Ionic Liquids Today

Issue No. 18, Monday, October 2nd, 2015.

>>> Purity of Ionic Liquids

>>> Magnetic Nanomaterials form MagnnPro

>>> From Science to Applications: IOLITEC's Technology Transfer

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Content:

1 Editorial

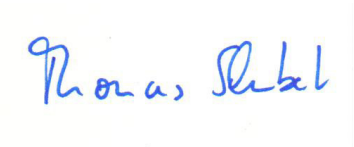
Though energy seems to be comparable cheap at the moment, there will be no doubt that the availability of energy will be a, or better will be *the* bottleneck in the future. As a German based company IOLITEC is already today in the position to watch all the challenges delivered directly or indirectly by the exit from nuclear power sources. Germany is thus forced to develop novel concepts and technologies to face the challenges delivered by the "Energiewende" (energy change/turn). In fact Germany tries to reach two goals at the same time: First of all, the exit from nuclear power until 2022, and secondly, the reduction of CO_2-emissions. As you can imagine, these two goals together may only be reached by increasing the share of renewable energies.

However, Germany has become more or less the "energy lab" of the world with a non-negligible uncertainty to reach these ambitious goals without losing to many industries and employment. It is not my job to make any comment on that – this should be the part of politicians!

Our job is to design, to synthesize, and to supply novel materials based on ionic liquids, nanomaterials and combinations thereof, being part of systems such as batteries, electrochemical double layer capacitors, fuel cells etc.

IOLITEC's own and joint developments in different fields are now summarized for the first time in our product list for "Materials for Energy Production, Transformation and Storage".

Sincerely Yours,



Thomas J. S. Schubert, CEO & Founder, IOLITEC.

2 News from IOLITEC Inc.

By Frank M. Stiemke and Peter von Czarnecki

Up to date the year 2015 has been quite a busy year for Iolitec's North America operation and now an organizational change is taking place: I have left the position as president at Iolitec Inc and moved back to Germany in order to take over a new position at Iolitec's Headquarters. I would like to take this opportunity to thank our customers in North America for their continued business with us in the past three years and would like to introduce to you my colleague and successor in the position as president, Peter von Czarnecki:

Peter, a chemist by education, has worked as R&D-Project manager and Sales Manager at Iolitec's Headquarters in Germany with several years of experience in the field of ionic liquids and has now taken the opportunity to move with his family to the US in order to take over this position starting October 1st, 2015.

I am sure he will take good care of all your ionic liquid and nanomaterial needs. The fast supply of products and quick and reliable answers to all your inquiries will continue as you are used to while doing business with Iolitec.

In the unlikely and very uncommon event that you do not get a response to your email or order after 48 h, please do not hesitate to contact us again or follow up by phone, because in that case the email most likely got lost due to a very rare email server outage or unscheduled maintenance.

Furthermore, we continuously expand the product portfolio at Iolitec Inc:

The so-called "optical pure" ionic liquids are available in US on request! These ILs will allow performing spectroscopic experiments without (or reduced) interfering of the IL-solvent with the species of interest. Beside this, Iolitec Inc. has continued to stock larger amounts of our standard ultra-pure (=colorless) versions of the most popular Ionic Liquids in order to further cut lead times. It is our goal to keep lead times as short as possible, even during times, in which the Iolitec Inc's office is unattended due to business travel. (To ensure fast replies during these business travel periods at Iolitec Inc. please sent only emails to info@iolitec-usa.com.)

In addition, IOLITEC and MagnnPro, LLC have put an agreement for the distribution of MagnnPro's highly uniform nano iron oxide products into effect. These highly uniform iron oxide nanospheres, nanocubes and nanoparticle conjugation kits are now available through IOLITEC nanomaterials.

For more information, please continue reading the article on page 13, visit our website http://www.iolitec-usa.com/General/distributionagreement-for-uniform-ironoxide-nps.html or inquire by email.

