Ionic Liquids Today

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Issue 3-07, Wednesday, 31th October, 2007.

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Nanoeurope 2007, St. Gallen, September 17th-18th 2007

Intertech Pira's Ionic Liquids event Prague, October 17th-18th 2007

Content:

I. Editorial

Only a couple of weeks and another interesting year for ionic liquids research and commercialisation will end. At exhibitions, fairs and conferences at least we at IOLITEC noticed that the concept of ionic liquids will surely become more than a footnote in chemistry books for the next generation of chemists. A still strongly increasing number of publications, patents and press releases demonstrates that it was a good decision to develop ionic liquids and applications. In addition, scientists, institutes and companies, who are involved in ionic liquids R&D have been awarded a number of prices. Are these just indicators or is it already possible to earn some money?

Well, if we take a look at the major chemical companies, their impressive engagement speaks for itself. Though I predict that the pre-financing of R&D and marketing activities are today probably still not compensated, the often massive power of those companies let suggest that there is money to earn now or in the very near future. The field that I am able to review best is of course IOLITEC: Founded in 2003 we are now in the position to end for the 5th time in a row in the black – without any acquisition of external money! And what about sales? Well, this year we observed a strong increase of sales, which belongs to the increasing demand on bulk quantities and about 150 new customers only in the first nine months.

Are there any good news for 2008? I suppose yes! Our portfolio gets wider and selected products will become cheaper, since they will be produced on a larger scale. I would be glad if you think in 2008 about IOLITEC when considering to use or to order high quality ionic liquids and nano materials!

Best regards,

Thomas J.S. Schubert, Managing Director, IOLITEC.

II Contract Research & Development at IOLITEC

By Andreas Reisinger.

As it is well known nowadays, ionic liquids possess several very interesting and unique physical and chemical properties such as

- very low to immeasurable vapor pressure,
- non-flammability below the decomposition temperature,
- high electric conductivity,
- high thermal and electrochemical stability and
- wide viscosity and liquid ranges.

Due to these and other interesting properties, many ionic liquids have been tested in a wide variety of different applications in such diverse areas as analytics, solvents, electrolytes, separation technology or performance chemicals and additives. Figure 1 gives an overview on the different areas including their commercialisation level.

However, as you might well know, you cannot talk of "the" Ionic liquid. Instead you have to talk of ionic liquids as a class of many different materials (according to K. Seddon the theoretically possible ionic liquids are as numerous as the grains of sand in the Sahara). Even the number of the already synthesized ILs easily exceeds thousand different compounds. This means one needs a detailed database of the ILs including all the different physical and chemical properties they possess. Therefore, throughout the past four years, IOLITEC collected data of more than 500 different ILs to substantiate its own extensive database.

Furthermore, in the past IOLITEC carried out numerous contract R&D tasks as well as almost 10 different government-funded joint research projects in most of the fields highlighted in Figure 1. As a result, IOLITEC has gained detailed experience and a profound expertise in research and development of various applications based on or related to ionic liquids. This means that we are able to help our customers with the selection of an appropriate IL for a certain application. Therefore our customers can be sure that they have the best liquid for their business and not just one off-the-

shelf. This of course also includes the development and custom synthesis of "tailor-made" Ionic Liquids, with task-specific, optimized physical and/or chemical parameters if necessary.

