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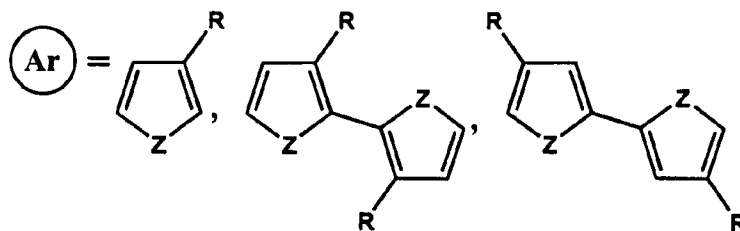
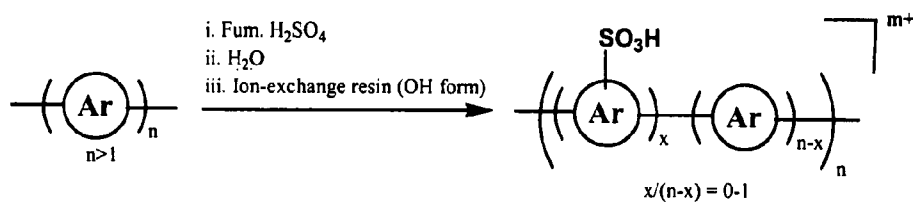
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[Continued on next page]

(54) Title: SULFONATION OF CONDUCTING POLYMERS AND OLED, PHOTOVOLTAIC, AND ESD DEVICES



Z = S, N (optionally substituted), Se, Te, Si

(57) Abstract: Conducting polymer systems for hole injection or transport layer applications including a composition comprising: a water soluble or water dispersible regioregular polythiophene comprising (i) at least one organic substituent, and (ii) at least one sulfonate substituent comprising sulfonate sulfur bonding directly to the polythiophene backbone. The polythiophene can be water soluble, water dispersible, or water swellable. They can be self-doped. The organic substituent can be an alkoxy substituent, or an alkyl substituent. OLED, PLED, SMOLED, PV, and ESD applications can be used.

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European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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**A. CLASSIFICATION OF SUBJECT MATTER**  
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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)  
**C08G C08L C09D H01L**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**EPO-Internal, CHEM ABS Data, WPI Data**

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>UDUM Y A ET AL: "Electrochemical synthesis of soluble sulfonated poly(3-methyl thiophene)"                      EUROPEAN POLYMER JOURNAL, PERGAMON PRESS LTD. OXFORD, GB,                      vol. 40, no. 6, 1 June 2004 (2004-06-01), pages 1057-1062, XP004506379                      ISSN: 0014-3057</p> <p>the whole document</p> <p align="center">----- -/--</p>	<p>1-6,9, 10,12, 15-21, 31, 34-38, 52,54, 55, 60-69, 71-77, 81-83, 87, 91-94,97</p>

Further documents are listed in the continuation of Box C.

See patent family annex.

\* 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 document 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

**11 September 2008**

Date of mailing of the international search report

**18 September 2008 (18.09.2008)**

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INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2007/015927

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>US 5 486 560 A (SHIGA TOHRU [JP] ET AL) 23 January 1996 (1996-01-23)</p> <p>example 2</p>	<p>1,2,9, 10,12, 15-17, 19,20, 31,32, 34-38, 52,54, 55,61, 62, 64-69, 71,72, 77,79, 81-83, 91, 93-95,97</p>
X	<p>US 5 648 453 A (SAIDA YOSHIHIRO [JP] ET AL) 15 July 1997 (1997-07-15)</p> <p>abstract column 3, line 4 - column 6, line 27 column 7, line 11 - line 33 column 10, line 44 - column 11, line 24 column 11, line 57 - column 14, line 62 column 15, line 27 - column 18, line 57 examples 10,11,16,17,28-30 claim 1</p>	<p>1-6, 9-13, 15-21, 23,25, 29, 31-38, 41-83, 85-95,98</p>
X	<p>EP 0 834 885 A (NITTO CHEMICAL INDUSTRY CO LTD [JP] MITSUBISHI RAYON CO [JP]) 8 April 1998 (1998-04-08) cited in the application</p> <p>page 2, line 5 - line 30 page 10, line 34 - line 37 examples 13,14</p>	<p>1-6, 9-21, 23-38, 41-83, 85-95, 97,98</p>
X	<p>EP 1 634 922 A (SHINETSU POLYMER CO [JP]) 15 March 2006 (2006-03-15) paragraphs [0282], [0336] - [0338]</p>	<p>1-98</p>