As many of you might already know, IOLITEC offers custom synthesis of all patent free ionic liquids and we would be glad to receive your inquiries for non-catalog products, too. Please do not hesitate to contact us if you cannot find the desired homologue of an ionic liquid you are looking for in our catalogue, we might be able to custom-make it.

And don't forget this year's "Black Friday sale"! See separate mailing or inquire for discount details.

Please direct inquiries now to:

Peter von Czarnecki
Email: czarnecki@iolitec.com
Phone: 1-205-348-2831
www.iolitec-usa.com

3 Purity of Ionic Liquids: 99% and Beyond

By Thomas J. S. Schubert.

3.1 Introduction

The purity of ionic liquids is – as one can imagine very easily – a very sensitive point for our academic partners and customers as well as for applied industrial researchers, since the performance of experimental R&D is influenced sometimes just by traces of impurities. Thus, the quality management is essential to guarantee good and reproducible results.

Over the past years we recognized that there are some ionic liquids cited in literature, having a purity of above 99.9%. In the following, we would like to explain our point of view about serious degrees of purity. Furthermore, we'll explain which parameters have an influence on purity and we would like to demonstrate which options we have for purification and quality control. As a final consequence, we'd like to conclude why in most cases purity above 99.5% is difficult to achieve and why we think purities of 99.9% are not serious.

3.2 Typical Impurities of Ionic Liquids and their analysis

The structures of most ionic liquids let suggest that they are easy to make. The classical synthesis protocols typically involve quite common types of reactions, such as alkylation or anion-metathesis. Nevertheless, to achieve high purities a lot of experience and cumulated knowledge about synthesis and in particular about the workup is essential.

Another important point is analysis: Ionic liquids are typically neither classical organic nor inorganic materials. During a typical synthesis other salts may be produced as waste, which are often soluble within the product. Of course also in many cases the use of solvents is necessary, which have to be removed after the procedure. Other sources may also be unreacted starting materials. Finally, also the work-up may introduce novel impurities, as we show later. To identify these completely different types of impurities by using just a single analytical method is impossible. The key is a combination of different (calibrated) methods, to get information about the content of the ionic liquid within a sample.

To achieve the best results the key to success is to work with pure starting materials and solvents, as well as with inert materials during the work-up-procedure.

In summary, the most important classes of impurities are

- Amines (also cyclic)
- Halides (in particular chlorides and bromides)
- Water (and other solvents)
- Alkaline Metals
- Alkyl Halides (in particular chlorides and bromides)
- Other alkylating agents