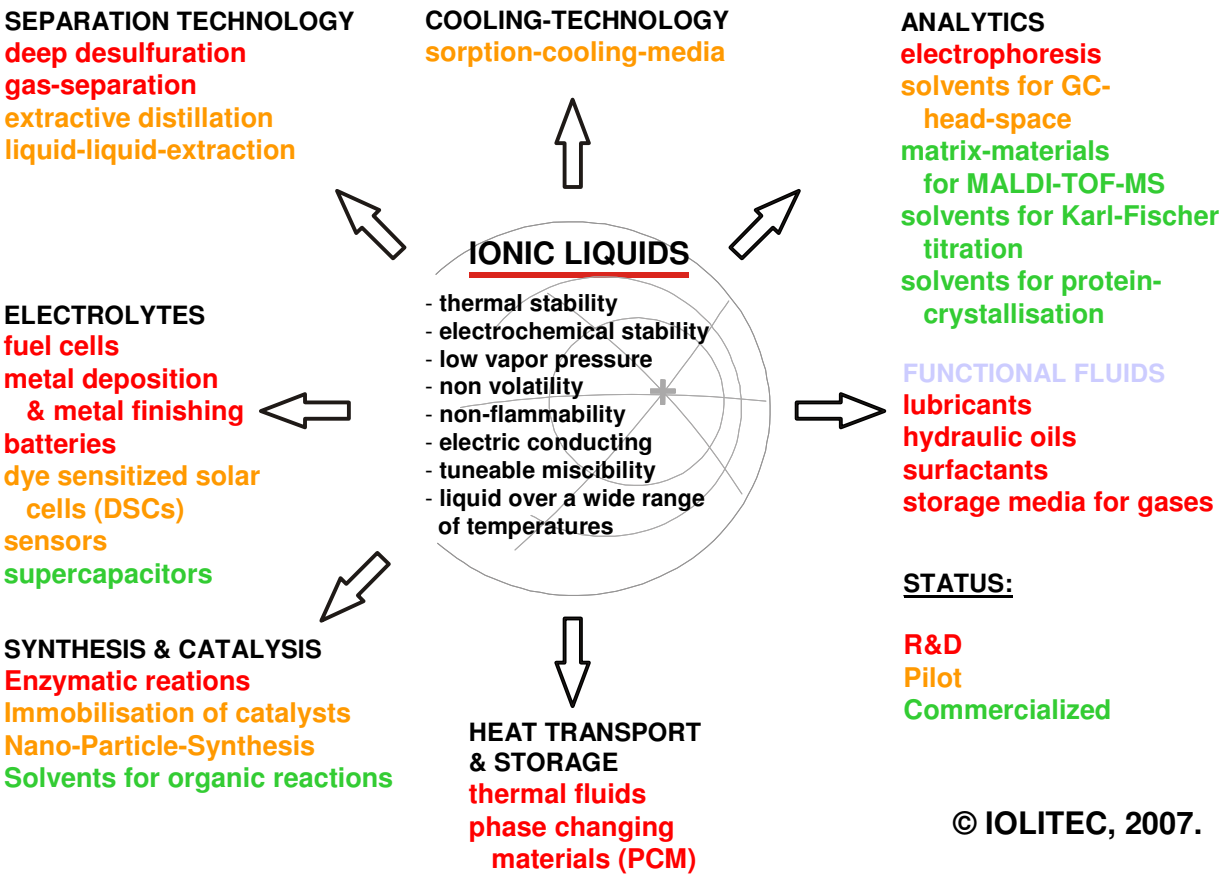


Figure 1. Potential application fields of ionic liquids including their commercialisation status.

Apart from the selection of the right candidates, the handling of ionic liquids is often not as straightforward as for other materials, e.g. dealing with high viscosities, non-volatility, hygroscopicity, and many others.

Furthermore, as a result of their unique properties, ionic liquids often have special requirements for the analytics and research instrumentation in the laboratory. IOLITEC fullfilled these requirements with a broad portfolio of in-house analytical methods related to the field of ionic liquids chemistry, e.g. conductivity measurements, determination of the electrochemical window, corrosion and electrochemical noise, UV/Vis spectroscopy, gas chromatography, ion chromatography with cation and anion mode, Karl Fischer titration, viscosity measurements and many more. In addition, IOLITEC has access to several other

methods such as NMR, IR and Raman spectroscopy, differential scanning calorimetry (DSC), transmission electron spectroscopy (TEM), particle size analysis and others through its cooperation partners. The analytical toolbox is complemented by a Thunder Scientific humidity generator for controlled athmosphere tests and a VLM thermostat for thermal stability tests.

