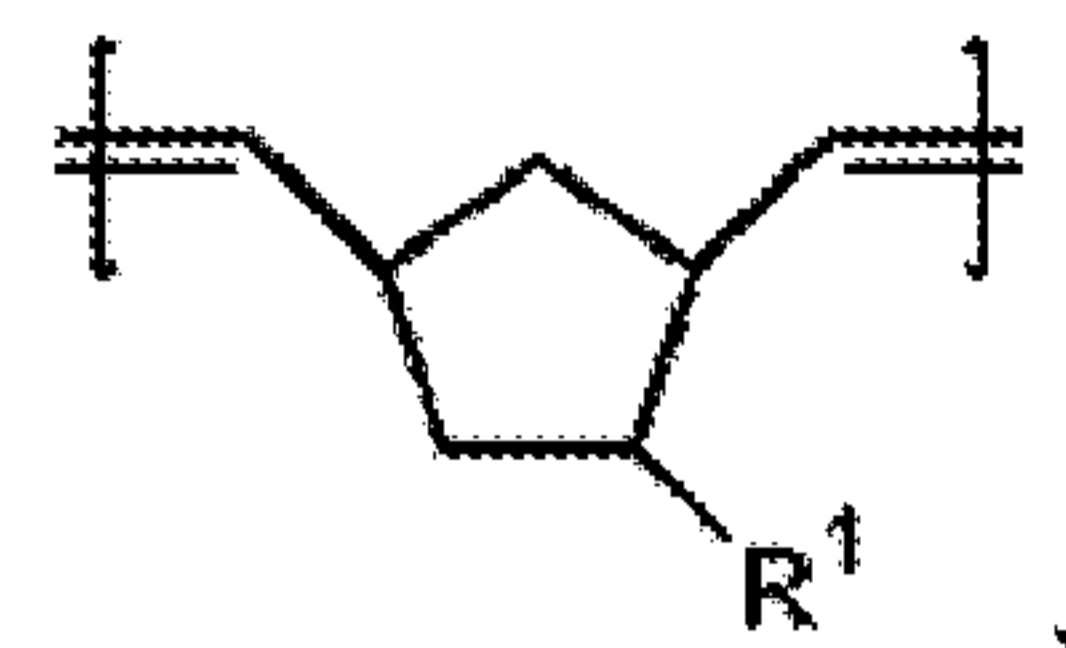
- EP2270104A1 [0004]
- US2011244368A1 [0004]

Patentkrav

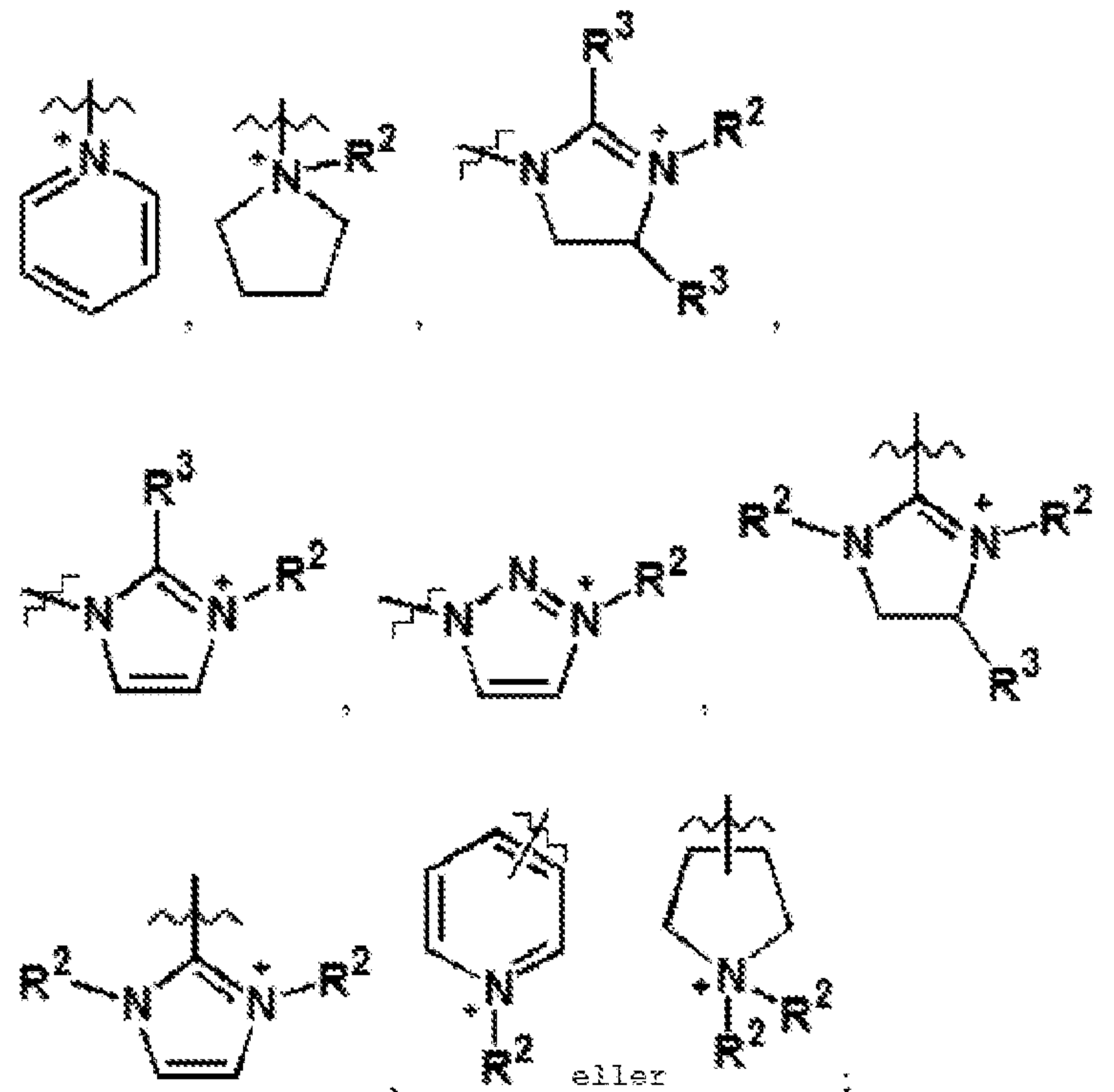
1. Polymer, omfattende en første gentagelsesenhed og en anden gentagelsesenhed, hvor den første gentagelsesenhed er



den anden gentagelsesenhed er

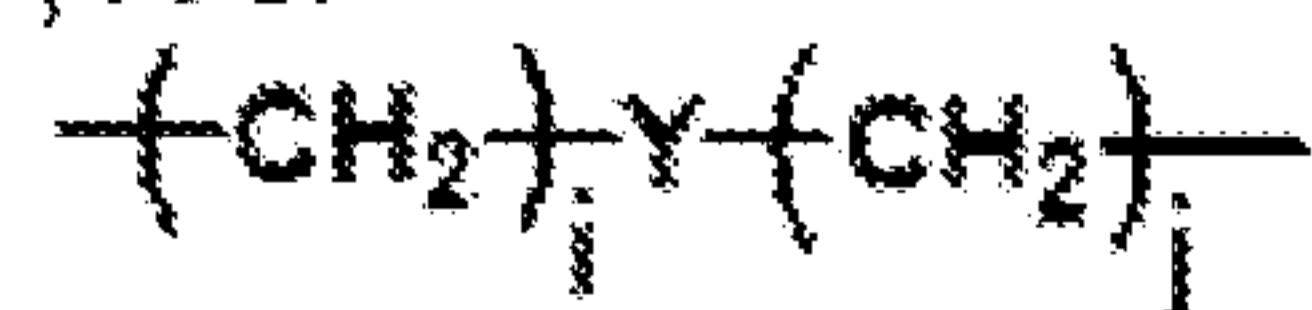


hvor R⁺ er



A er F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻ eller H₂PO₂⁻

; X er



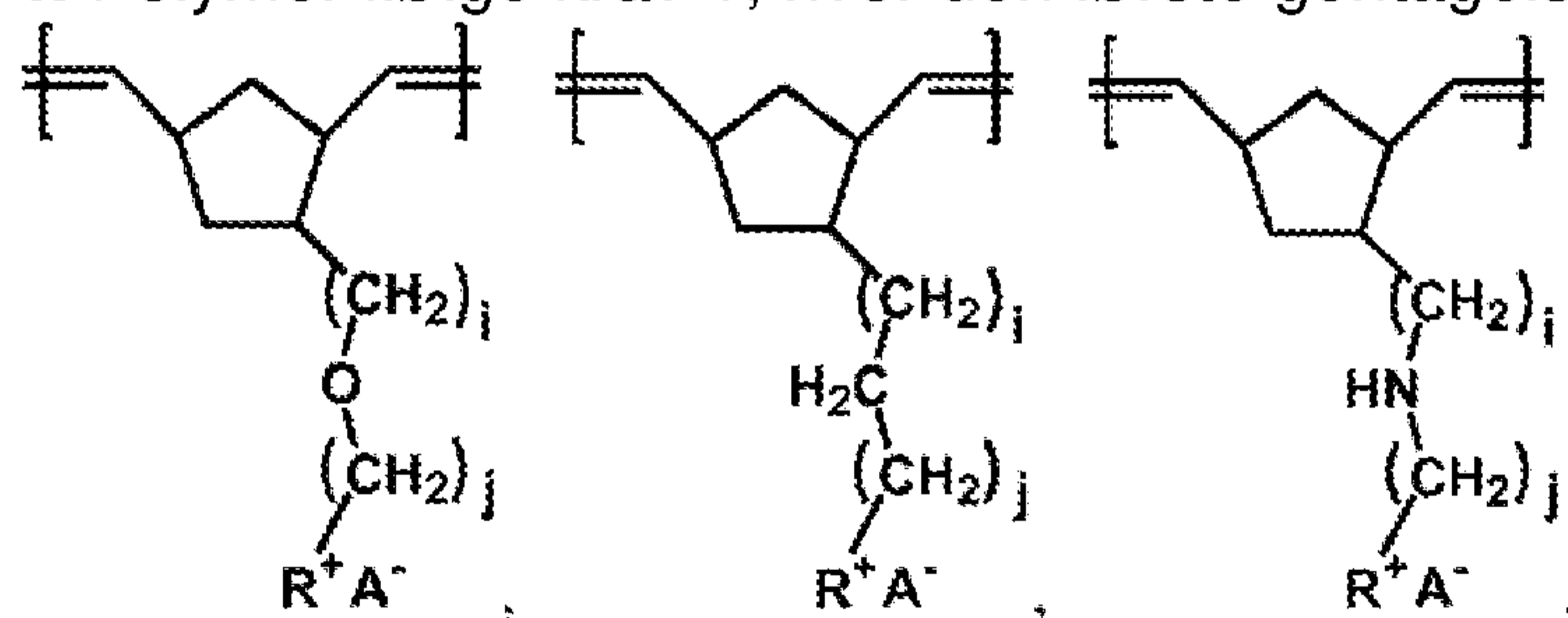
i og j uafhængigt er 0 eller et heltal fra 1 til 6, Y er -O-, -S-, -CH₂- eller -NH-; R¹