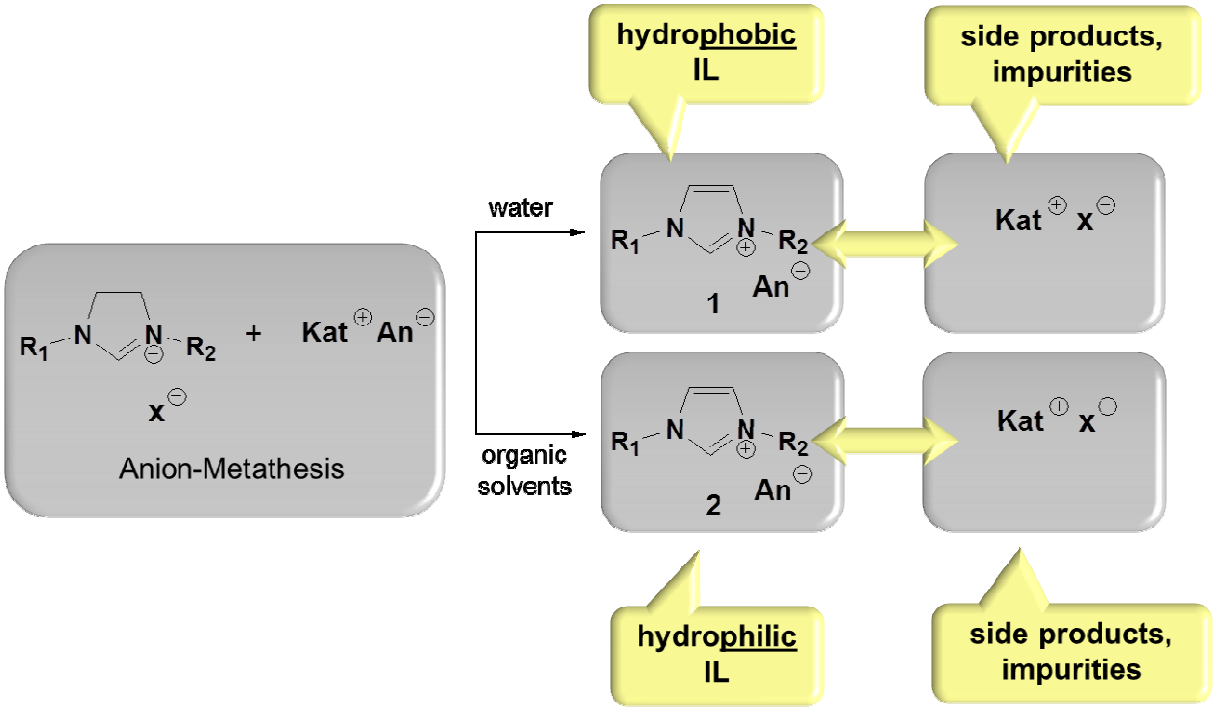
Halides

Halides can be found inside ionic liquids in larger amounts if the anion-metathesis reaction was incomplete, because there is some cross-solubility of metal halides within ionic liquids. Other typical sources of halides are impure water or impure reaction flasks.

Only a calibrated ion chromatography method provides information about the content of an ionic liquid *and* halide impurities!

Sometimes even small halide contents are leading to large shifts of a specific physical-chemical property. At electrochemical interfaces halides show often strong effects which can be monitored easily by using cyclovoltametry. As one can imagine easily, halides are thus for some applications a very critical impurity: They are e.g. influencing the ion mobility, resulting typically in higher viscosity and lower conductivity. Even more problematic is corrosion of metals and other materials.

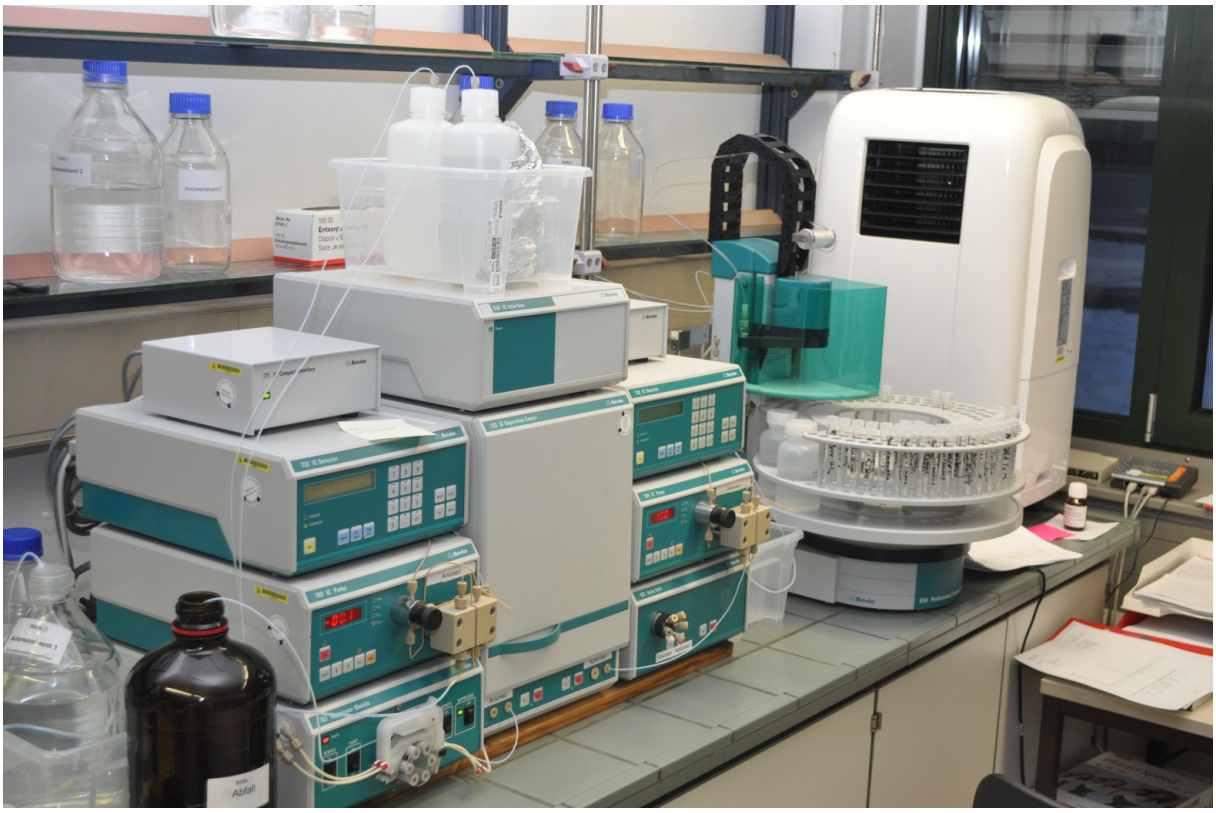
Though some ionic liquids can be synthesized via expensive halide free methods, numerous materials involve a more or less critical metathesis step. The anion-metathesis, which is often mixed up with the better known "ring-closing-metathesis", is in principle a comparable simple synthetic procedure for the exchange of one anion towards another.