Especially gas chromatography, or more precisely inverse gas chromatography, turned out as a powerful and versatile tool for screening experiments of ionic liquids. In contrast to conventional GC, inverese GC uses the interaction of a known gas or organic substance with different column materials. Based on the retention time of the substance, one can get informations about the interaction, affinity or solubility with the stationary phase. In our case we use ionic liquids that have been immobilised on the stationary phase in combination with various volatile compounds. With this technique we are in the position to swiftly obtain information on separation or purification possibilities in a simple and cost-effective way. For this purpose our analytical chemistry laboratory is equipped with different gas chromatographs including different detectors that have also the possiblity to work with self-made columns.

This example shows that we are in the position to deal with questions from different areas of interest, that adress not only chemistry but also physics or engineering topics. In combination with our skilled and interdisciplinar team of scientists we can give you a sound and detailed answer to your questions regarding ionic liquids applications.

If you are interested in our Reasearch and development services, please do not hesitate to contact us! Based on the information you provide we will submit a quotation without obligation. If necessary we can also sign a "Non disclosure agreement" if necessary (a draft can be found on our homepage www.iolitec.de). In addition we can assure you that we are an independent and 100% privately owned company, which is not linked to any of the major chemical companies. Research groups from universities are also welcome to discuss with us any topic from Ionic Liquid research.

Contact:

info@iolitec.de, www.iolitec.com

III Nanoparticles and Nanoparticle Dispersions

By Marie Mahé.

Nanoparticles

Nanoparticles present very interesting properties due to their very small size (1 nm = 10^{-9} m). Two of the main advantages of nanoparticles are the high surface-area-to-volume ratio as well as the possibility of reaching quantum effects. These properties make them attractive for researchers and industrials, who study and use nanoparticles in different fields of application like coatings, cosmetics, electronics, packagings, optics, catalysis and even biotechnological applications. Material performances can be drastically increased by the development of nanotechnology (nanostructured materials, nano-additives). At IOLITEC, you can find high-quality metal, metal oxide, nitride and carbide nanomaterials as well as carbon-based particles (fullerenes, nanotubes, graphite). Most materials are powders, which can be used as additives or as raw materials for nanostructured materials. Our nanopowders are packed in PE or glas bottles. For safety reasons, most of the metal nanopowders are packed under argon or partially passivated (partially oxidized surface) or dispersed in a solvent. Attached to this edition of Ionic Liquids Today, you can find the product and price list of IOLITEC nanomaterials. If you have any questions concerning the applications or properties of these materials, please contact us and we will be glad to help you finding the right material for your application.

Nanoparticle dispersions

Nanomaterials present unique properties due to their very small size, which can also present less desirable properties like a strong tendency to agglomeration or dust formation. Depending on the application, this can complicate the handling of these materials and affect their performance.[1]

Dispersions represent an interesting solution to prevent agglomeration and dust formation. In this case, nanopowders can be mechanically deagglomerated in an

[1] M. Pohl, S. Hogekamp, N.Q. Hoffamnn, H. Schuchmann, *Chemie Ingenieur Technik* **2004**, *4*, 76

appropriate solvent through mechanical energy (like ultrasonic treatment) and stabilized by surface-active agents or the solvent itself. Depending on the compatibility between nanoparticles/surface-active agents/solvent, the dispersion media can be adapted to the later application.

Next to this practical aspect, dispersions can also be interesting for their functional aspect. In the case of ferrofluids (magnetorheological fluids composed of magnetic particles in a carrier)[2] or nanofluids (thermal conductive fluids composed of thermal conductive particles dispersed in a thermal conductive fluid)[3], dispersions are considered as composites where properties of both phases (fluid and nanoparticles) are useful to the final application.


Nano-TiC in water with (l.) and without (r.) ionic liquid (5 wt.%)

IOLITEC is active on the field of nanoparticle dispersions. At our laboratories, we study the dispersibility of nanoparticles in different media. This includes of course also the possible applications of ionic liquids as carrier liquid or surface-active agent in nanoparticle dispersions.