uafhængigt er en C₁₋₈-alkylgruppe; og R² og R³ uafhængigt er hydrogen eller en C₁₋₈-alkylgruppe, hvor forholdet mellem den første gentagelsesenhed og den anden gentagelsesenhed er mellem 1:99 og 99:1.

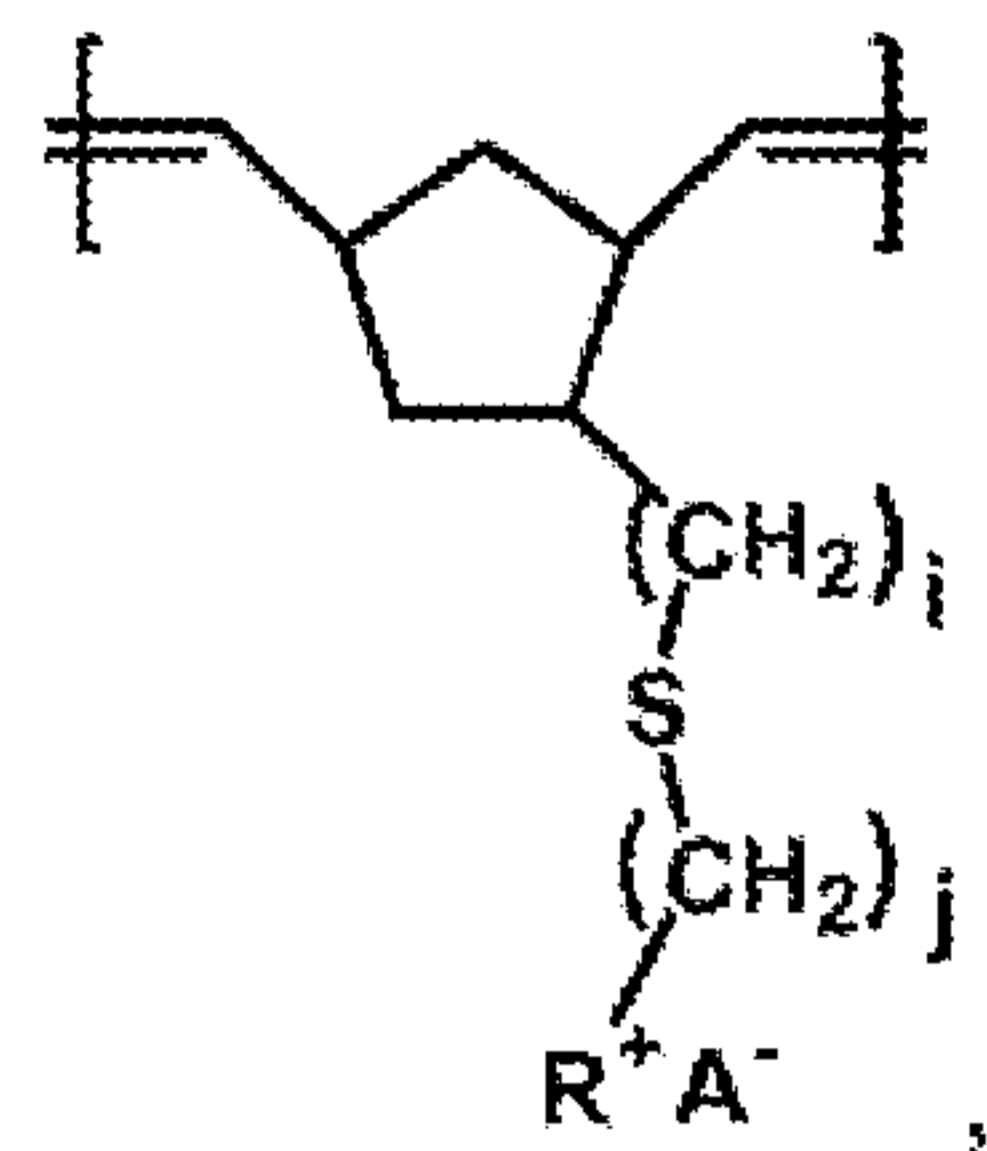
5 2. Polymer ifølge krav 1, hvor R¹ er methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, cyclohexyl, cyclopentyl, heptyl eller octyl.

10 3. Polymer ifølge krav 1, hvor R² og R³ uafhængigt er hydrogen, methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, cyclohexyl, cyclopentyl, heptyl eller octyl.

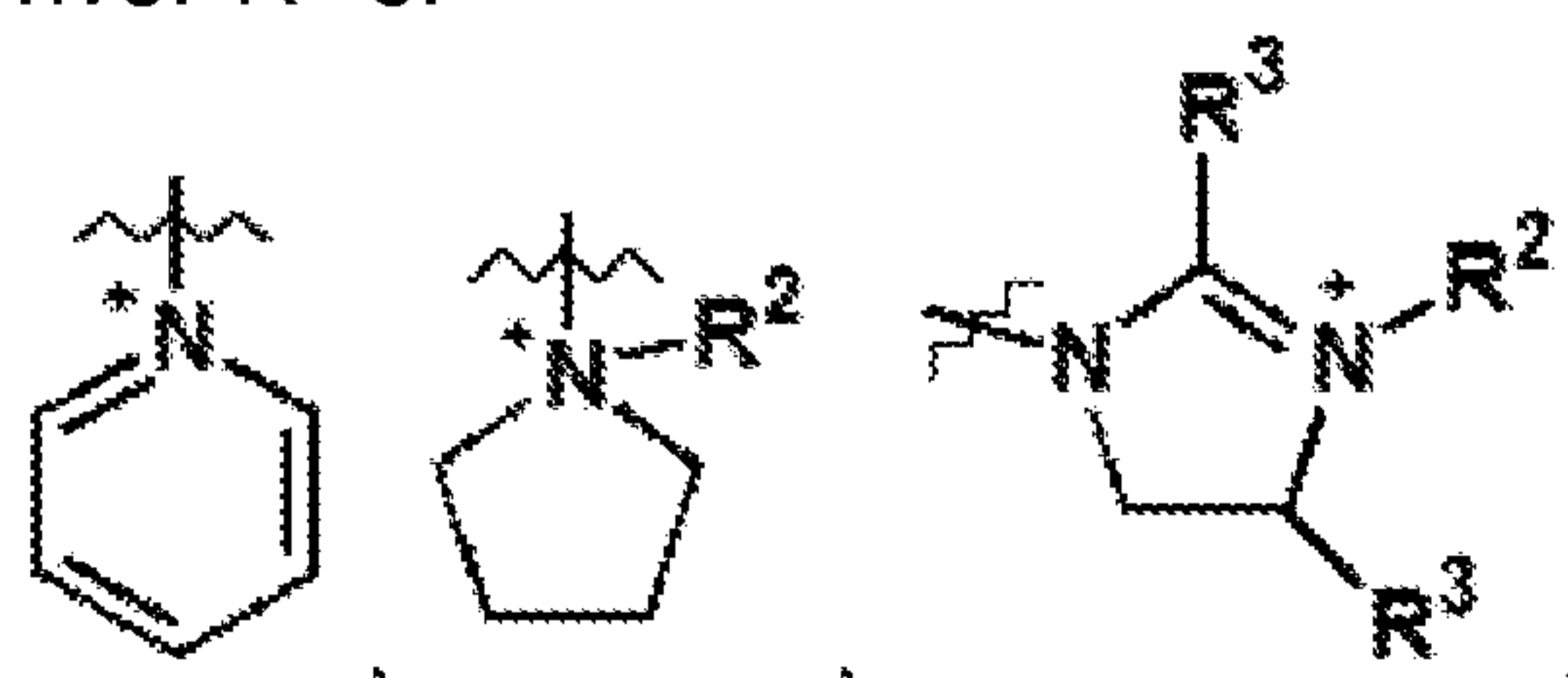
4. Polymer ifølge krav 1, hvor den første gentagelsesenhed er