Scheme 1. Anion-metathesis – a critical step.

The exchange is never completed to 100%, since there's always a cross-solubility between an ionic liquid and the waste inorganic salt. As a consequence, even after several steps of purification small amounts of halides are remaining within the ionic liquid. The halide contents are depending on the cross-solubility and specific for each material.

In the early 2ks IOLITEC was the first company to apply ion chromatography (IC) for analysis of ionic liquids and to implement a professional quality management. The chromatograms from IC-analysis provide information about all cations (cation chromatography) *or* anions (anion chromatography) within a sample. It is e.g. possible to quantify a hexafluorophosphate anion next to a halide impurity, but only if the system is calibrated. Without calibration the obtained values give no idea about the total content of ionic liquid within the sample. Peaks of the same size but resulting from different anions such as hexafluorophosphate and halide do not represent their molar concentration, because each anion has a specific response to the detector!



Picture 1. Ion Chromatography (IC) combined with an autosampler.

Detection limits

Fluoride:	50 ppm
Chloride:	10 ppm
Bromide:	10 ppm

Alkaline Metals

Alkaline metals are another common impurity, which are also critical if ionic liquids are used in interface sensitive applications, such as electrochemistry. Their source is typically also the metathesis reaction. The analytical method of choice is the same as for halides: ion chromatography (IC), but using different columns and eluents. It is no surprise that for quantitative essays the system has also to be calibrated.

The detection limits for calibrated systems are:

Detection limits

Sodium:	90 ppm
Potassium:	150 ppm
Lithium:	30 ppm

Water

Water is a quite usual impurity of ionic liquids: Every ionic liquid has a specific uptake of water at a given temperature and pressure. This does mean explicitly that even hydrophobic ionic liquids are containing residual amounts water (which is by the way true for every substance!).

In combination with numerous materials water can lead as well as halides to corrosion. In particular the combination of both is critical. Furthermore, if ionic liquids are used as reaction media the residual water may react with starting materials to reduce the overall yield caused by side reactions.