## INTERNATIONAL SEARCH REPORT

International application No

PCT/US2007/015927

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>PILSTON R L ET AL: "TOWARD HIGHLY FLUORESCENT POLYTHIOPHENES: HEAD-TO-TAIL COUPLED COPOLYMERS OF 3-(METHOXYETHOXYETHOXYMETHYL) THIOPHENE AND 3-(PERFLUOROALKYL) THIOPHENE" SYNTHETIC METALS, ELSEVIER SEQUOIA, LAUSANNE, CH, vol. 111/112, 15 May 1989 (1989-05-15), pages 433-436, XP001151608 ISSN: 0379-6779 the whole document</p>	1-98
A	<p>SHEINA, E.E.; KHERSONSKY, S.M.; JONES, E.G.; MCCULLOUGH, R.D.: "Highly Conductive, Regioregular Alkoxy-Functionalized Polythiophenes: A New Class of Stable, Low Band Gap Materials" CHEMISTRY OF MATERIALS, vol. 17, no. 13, 28 June 2005 (2005-06-28), pages 3317-3319, XP002485193 the whole document</p>	1-98
X	<p>WO 2005/091309 A (SHOWA DENKO KK [JP]; SAIDA YOSHIHIRO [JP]; OHKUBO TAKASHI [JP]) 29 September 2005 (2005-09-29) figure 7 page 21, line 12 - line 14 page 62, line 17 - page 65, line 14 examples 1-20</p>	64-66
X	<p>YAMAMOTO T: "p-Doping of poly(3-hexylthiophene-2,5-diyl) with sulfonic acids and oxygen related to self-doping of sulfonated polythiophenes" REACTIVE &amp; FUNCTIONAL POLYMERS, ELSEVIER SCIENCE PUBLISHERS BV, NL, vol. 55, no. 2, 1 April 2003 (2003-04-01), pages 231-234, XP004421385 ISSN: 1381-5148 abstract text sections "2.Experimental", "3. Results and discussion"</p>	64-67
X	<p>HUER ET AL: "Corrosion performance of self-doped sulfonated polypyrrole coatings on stainless steel" MATERIALS CHEMISTRY AND PHYSICS, ELSEVIER, vol. 100, no. 1, 4 January 2006 (2006-01-04), pages 19-25, XP005661230 ISSN: 0254-0584 abstract</p>	64,65

INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2007/015927

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/78464 A (KOREA INST SCIENCE TECHNOLOGY [KR]; PARK O OK [KR]; LEE TAE WOO [KR]) 18 October 2001 (2001-10-18) abstract page 5, line 11 - page 6, line 28 examples 2-4 claim 11 -----	64

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2007/015927

## 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 additional sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.
  
2.  As all searchable claims could be searched without effort justifying an 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.:  
  
1 - 63, 68 - 98
  
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.:

### 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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-63,68-98

Compositions comprising a water-soluble, water-dispersible, or water-swellaible heterocyclic polymer comprising (i) at least one organic substituent, and (ii) at least one sulphonate substituent comprising sulphonate sulphur bonding directly to the heterocyclic polymer backbone.

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2. claims: 64-67

A device comprising a hole injection layer or a hole transport layer, the layer comprising a sulphonated conducting polymer.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No <b>PCT/US2007/015927</b>
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Patent document cited in search report	A	Publication date	Patent family member(s)	Publication date
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US 5648453	A	15-07-1997	US 5688873 A	18-11-1997
EP 0834885	A	08-04-1998	AU 733376 B2 CA 2217378 A1 DE 69709819 D1 DE 69709819 T2 US 5980784 A	10-05-2001 02-04-1998 28-02-2002 14-08-2002 09-11-1999
EP 1634922	A	15-03-2006	WO 2004113441 A1	29-12-2004
WO 2005091309	A	29-09-2005	NONE	
WO 0178464	A	18-10-2001	DE 10191386 B4 DE 10191386 T0 JP 3898952 B2 JP 2003530676 T KR 20010095429 A KR 20020034981 A US 2002037432 A1	06-04-2006 20-06-2002 28-03-2007 14-10-2003 07-11-2001 09-05-2002 28-03-2002