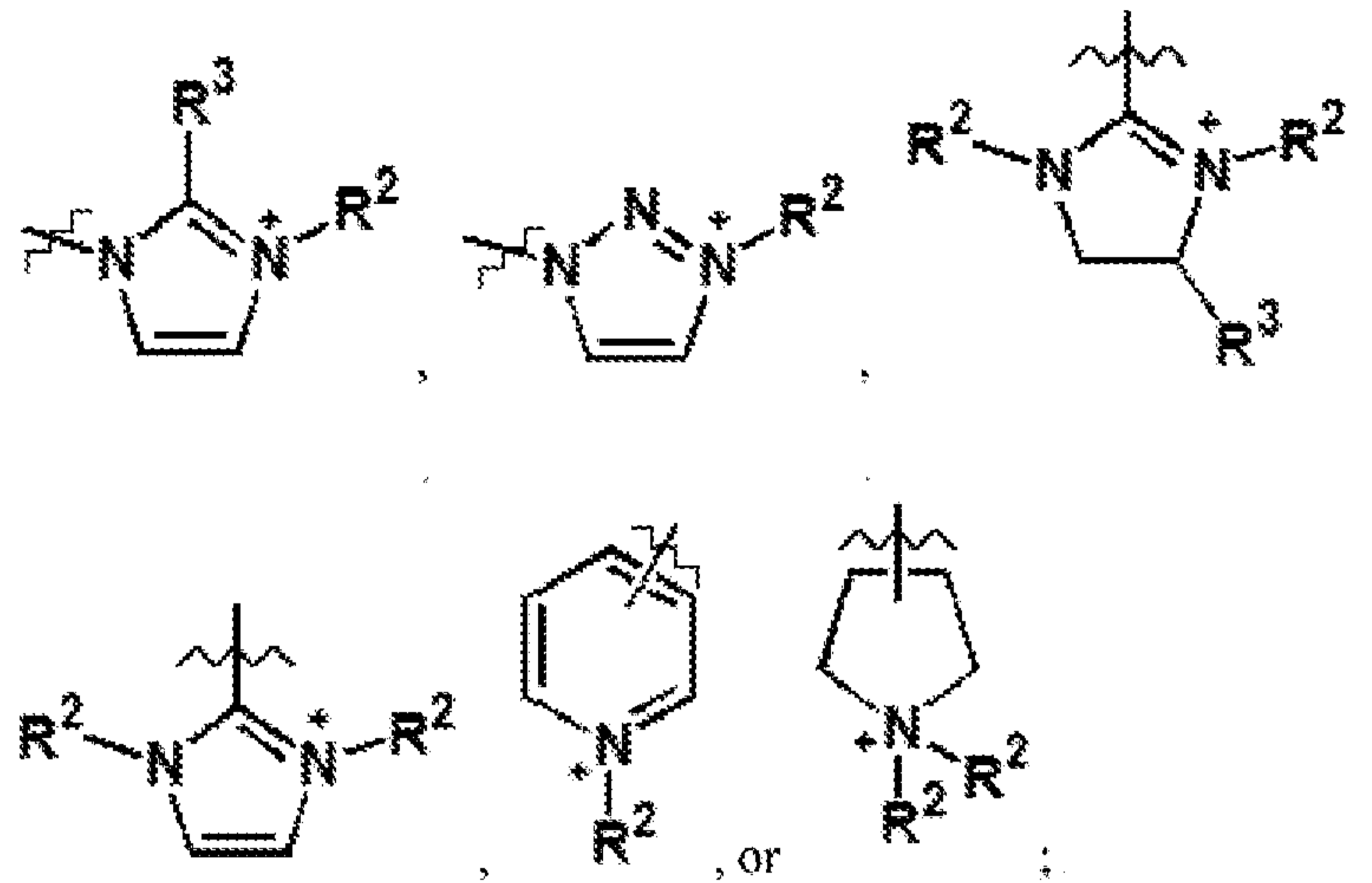
15 eller



hvor R⁺ er

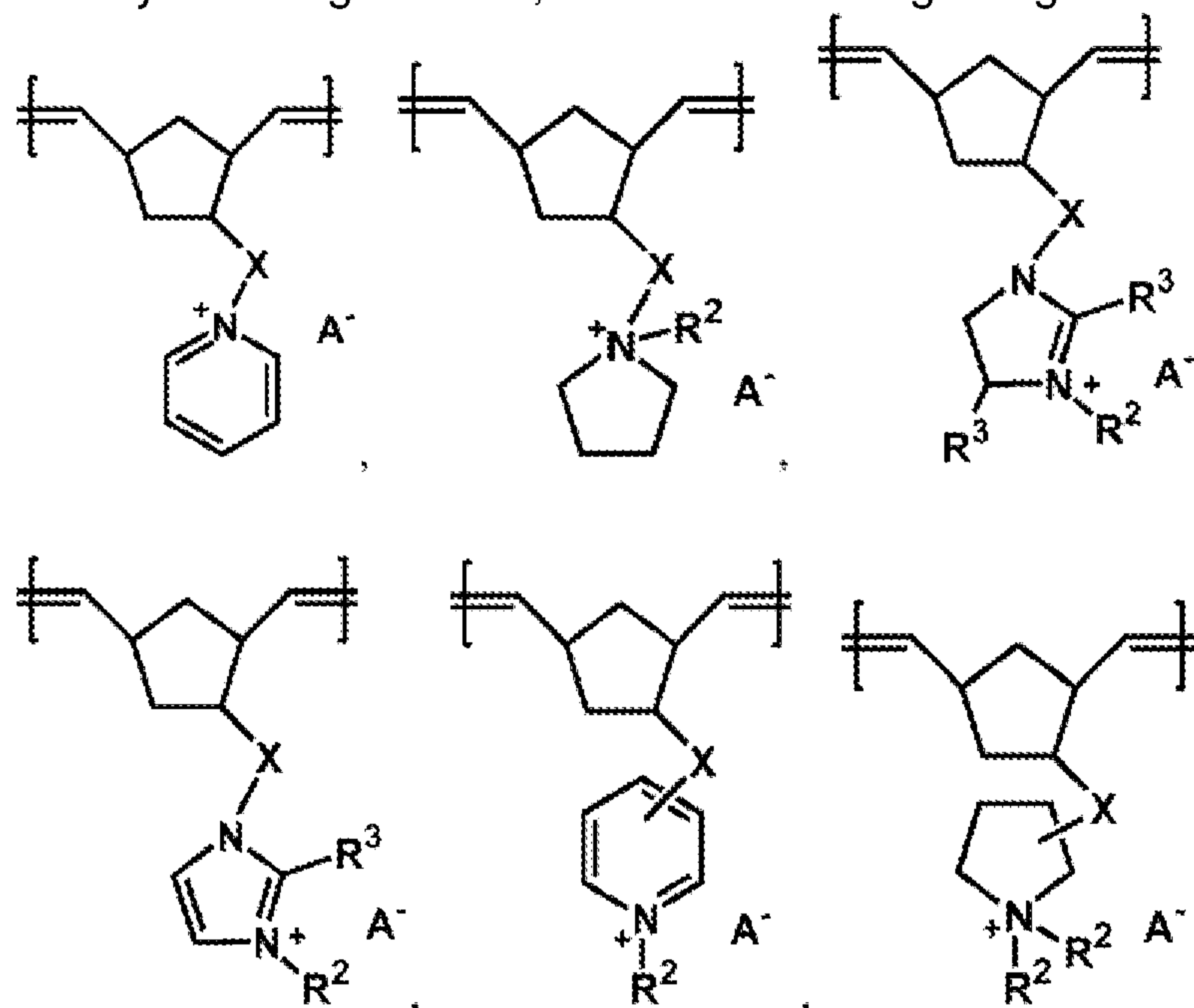


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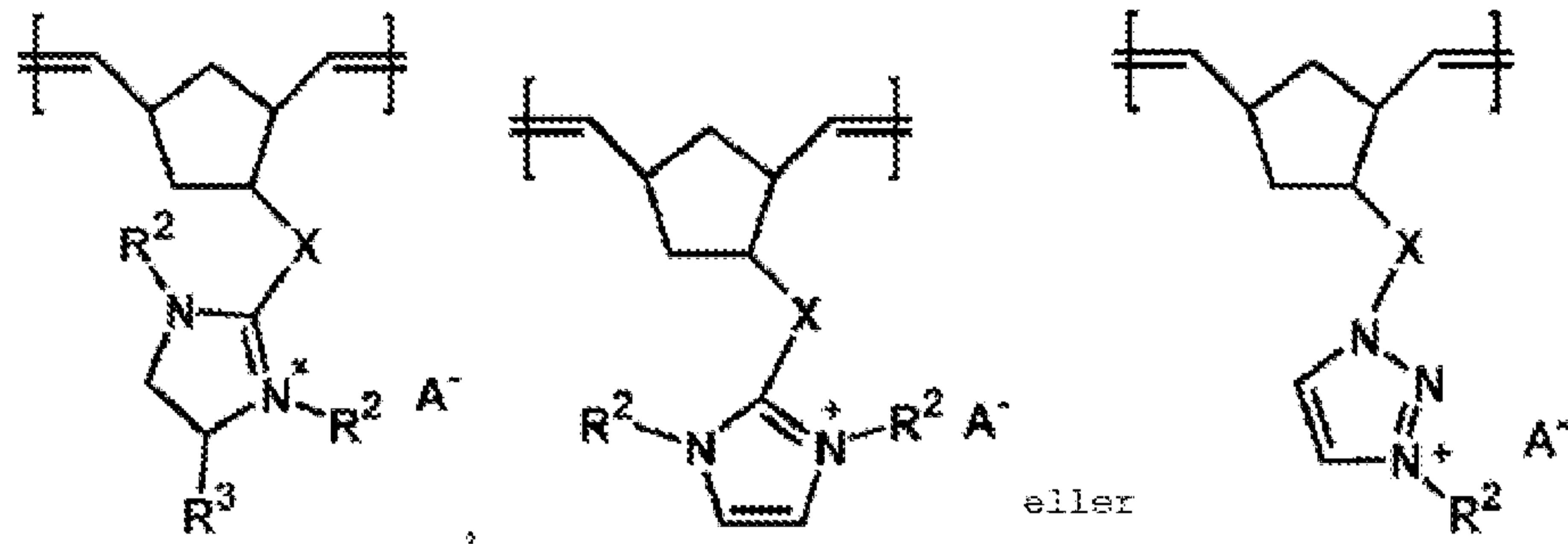


5 A⁻ er F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻ eller H₂PO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻ eller H₂PO₂⁻; i og j uafhængigt er 0 eller et heltal fra 1 til 6; og R² og R³ uafhængigt er hydrogen eller en C₁₋₈-alkylgruppe.