But one of the most water sensitive fields in which ionic liquids can be applied is electrochemistry: In many types of batteries or in supercapacitors the use of ultra-dry organic solvents ("electrochemical grade") such as ethylene carbonate (EC) or acetonitrile is state of the art. To use ionic liquids in these technologies, the water content has as well to be reduced to the highest technically available minimum. To keep moisture out of ionic liquids, the synthesis procedure has to be performed under an inert atmosphere. For the highest available quality, which is strongly depending on the water content, the materials have to be bottled in a glove box.

Picture 2. Karl-Fischer-Titration for the determination of water content.

The final challenge is the analysis of water within ionic liquids: The most typical way to determine the water content is Karl-Fischer-titration, which is for larger samples limited to a detection limit of 50 ppm. If only small samples are available, coulometry is the better choice. The detection limit drops by using this method below 10 ppm.

<u>Detection limits</u>

Volumetric: < 50 ppm (for larger samples)
Coulometric: < 10 ppm

Alkyl Halides

In the quaternization step the coulombic charges are introduced e.g. by reaction of an amine with an alkylating agent to form a precursor or often also the final ionic liquid (e.g. several imidazolium halides).

Unreacted alkyl halides are typically not a real problem in terms of purification, since they have a low vapor pressure and can be removed easily by drying at reduced pressure.

Other Impurities

The alkylation reaction is often the most critical in terms of side reactions, in particular if the reaction is strongly exothermic. Typically if side chains of amines, in particular of aromatic amines such as imidazoles or pyridins become longer, side reactions can occur, leading often to colored impurities. At low concentrations the typical colorization is slightly yellowish, while ending up at higher concentrations in brown to black colored ionic liquids. Nevertheless, colored side products represent often only a very small part of the overall impurities in an ionic liquid, but the one that can be analyzed in qualitative way just by taking a brief look at the specific sample: A slightly yellowish colorization can be obtained visually at concentration around a few ppb!

Anyhow, in applications which are sensitive to organic traces, such as electrochemical or those where the color plays a significant role (e.g. optical), colored ionic liquids should of course be avoided. On the other hand in cost sensitive large scale processes, the production and purification of ionic liquids is a cost driver. This means in other words, where color does not matter, but the ionic liquid does its work well, there's no reason to use an expensive colorless ionic liquid!

3.3 Summary

For scientific as well as for commercial applications reliable specifications of ionic liquids are the key to sustainable success. As a consequence, it is necessary to implement tailor-made analytics. The purity of ionic liquids cannot be described by a single analytical method, but by a combination of a couple of techniques.

We finally believe that purities of any ionic liquids above 99.5% are difficult to achieve, but we are sure that 99.9% is today simply not possible, since, as described above, the cumulated traces of all potential impurities always are cumulating to values above 0.1%. But, never say "never": If you are in the position to convince us by arguments or better by offering us samples, you are cordially invited to discuss with us about that topic (science@iolitec.de)!

4 Novel Nanomaterials

MagnnPro LLC
An iron oxide nanomaterial expert

By Thomas Macher, MagnnPro.

MagnnPro, LLC is a high-tech start-up company that has its origins in the Chemical and Biological Engineering laboratory at The University of Alabama. Founded in May, 2012 the company is housed in the Alabama Institute for Manufacturing Excellence (AIME) building, a state-of-the art facility. MagnnPro, LLC is run by a chief executive officer and experienced researchers. We anticipate fast company growth as a result of patent protected technology; which provides an advantage over current technology, all at a competitive price.

MagnnPro mainly produces four categories of iron oxide based products, including Nanoparticle Conjugation Kits, uniform and shape controlled water soluble nanoparticles, organic soluble nanoparticles, and nano powders.