[2] S. Odenbach, *Physik in unserer Zeit* **2001**, *32(3)*, 122-127
[3] J.A. Eastman, S.U.S. Choi, S. Li, W. Yu, L. J. Thompson, *Appl. Phys. Lett.* **2001**, *78 (6)*, 718-720

IV Novel Superacids for Catalysis

by Tom F. Beyersdorff.

Acid catalysis is an important tool in chemistry. Many reactions such as alkylations, acylations, rearrangements, oligomerisations or olefin isomerisations can be promoted by homogenous catalysis by either Lewis ($AlCl_3$, $FeCl_3$, BF_3…) or Bronstedt acids (H_2SO_4, H_3PO_4, HF…). Alkylations and acylations of aromatic compounds play an important role in fine chemisttry and are in most cases catalysed by $AlCl_3$. Examples for acid catalysed rearrangement reactions are the Beckmann (H_2SO_4, PCl_5), pinacol (H_2SO_4) and Fries ($AlCl_3$, BF_3) rearrangements.

In some cases, however, the traditional acid catalysts mentioned above suffer from major drawbacks. Lewis acids such as $AlCl_3$ or $FeCl_3$ often have to be added in stoichiometric amounts and produce large amounts of waste. In order to overcome this problem efforts have been made to immobilize the acid catalyst[4,5] resulting in a recyclable material and reduced production of waste. An alternative approach is the use of superacids which are defined as acids with a Hammett acidity constant of more than 12 which makes these acids more acidic than 100% H_2SO_4.[6] The high acidity of these acids can enable lower reaction temperatures, and smaller amounts of acid can be used in many cases compared to reactions catalysed by H_2SO_4. Triflic acid is a superacid that is already employed in industrial applications such as fine chemical synthesis, batteries and ionic liquids.

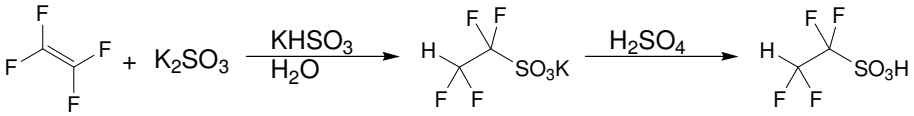
Very recently *Harmer et al.* reported on the synthesis and application of new fluoroalkylsulfonic superacids.[7] Addition of alkali metal sulfites to fluorinated alkenes in a buffered solution results in formation of fluoroalkyl sulfonate salts which can be converted to the corresponding acids in high yields by distillation from concentrated sulfuric acid. Sulfite addition to tetrafluoroethylene (TFE) followed by protonation results in the formation of 1,1,2,2-Tetrafluorethanesulfonic acid TFESA (Scheme 1).

TFESA in >98% purity is a liquid with a boiling point of 210 °C, a vapour pressure of 0.38 mmHg @ 20°C and a density of 1.7 g/ml @ 25°C. It is miscible with polar

[4] G. Sartori, R. Maggi, *Chem. Rev.* **2006**, *106*, 1077-1104.
[5] M.A. Harmer, W.E. Farneth, Q. Sun, *Adv. Mater.* **1998**, *10*, 1255-
[6] G. A. Olah, G. K. Surya Prakash, J. Sommer, *Superacids*, Wiley Interscience, New York, **1985**.
[7] M. A. Harmer, C. Junk, V. Rostovtsev, L.G. Carcani, J. Vickery, Z. Schnepp, *Green Chem.* **2007**, *9*, 30-37.

solvents like water or acetonitrile but immiscible with apolar solvents like toluene or hexane. Decomposition of TFESA appears at temperatures above 280°C. In contrast to triflic acid, TFESA shows less fuming when contacted with air. The low vapour pressure of TFESA makes handling of the acid much easier and safer. In addition the high boiling point increases the temperature range for reactions involving acid catalysis.