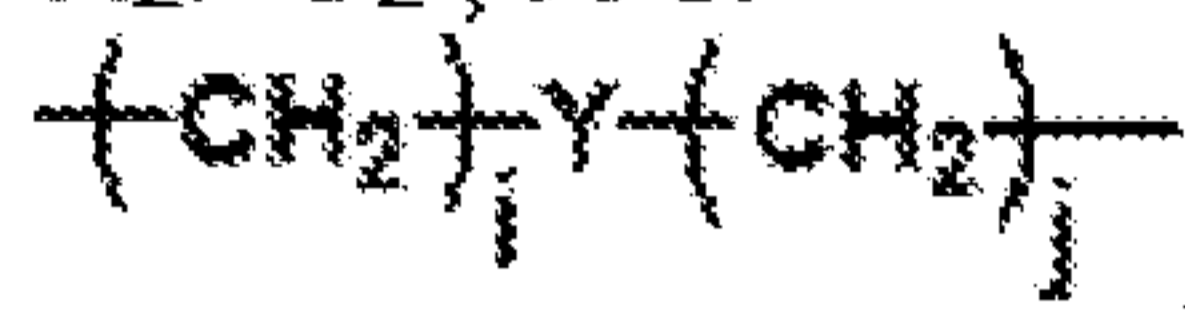
5. Polymer ifølge krav 1, hvor den første gentagelsesenhed er



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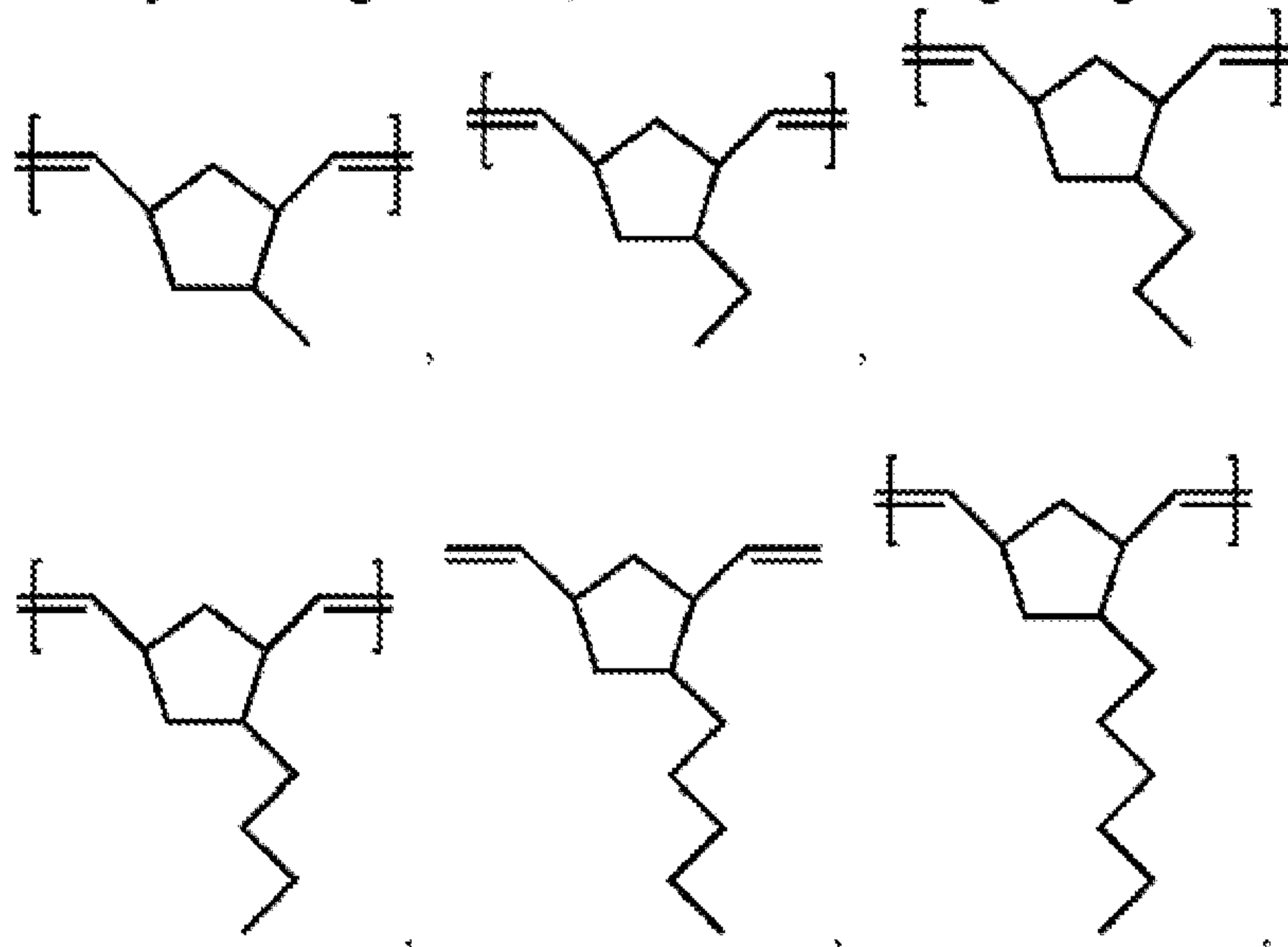


hvor A⁻ er F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻ eller H₂PO₂⁻; X er

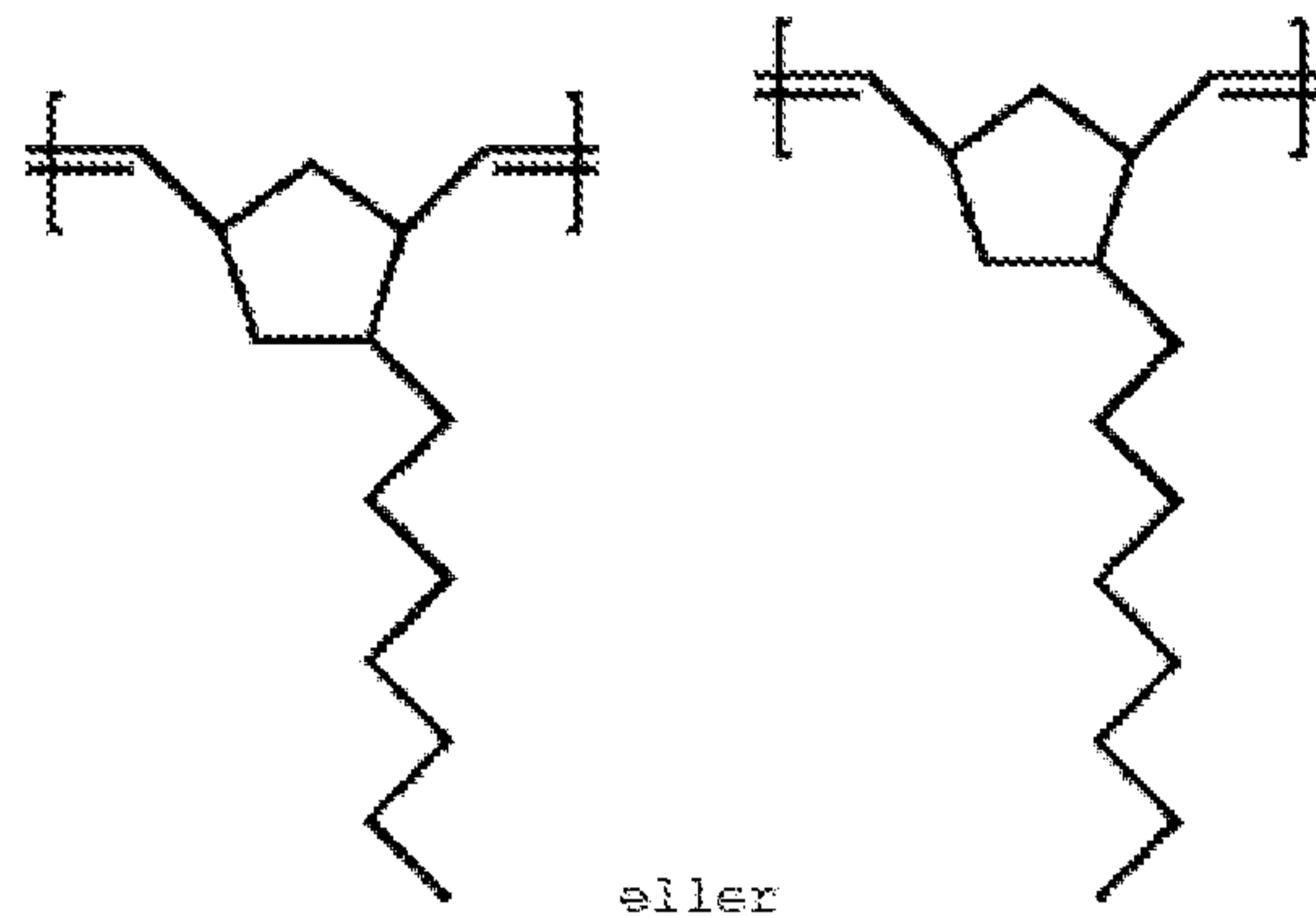


5 i og j uafhængigt er 0 eller et heltal fra 1 til 6, Y er -O-, -S-, -CH₂- eller -NH-; og R² og R³ uafhængigt er hydrogen eller en C₁₋₈-alkylgruppe.