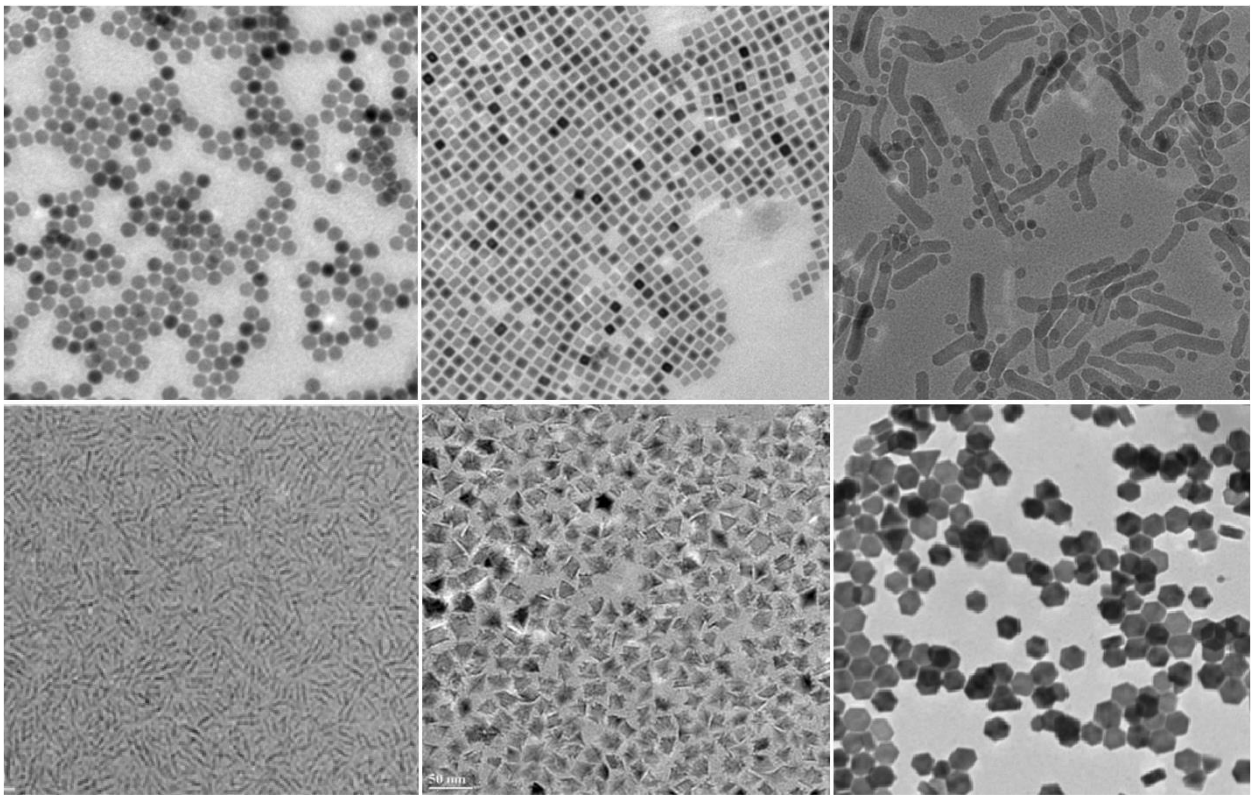


Figure 1. TEM images of MagnnPro's uniform and shape controlled iron oxide nano-materials.

Nanoparticle conjugation kits consist of high quality magnetic nanoparticles with a uniquely designed functional surface. The nanoparticles prepared for each of our kits will be produced using a newly modified heat-up method developed in house. This method allows the production of iron oxide nanoparticles with great control over nanoparticle size, shape, and size distribution. The uniquely designed functional surfaces of the nanoparticles allow facile conjugation of chemical and biological molecules (DNA, protein, etc.), without the need for any type of chemical linkers. The kits will have the capability to be specifically designed to meet the detailed needs of potential customers in nanobiotechnology. Our products have demonstrated the ability to effectively attach large proteins (e.g., antibody, albumin), short peptides (glutathione), chemicals (histamine), and polymers (amine-terminated polyethyleneglycol) onto nanoparticle surfaces. Each kit contains easy operating instructions to perform the conjugation without the need for prior training or advanced degrees (Fig. 2).