Scheme 1: Synthesis of 1,1,2,2-Tetrafluoroethanesulfonic acid

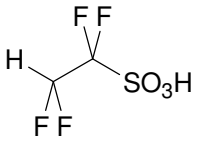


overall yield
85%

It was shown by the authors that this superacid can improve a number of reactions such as formation of linear alkyl benzenes from benzene and olefins, Fries rearrangement of acetylphenol, acylation of anisol or olefin isomerisation.[7] Another benefit of TFESA is that it can be easily immobilized on silica with a loading of 20% wt.

IOLITEC is in the position to supply this unique product in the liquid form at an exceptional price.

1,1,2,2,-Tetrafluoroethanesulfonic acid: TFESA



TFESA liquid (>98%):

KI-0028-50 g	230,00 €
KI-0028-100 g	395,00 €
KI-0028-250 g	835,00 €
KI-0028-500 g	1.415,00 €
KI-0028-1 kg	2.400,00 €

V Community

NanoEurope 2007, Fair & Conference, St. Gallen/CH
& 2nd International Conference on Industrialization of Dye Sensitized Solar Cells

For the first time IOLITEC was present with a booth at a fair focusing on nano technology. The fair was covered by a couple of conferences, which all had a certain relation to nano technology:

- textiles
- medical devices
- packaging
- plastics
- dye sensitized solar cells
- nanoregulation

IOLITEC participated at the 2nd International Conference on Industrialization of Dye Sensitized Solar Cells, where many interesting scientific, but also business oriented talks were presented. Andreas Luzzi guided the more than 200 participants of the conference in a competent and comic way.

In summary, this technology is ready to take off: The DSC technology will soon be used in different applications, such as

- flexible solar cells, e.g. for mobile applications
- glass based, building integrated modules for façades.

The requirements for flexible DSCs are a bit different compared to glass based modules: The main field of application for flexible cells will certainly be mobile applications, e.g. to charge cell phones, notebooks or iPods. As a consequence, the costs have to be as low as possible. In addition, the demands on long term stability are not as high as for architectural applications. This was demonstrated in an impressive talk from the company G24i, which announced to start with the production of flexible DSCs in 2007.

IOLITEC's & COLORSOL's booth at the NanoEurope 2007.

For glass based cells, focusing on the use for building integrated photovoltaics, the situation is different. Though there's knowledge concentrated in Europe, and surely also in Japan, China and South Korea, the long-term stability is still a question where a serious answer has to be found. In this context, Dyesol, the official sponsor of the conference, presented as a result of a long-term stability study of their cells that they are stable today for more than 15.000 hours. In an enthusiastic talk, Dyesol's CEO, Dr. Gavin Tulloch, emphasized that the business case is already there. This was also confirmed by the inventor of the DSC technology, Professor Michael Grätzel from the ETH Lausanne. Furthermore, Professor Grätzel, who is the most cited scientist in photovoltaic research, put the DSC technology in his talk into broader, more global context. He gave also a brief summary of DSC history, latest developments, and an overview of worldwide DSC activities.

IOLITEC's Managing Director, Dr. Thomas J.S. Schubert, was also invited as speaker at the dye sensitized solar cells conference. The subject of his talk at the "Progress in

materials"-session was "Recent Developments in Ionic liquid technology for DSC applications". We offer interested people to send the slides of his presentation by e-mail.

IOLITEC is partner in the COLORSOL®-consortium (BGT, Borderstep Institute, Engcotec, Fraunhofer IAO, Fraunhofer ISE, Pröll KG) that focuses on the commercialisation of DSCs for façade applications. COLORSOL® is funded by the German Ministry for Education and Research (BMBF). COLORSOL® presented the latest prototype, showing the unique possibilities to use and to design the transparent cells.

At St. Gallen we noticed a strong interest in this exciting technology from producing industry, component suppliers, and potential users, architects in particular. The latter are very important as lead users bringing the technology with selected projects into the heads of a broader public.