6. Polymer ifølge krav 1, hvor den anden gentagelsesenhed er

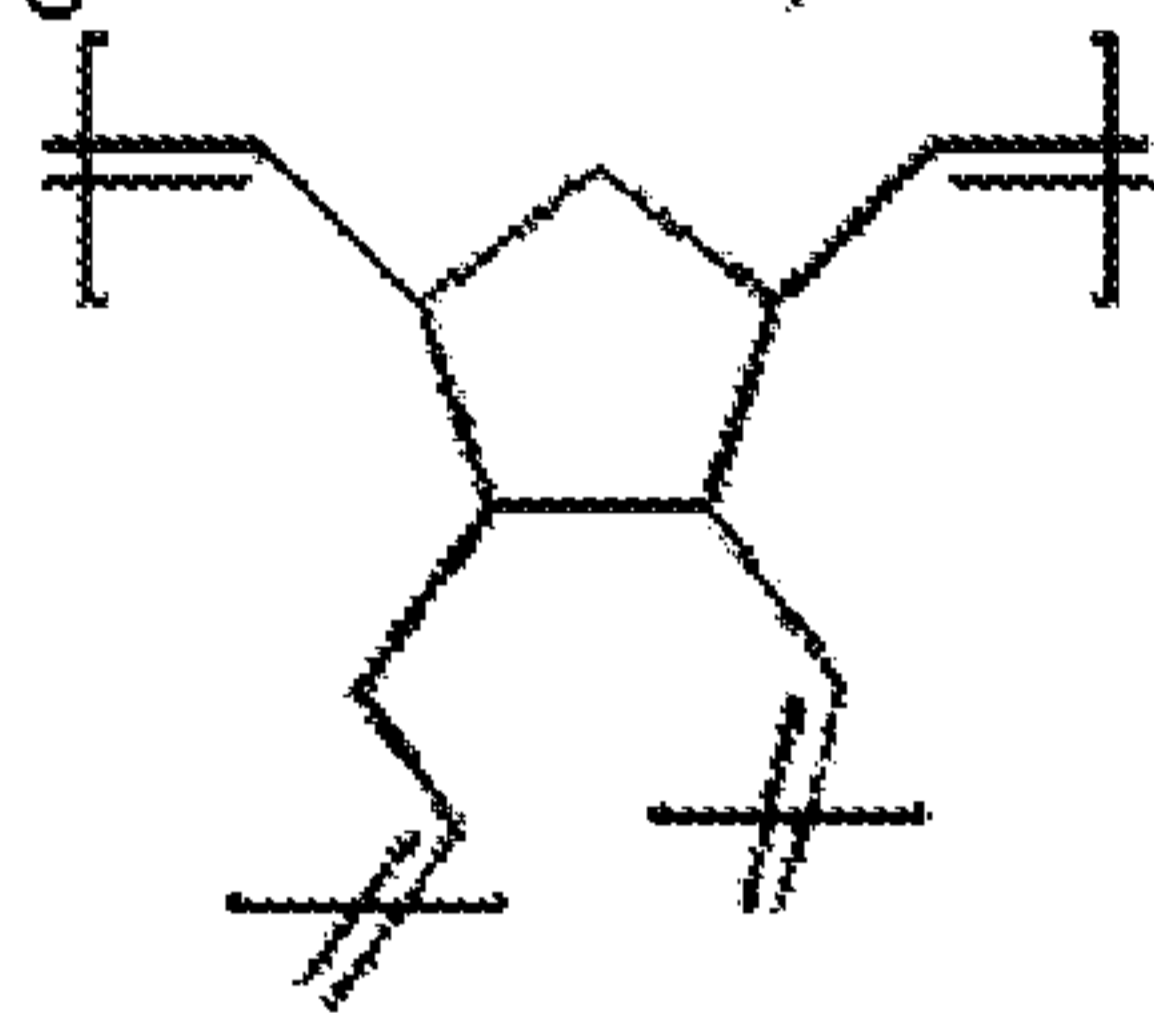


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7. Polymer ifølge krav 1, hvor polymeren endvidere omfatter en tredje gentagelsesenhed, hvor den tredje gentagelsesenhed er

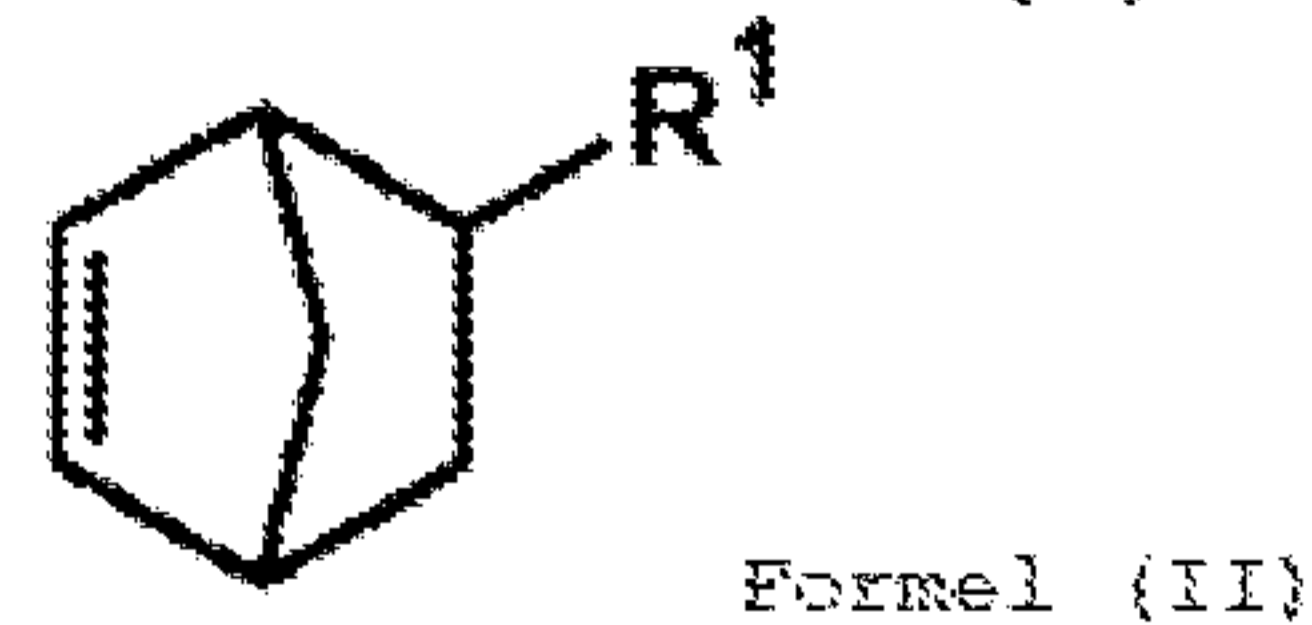
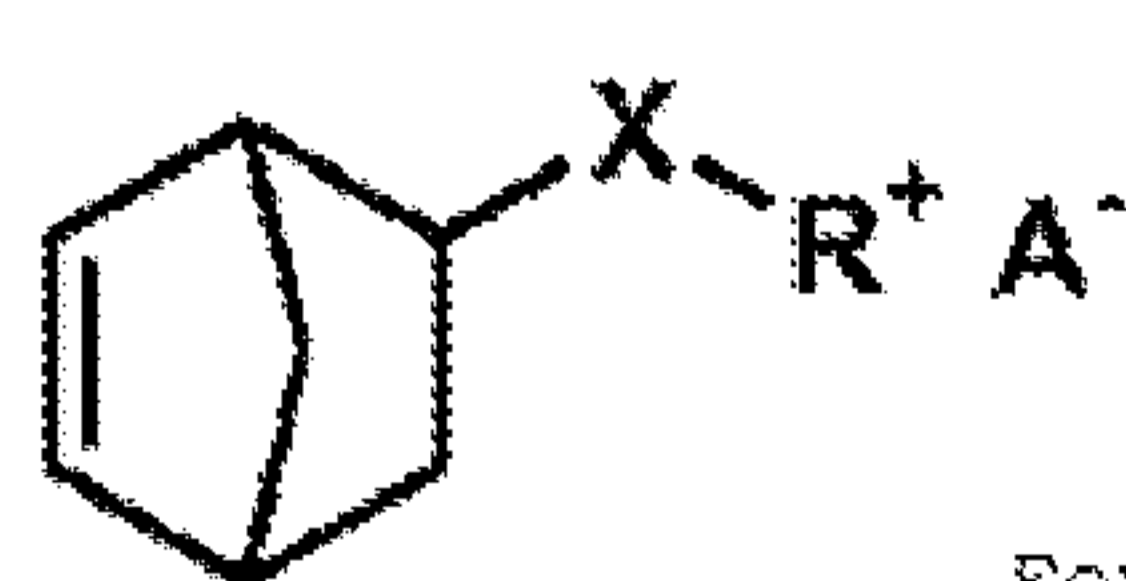


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8. Polymer ifølge krav 7, hvor forholdet mellem den tredje gentagelsesenhed og summen af den første gentagelsesenhed og den anden gentagelsesenhed er mellem 0,1:100 og 5:100.