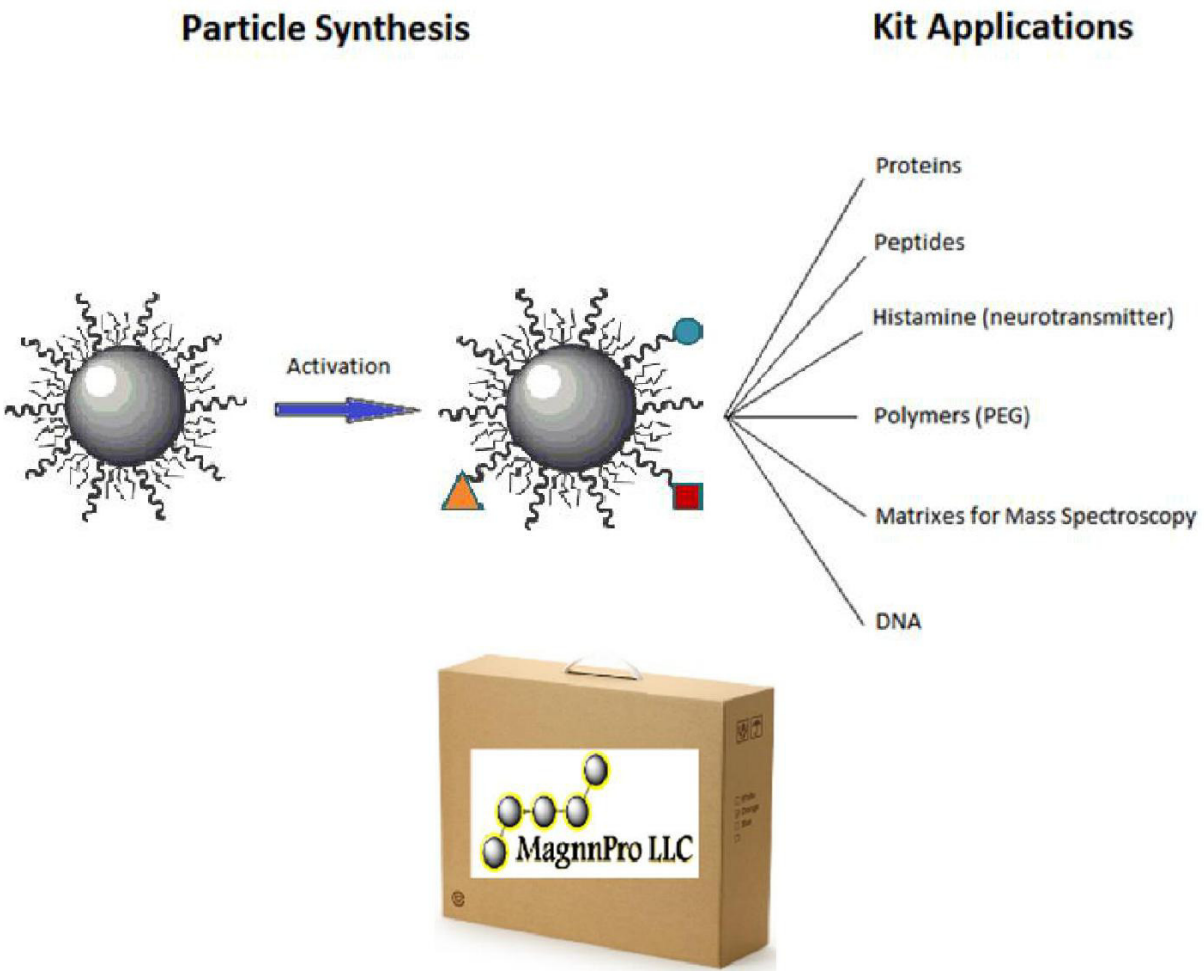


Figure 2. Applications of MagnnPro's Kits.