Next to IOLITEC's portfolio of ionic liquids for the use in DSCs, we will extend our activities to the development of new, more efficient dyes. Please contact us if you are interested in this technology and watch also the activities of COLORSOL®.

Contact:
info@iolitec.de; www.iolitec.com

Intertech Pira, "Ionic Liquids", Prague, Czech Republic

October 17th-18th 2007

By Thomas J.S. Schubert.

For the second time after December 2006 Intertech organized a conference about ionic liquids. Selected groups from academia and all major players were present and demonstrated latest developments and further steps towards commercialisation.

Chairman Professor Robin Rogers from the University of Alabama, Tuscaloosa (USA) and Queen's University Ionic Liquids Laboratory, Belfast, UK, guided the participants throughout the two conference days in a highly competent and dedicated way. He was supported brilliantly by the charming producer of the conference, Olga

Adamovich from Intertech Pira. In this context, it became obvious that most major chemical companies considered to develop or to use ionic liquids in the very near future.

Dr. Peter Schwab, chemist at a company formerly known as Degussa, demonstrated that even the new "Evonik" is still active in ionic liquids R&D and successful commercialization. Of course usual suspicious as BASF's Dr. Uwe Vagt demonstrated their latest activities in an impressive and sovereign talk. Merck introduced Dr. Emil Aust, the new Head of Ionic Liquids, with his first talk in the ionic liquids community, who made a real good job.

Dr. Adam Walker from Bioniqs introduced his concept of designing solvent solutions, and Professor Andy Abbott reported applications for electrodeposition and electropolishing.

Though Dr. Janet Scott from Unilever presented none of the company's R&D, she left no doubt that there's a strong competence at Unilever to make applications soon possible. A contribution that also should be put on record, was a pessimistic estimation from Akzo Nobel, wether ionic liquids might bring benefit into internal processes.

Selected academic research groups demonstrated clearly that the power of ionic liquids to enforce innovations in different fields of technology still has not come to an end: Professor Anja-Verena Mudring (Ruhr University Bochum) highlighted applications in the field of inorganic synthesis, such as nano particle synthesis in general and magnetic and luminescent materials, in particular. Professor Frank Endres (TU Clausthal) demonstrated the possibilities to control surface properties by the use of different ionic liquids in electrodepostion technology. Finally, Professor Robin Rogers reported *inter alia* on the amazing concept of using ionic liquids as pharmaceuticals agents.

As Managing Director of IOLITEC, I was also invited and demonstrated developments based on our IL technology for dye sensitized solar cells, sorption cooling media, solvents for enzyme catalyzed reactions and electrodeposition.

If I was asked, of course being a bit prejudiced, I would recommend Mrs. Adamovich to continue Intertech Pira's Ionic Liquids events in the future.

VI New Ionic Liquids & Key Intermediates

Our revised catalogue 2008 will be released in January 2008!

Many new products will be added and price adjustments will be made!

To receive the newest updates of our catalogue please subscribe for our newsletter @ www.iolitec.de or www.iolitec.com.

The formation of highly organized liquid crystalline phases is well known for many years and the basic principal for many optical applications such as LC-displays. An important requirement for the formation of LC mesophases is the form anisotropy of the molecules which can be either rod- or disc-like. Besides form anisotropic molecules amphiphilic molecules, which consist of a hydrophilic headgroup and a hydophobic tail, are able to form liquid crystalline mesophases.

The high order of liquid cristallin mesophases is based on the micro-phase separation of incompatible subunits which are covalently linked within a molecule. A general diffrentiation can be made between thermotropic and lyotropic liquid crystals.

Thermotropic ionic liquids form highly ordered mesophases upon temperature change whereas lyotropic mesophases are generated by addition of a solvent.

Having a look at ionic liquids with at least one long alkylchain covalently bound to the cation these materials represent classic amphiphiles as well and form lyotropic and thermotropic mesophases upon addition of a solvent such as water or increase of temperature.