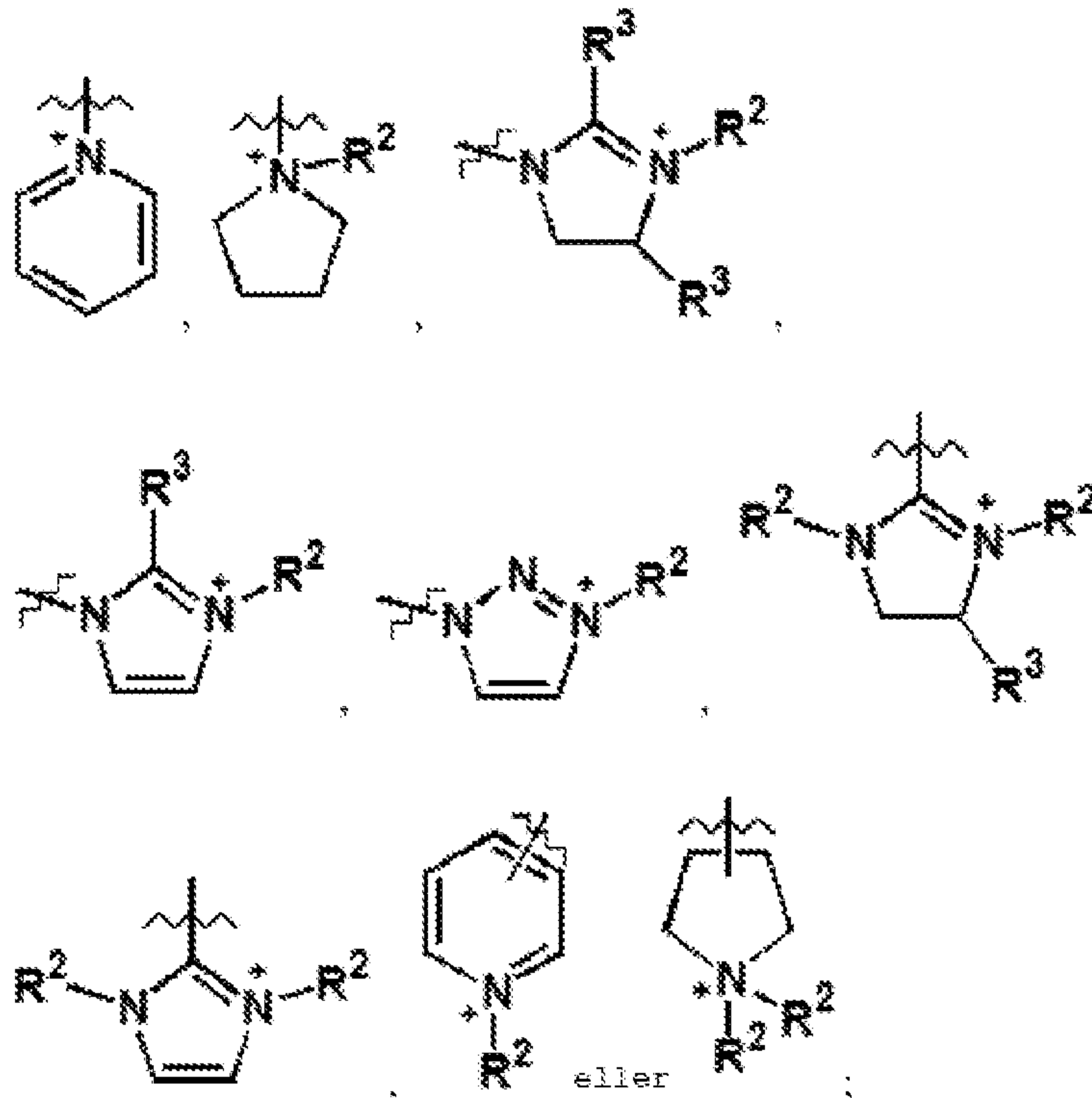
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9. Fremgangsmåde til fremstilling af polymeren ifølge krav 1, omfattende: at udsætte en sammensætning for en polymerisering, hvor sammensætningen omfatter en første monomer med en struktur i henhold til formel (I) og en anden monomer med en struktur i henhold til formel (II)



hvor R⁺ er

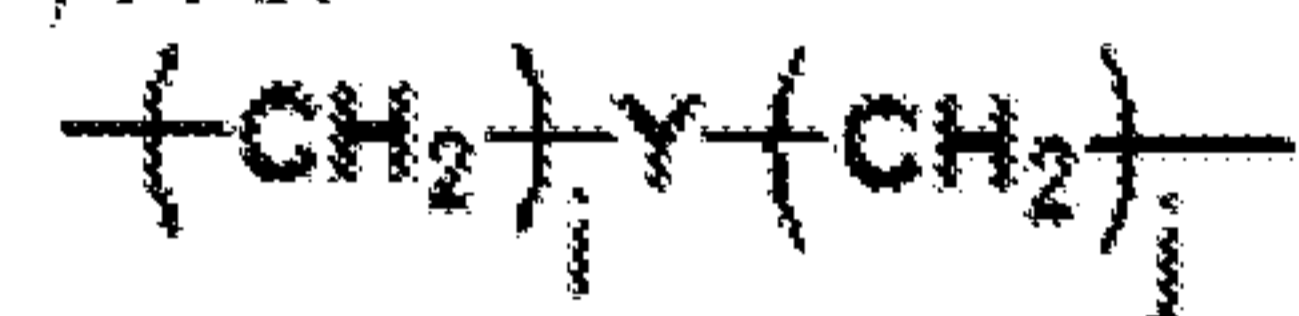
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A⁻ er F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻ eller H₂PO₂⁻

; X er



i og j uafhængigt er 0 eller et heltal fra 1 til 6, Y er -O-, -S-, -CH₂- eller -NH-; R¹ uafhængigt er en C₁₋₈-alkylgruppe; og R² og R³ uafhængigt er hydrogen eller en C₁₋₈-alkylgruppe, hvor molforholdet mellem den første monomer og den anden monomer er mellem 1:99 og 99:1.

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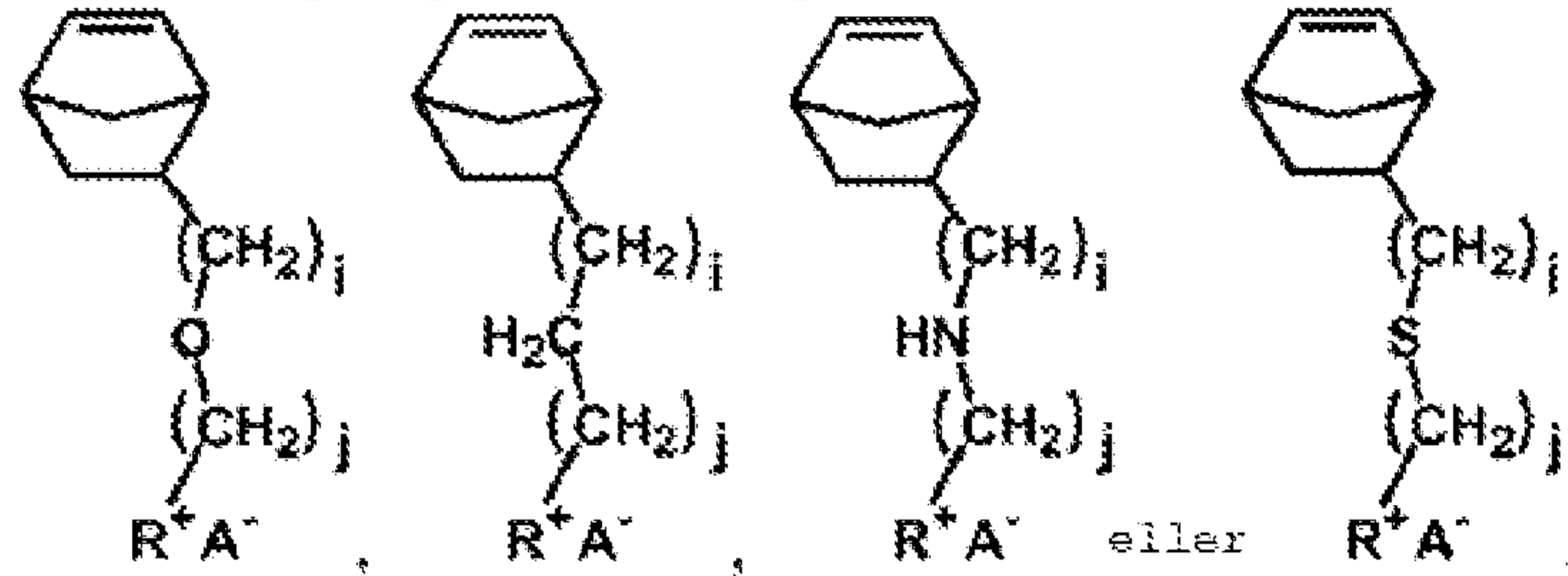
10. Fremgangsmåde ifølge krav 9, hvor R¹ er methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, cyclohexyl, cyclopentyl, heptyl eller octyl.

