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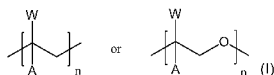
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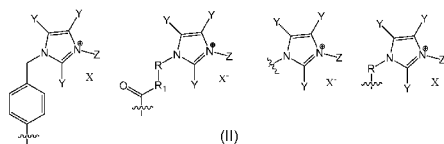
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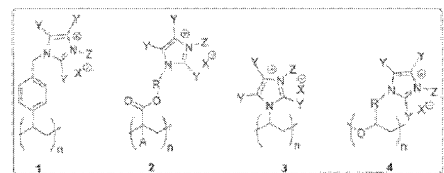
(54) Title: COMPOSITES COMPRISING NOVEL RTIL-BASED POLYMERS, AND METHODS OF MAKING AND USING SAME



wherein W is the side chain selected from the group consisting of:



Non-limiting examples



Z = Pendant curable group:

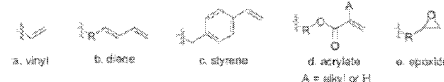


Figure 1

(57) Abstract: The invention includes compositions comprising curable imidazolium- functionalized poly(room-temperature ionic liquid) copolymers and homopolymers. The invention further includes methods of preparing and using the compositions of the invention. The invention further includes novel methods of preparing thin, supported, room-temperature ionic liquid-containing polymeric films on a porous support. In one embodiment, the methods of the invention avoid the use of a gutter layer, which greatly reduces the overall gas permeance and selectivity of the composite membrane. In another embodiment, the films of the invention have increased gas selectivity and permeance over films prepared using methods described in the prior art.



TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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1 May 2014

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/049765

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - B01D 53/22 (2014.01) USPC - 95/44 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC(8) - B01D 53/00, 53/22, 71/00, 71/64; C09K 19/34; C08L 39/04 (2014.01) USPC - 95/44; 96/5; 525/204 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched CPC - B01D 53/228, 2252/30, 2325/16; C08L 79/04 (2013.01) Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Orbit, Google Patents, Google Scholar		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/046661 A1 (BARA et al) 21 April 2011 (21.04.2011) entire document	1-10
A	US 2009/0266230 A1 (RADOSZ et al) 29 October 2009 (29.10.2009) entire document	1-10
A	US 2011/0236295 A1 (ANDERSON et al) 29 September 2011 (29.09.2011) entire document	1-10
X, P	NOBLE et al. Ionic liquids as novel materials for energy efficient CO ₂ separations. Sustainable Technologies, Systems and Policies 2012 Carbon Capture and Storage Workshop: 15. Pages 1-7. 19 December 2012. [Retrieved 30/01/2014]. Retrieved from the Internet. <URL: http://www.qscience.com/doi/pdf/10.5339/stsp.2012.ccs.15@cop18.2012.2012.issue-1 > entire document	1-10
☐ Further documents are listed in the continuation of Box C. ☐		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 03 February 2014		Date of mailing of the international search report 26 FEB 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201		Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

<Continued from Box III: Observations where unity of invention is lacking>

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I: Claims 1-10 are drawn to a composition comprising a curable imidazolium-functionalized poly(room temperature ionic liquid) (poly(RTIL)) copolymer.

Group II: Claim 11 is drawn to a method of preparing a curable poly(RTIL).

Group III: Claims 12-15 are drawn to a method of processing a gas mixture.

Group IV: Claims 16-25 are drawn to a composition and method of using a composition comprising a RTIL, a step-growth imidazolium-based RTIL monomer and an amine-containing monomer.

Group V: Claims 26-32 are drawn to a method of preparing a thin, supported, room-temperature ionic liquid (RTIL)-containing polymeric film on a porous support.

The inventions listed as Groups I through V do not relate to a single general inventive concept under PCT Rule 13.1 because under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, a composition comprising a curable imidazolium-functionalized poly(room temperature ionic liquid) (poly(RTIL)) copolymer, are not found in Groups II through V; the special technical features of Group II, a method for preparing a curable poly(RTIL), are not found in Groups I and III through V; the special technical features of Group III, a method of processing a gas mixture, are not found in Groups I, II, IV, and V; the special technical features of Group IV, a composition and method of using a composition comprising a RTIL, a step-growth imidazolium-based RTIL monomer and an amine-containing monomer, are not found in Groups I through III and V; the special technical features of Group V, a method of preparing a thin, supported, room-temperature ionic liquid (RTIL)-containing polymeric film on a porous support, are not found in Groups I through IV.