The lyotropic mesophases formed by ionic liquids can be used as templates for the synthesis of nanoporous materials such as SiO_2 as shown by Smarsly.[8,9]

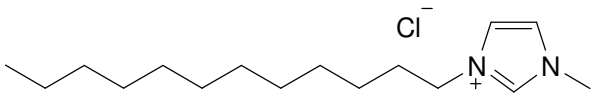
A possible application of a thermotropic mesophase formed by 1-Dodecyl-3-methylimidazolium iodide been described by Yanagida *et al.* who used this ionic liquid as electrolytes in DSSC.[10,11]

[8] T. W. Wang, H. Kaper, M. Antonietti, B. Smarsly, *Langmuir* **2007**, *23 (3)*, 1489-1495.
[9] H. Kaper, B. Smarsly, *Zeitschrift für Physikalische Chemie-International Journal of Research in Physical Chemistry & Chemical Physics* **2006**, 220 (10-11), 1455-1471.
[10] N. Yamanaka, R. Kawano, W. Kubo, N. Masaki, T. Kitamura,Y. Wada, M. Watanabe, S. Yanagida, *J. Phys. Chem. B* **2007,** *111,* 4763-4769.
[11] N. Yamanaka, R. Kawano, W. Kubo, N. Masaki, T. Kitamura,Y. Wada, M. Watanabe, S. Yanagida, *Chem. Commun.* **2005**, 740-742.

As a consequence from an increased demand, we added "long chain" imidazolium ionic liquids to our standard portfolio. Special promotion rates are valid until December 31st, 2007.

Special Offers from our Portfolio: *
(Temporary promotion prices for the following products!)

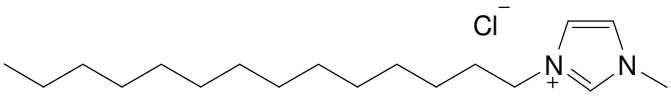
1-Dodecyl-3-methylimidazolium chloride: DodecMIM Cl



DodecMIM Cl (>98%):

IL-0120-HP-25g	92,50 €
IL-0120-HP-50 g	122,50 €
IL-0120-HP-100 g	195,00 €
IL-0120-HP-250 g	390,00 €
IL-0120-HP-500 g	622,50 €
IL-0120-HP-1 kg	995,00 €

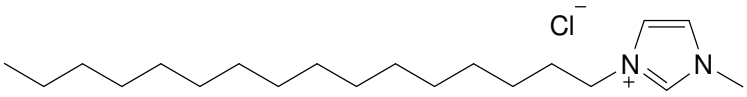
1-Methyl-3-Tetradecylimidazolium chloride: TetradecMIM Cl



TetradecMIM Cl (>98%):

IL-0141-HP-25g	110,00 €
IL-0141-HP-50 g	147,50 €
IL-0141-HP-100 g	235,00 €
IL-0141-HP-250 g	465,00 €
IL-0141-HP-500 g	747,50 €
IL-0141-HP-1 kg	1195,00 €

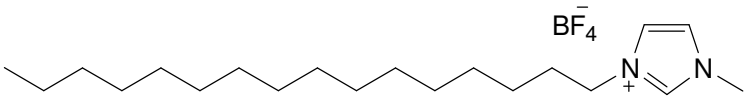
1-Hexadecyl-3-methylimidazolium chloride: HexadecMIM Cl



HexadecMIM Cl (>98%):

IL-0115-HP-25g	97,50 €
IL-0115-HP-50 g	130,00 €
IL-0115-HP-100 g	210,00 €
IL-0115-HP-250 g	417,50 €
IL-0115-HP-500 g	670,00 €
IL-0115-HP-1 kg	1.065,00 €

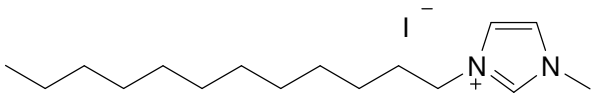
1-Hexadecyl-3-methylimidazolium tetrafluoroborate: HexadecMIM BF_4