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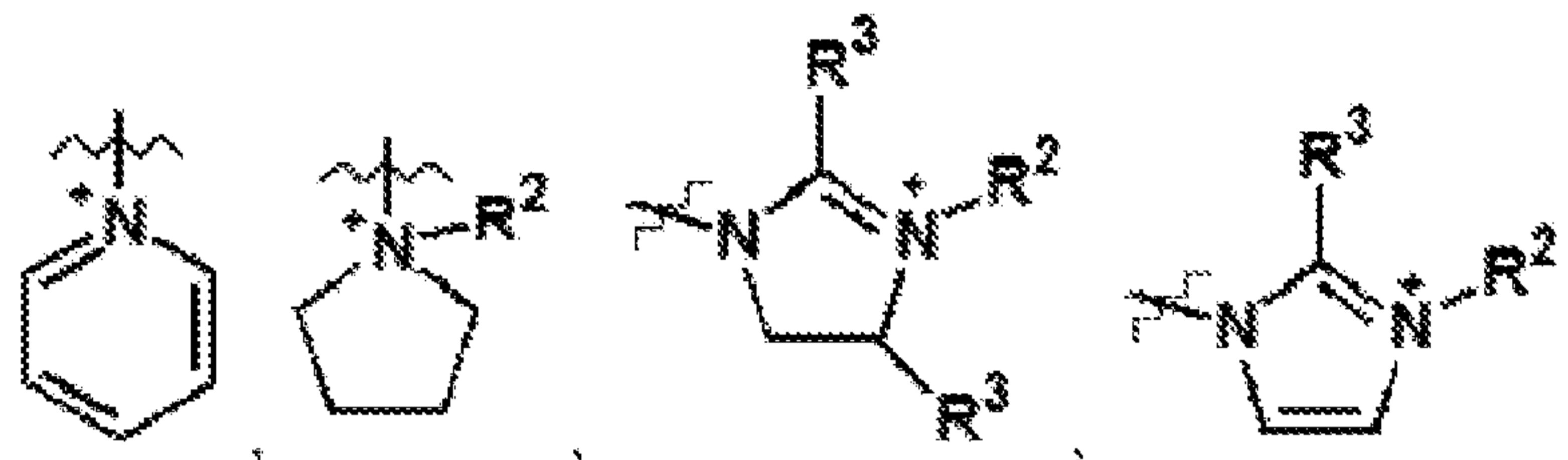
11. Fremgangsmåde ifølge krav 9, hvor R² og R³ uafhængigt er hydrogen, methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, cyclohexyl, cyclopentyl, heptyl eller octyl.

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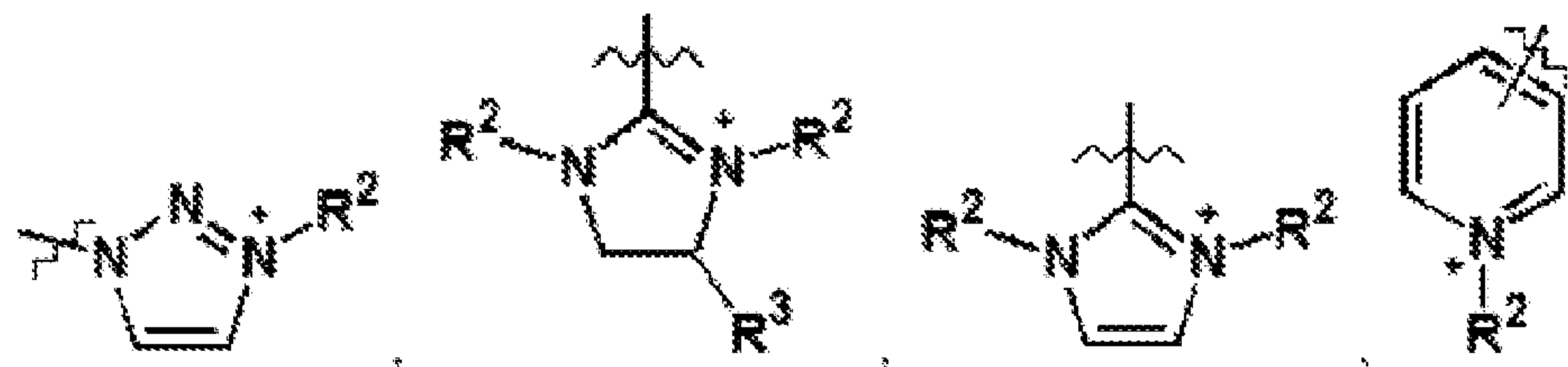
12. Fremgangsmåde ifølge krav 9, hvor den første monomer er



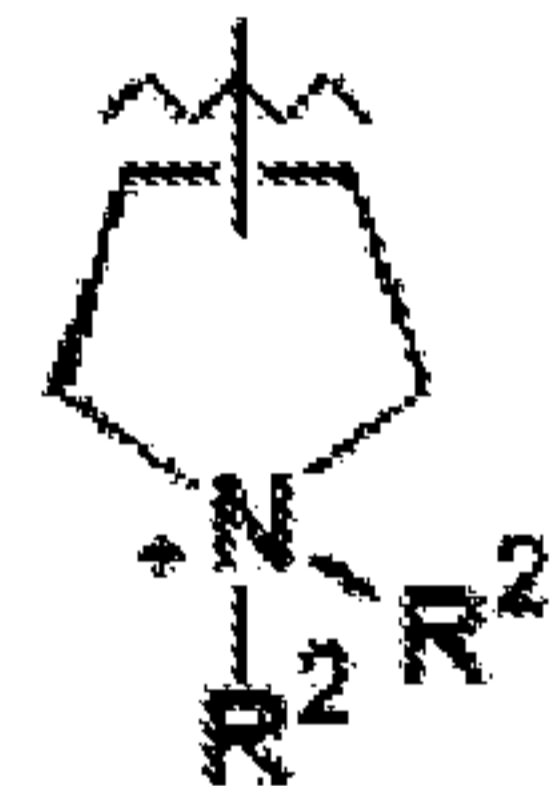
hvor R⁺ er



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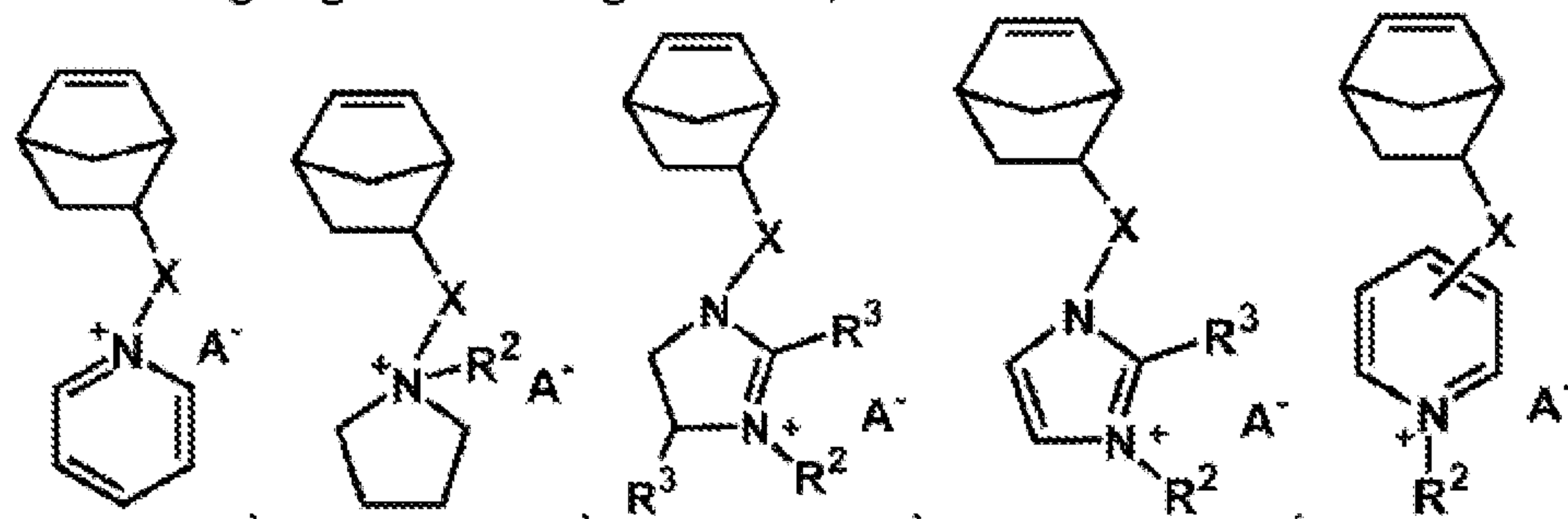
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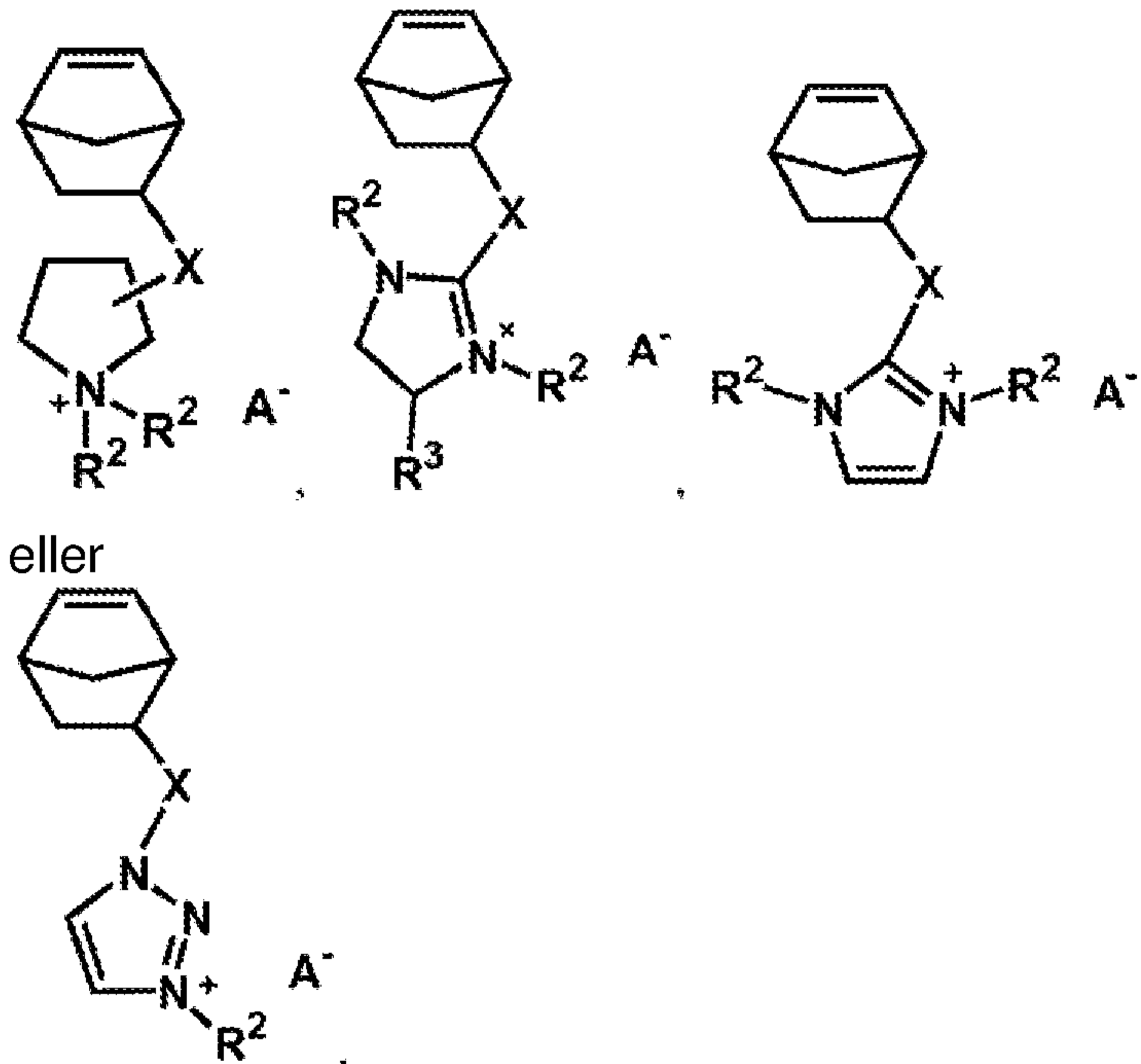