Groups I through V share the technical features of a composition comprising a curable imidazolium-functionalized poly(room temperature ionic liquid) (poly(RTIL)) copolymer, wherein the copolymer comprises a plurality of imidazolium-functionalized monomeric units, wherein (100x(1-p))% of the monomeric units comprise a side-chain imidazolium group substituted with a curable group, further wherein (100xp)% of the monomeric units comprise a side-chain imidazolium group substituted with a non-curable group, wherein p ranges from 0 to 1 and a method of processing a given gas mixture comprising a first gas component and a second gas component, the method comprising the steps of: providing a membrane or film comprising the composition, wherein the composition is at least partially cured, further wherein the membrane or film comprises a feed side and a permeate side, further wherein the membrane or film is selectively permeable to the first gas component over the second gas component; contacting the given gas mixture with the feed side of the membrane or film; and applying a pressure difference across the membrane or film; whereby the gas mixture isolated at the permeate side of the membrane or film is enriched for the first gas component over the second gas component as compared to the given gas mixture. However, these technical features do not represent a contribution over the prior art.

Specifically, WO 2011/046661 A1 to Bara et al. teaches a composition comprising a curable imidazolium-functionalized poly(room temperature ionic liquid) (poly(RTIL)) copolymer (Abstract. ...polymerized and/or non-polymerized room-temperature ionic liquids (RTILs)...; Para. [0014], ...the RTILs are imidazolium-based RTILs...; Para. [0016], ...an imidazolium-based cation...the cation is a substituted imidazolium-based heterocycle with substituents at both nitrogen atoms of the five-membered ring...; Para. [0026], ...provides compositions and composites...comprising RTILs...; Para. [0059]), wherein the copolymer comprises a plurality of imidazolium-functionalized monomeric units, wherein (100x(1-p))% of the monomeric units comprise a side-chain imidazolium group substituted with a curable group, further wherein (100xp)% of the monomeric units comprise a side-chain imidazolium group substituted with a non-curable group, wherein p ranges from 0 to 1 (Para. [0027], Polymerized RTILs of the present invention, also referred to herein as "poly(RTIL)s", primarily comprise RTIL cations attached to a polymer backbone...side-chain configuration...; Formula 4a; Para. [0043], ...a polymerized RTIL comprising a plurality of RTIL-based repeating units...; Paras. [0045]-[0048], where the imidazolium-based side chains can independently contain polymerizable and unpolymerizable groups; Para. [0059], ...composites of polymerized RTILs and unpolymerized RTILs...monomer mixture comprising a plurality of polymerizable salts of the inventions, and a polymerization initiator...mixture also comprises a nonpolymerizable RTIL...cross-linking agent molecule to help promote intermolecular bonding between polymer chains...cross-linking agent or curing agent...) and a method of processing a given gas mixture comprising a first gas component and a second gas component (Para. [0070], ...a method of separating a first gas component from a gas mixture containing at least a first and a second gas component...), the method comprising the steps of: providing a membrane or film comprising the composition (Para. [0070], ...providing a membrane or film comprising a polymerized RTIL-unpolymerized RTIL composition...), wherein the composition is at least partially cured (Para. [0070], ...providing a membrane or film comprising a polymerized RTIL-unpolymerized RTIL composition...; Para. [0059]), further wherein the membrane or film comprises a feed side and a permeate side (Para. [0070], ...the membrane or film having a feed side and a permeate side...), further wherein the membrane or film is selectively permeable to the first gas component over the second gas component (Para. [0070], ...being selectively permeable to the first gas component over the second gas component...); contacting the given gas mixture with the feed side of the membrane or film (Para. [0070], ...applying a feed stream including the first and second gas components to the feed side of the membrane...); and applying a pressure difference across the membrane or film (Para. [0070], ...providing a driving force sufficient...; Para. [0131], ...forces such as the pressure differential across the membrane...); whereby the gas mixture isolated at the permeate side of the membrane or film is enriched for the first gas component over the second gas component as compared to the given gas mixture (Para. [0070], ...thereby producing a permeate stream enriched in the first gas component from the permeate side of the membrane...)

The inventions listed in Groups I through V therefore lack unity under Rule 13 because they do not share a same or corresponding special technical feature.

<End Box III: Observations where unity of invention is lacking>

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/049765

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Extra Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-10

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.