HexadecMIM BF_4 (>98%):

IL-0041-HP-25g	125,50 €
IL-0041-HP-50 g	200,00 €
IL-0041-HP-100 g	325,00 €
IL-0041-HP-250 g	642,50 €
IL-0041-HP-500 g	1025,00 €
IL-0041-HP-1 kg	1645,00 €

1-Dodecyl-3-methylimidazolium iodide: DodecMIM I



Many electrolytes have been developed in the past to increase the performance of dye-sensitized solar cells. Many of these electrolytes are mixtures of imidazolium iodides, iodine, organic solvents and other additives. Other attempts to increase the performance of the DSSCs is to direct the transport of electrons from the counter electrode to the oxidized dye by preorganisation of the electrolyte in the cell. One possibility for a preorganisation is the application of DodecMIM I which forms a liquid crystalline smectic A phase. The LC-phase consists of a multilayered structure with the alkylchains intercalacting between the channels formed by the cationic imidazolium moeties and the iodide/triiodide redox-couples.

DodecMIM I (>98%):

IL-0136-HP-25g	227,50 €
IL-0136-HP-50 g	302,50 €
IL-0136-HP-100 g	482,50 €
IL-0136-HP-250 g	965,00 €
IL-0136-HP-500 g	1.545,00 €
IL-0136-HP-1 kg	2.470,00 €

*** All special offers are valid until December 31st, 2007.**

All prices are FOB Denzlingen, costs for shipping and handling and custom charges are not included in the prices and are payable by customer.

VII Special Offers* from our Nanomaterials Portfolio:

Temporary promotion prices for the following products:

IOLITEC supports you exploring the fascinating properties of nanomaterials for innovative applications. Please take a look at our current special offers and find the product you need for your new research ideas.

Fullerene: C_{60}

C_{60} (99.5%)

CP-0001-HP-01g	129.00 €
CP-0001-HP-02g	167.00 €
CP-0001-HP-05g	284.00 €
CP-0001-HP-10g	477.00 €
CP-0001-HP-25g	1.059.00 €

Fullerenes and/or their derivatives are used in different application fields like organic solar cells, pharmaceuticals or biomedicine.

Silver: Ag

Ag, 35 nm, 99.5%

NM-0023-HP-05g	112.00 €
NM-0023-HP-10g	187.00 €
NM-0023-HP-25g	374.00 €
NM-0023-HP-50g	535.00 €
NM-0023-HP-100g	765.00 €
NM-0023-HP-250g	1.276.00 €

The antimicrobial effect of silver nanopowder is of great interest for researchers. The thermal and electric conductivity of Silver nanopowders also make them a veryinteresting additive in different applications like conductive pastes or inks.

Aluminium oxide: α-Al_2O_3

Al_2O_3, 80 nm, 99.9%

NO-0003-HP-100g	44.00 €
NO-0003-HP-250g	96.00 €
NO-0003-HP-500g	154.00 €
NO-0003-HP-1kg	256.00 €

Alumina is a refractory material and electric insulator largely used in coatings application. In addition, alumina is a highly corrosion resistant material.

Aluminium nitride: AlN

AlN, 40 nm, 99%

NC-0001-HP-050g	49.00 €
NC-0001-HP-150g	86.00 €
NC-0001-HP-250g	184.00 €
NC-0001-HP-500g	308.00 €
NC-0001-HP-1kg	492.00 €

Aluminium nitride is a refractory material. It is a semi conductor with a very large band gap, so it is an electric insulator but it exhibits a rather high thermal conductivity. This material is largely used in opto-electronics applications.

*** All special offers are valid until December 31st, 2007.**
All prices are FOB Denzlingen, costs for shipping and handling and custom charges are not included in the prices and are payable by customer.

Imprint

Ionic Liquids Today will be released 3 times a year.

Contact:

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