A⁻ er F⁻, Cl⁻, Br⁻, I⁻, OH⁻, HCO₃⁻, HSO₄⁻, SbF₆⁻, BF₄⁻, H₂PO₄⁻, H₂PO₃⁻ eller H₂PO₂⁻
 ; i og j uafhængigt er 0 eller et heltal fra 1 til 6; og R² og R³ uafhængigt er hydrogen eller en C₁₋₈-alkylgruppe.

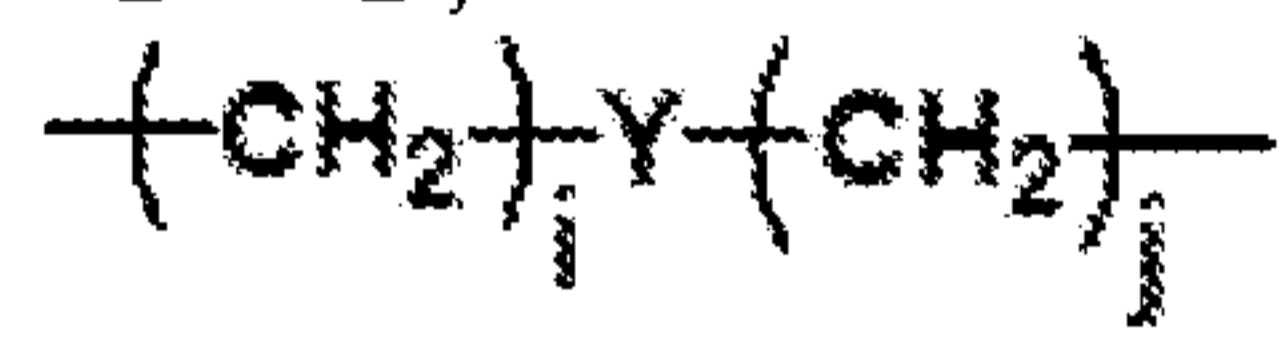
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13. Fremgangsmåde ifølge krav 9, hvor den første monomer er





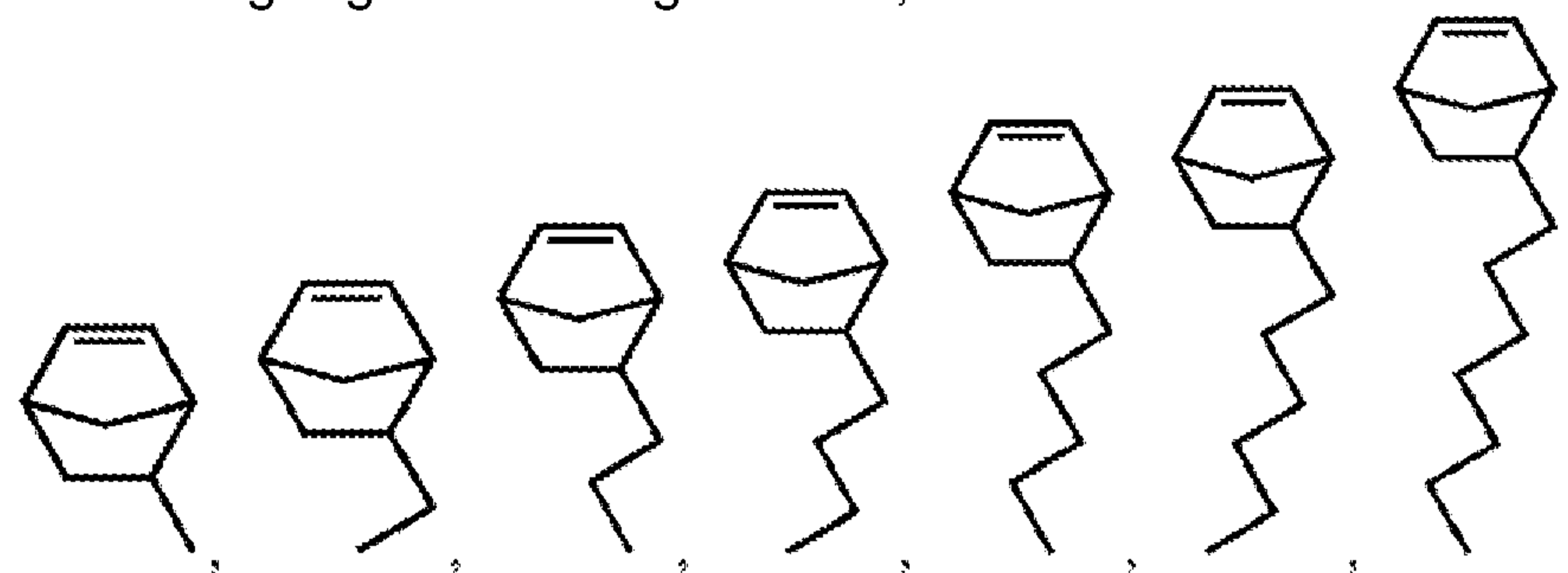
5 hvor A^- er F^- , Cl^- , Br^- , I^- , OH^- , HCO_3^- , HSO_4^- , SbF_6^- , BF_4^- , $H_2PO_4^-$, $H_2PO_3^-$ eller $H_2PO_2^-$; X er



i og j uafhængigt er 0 eller et heltal fra 1 til 6, Y er -O-, -S-, -CH₂- eller -NH-; og R² og R³ uafhængigt er hydrogen eller en C₁₋₈-alkylgruppe.

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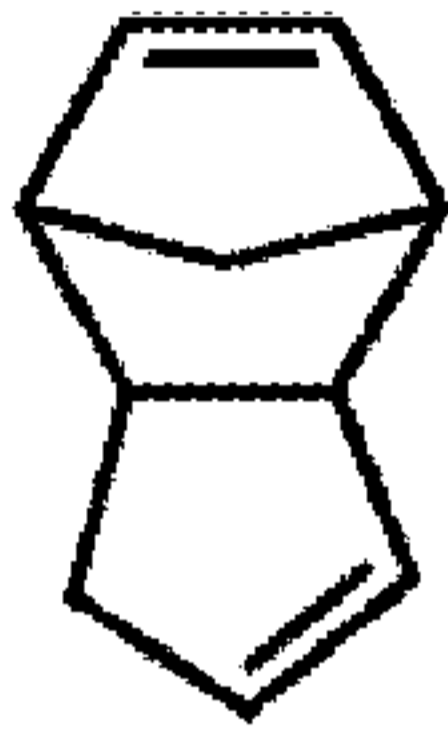
14. Fremgangsmåde ifølge krav 9, hvor den anden monomer er



eller



15. Fremgangsmåde ifølge krav 9, hvor sammensætningen endvidere omfatter en tredje monomer, hvor den tredje monomer er



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16. Fremgangsmåde ifølge krav 15, hvor molforholdet mellem den tredje monomer og summen af den første monomer og den anden monomer er mellem 0,1:100 og 5:100.