Nanomaterial in water, in organic solvents, and as a powder - MagnnPro also manufactures and sells iron oxide nanomaterials in different shapes, different solvent media, and with different solubility capabilities, for those who do not need the functionality of the amine coated kits. Unlike the currently commercially available iron oxide nanoparticles produced from a co-precipitation method, generating nanoparticles with wide size distribution and uncontrolled magnetic properties. MagnnPro's uniquely designed and patented procedure allows for the functionalization of high quality magnetic nanoparticles with dopamine molecules. Once activated the dopamine groups can directly interact with biological molecules containing amine and/or thiol groups through Michael addition and/or Schiff base formation. The particles are made at an average size of 12 nm ± 2. MagnnPro has the capability to make different sizes (between 4 nm – 50 nm). The distinct advantage of this approach is the elimination of the use of chemical linkers during conjugation, which significantly simplifies the conjugation process, reduces the requirements of well-trained personnel, and increases the conjugation efficiency (Fig. 3). To make the iron oxide particles adaptable to medical applications, such as drug delivery and as contrast agent for MRI, MagnnPro has made the particles water soluble, this work has been highlighted in Nature.[1]

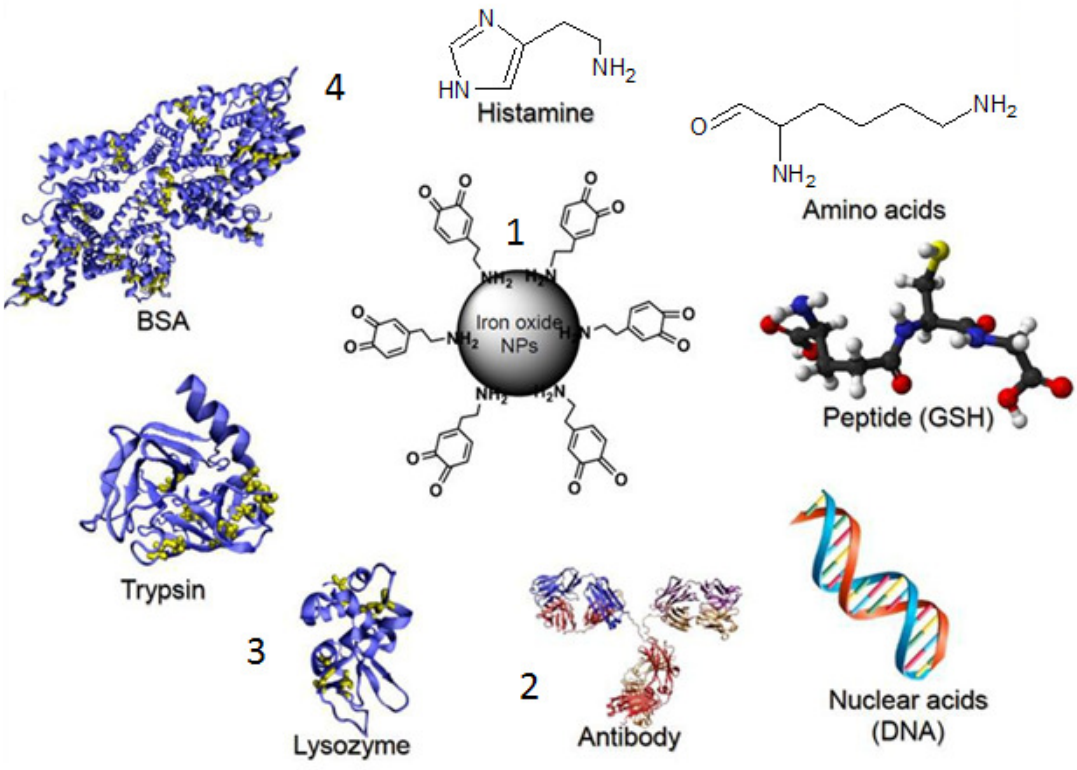


Figure 3. Potential applications of MagnnPro's functionalized nanomaterial with publication references.[2]

[1] http://www.nature.com/nature/journal/v476/n7358/full/476009e.html

[2] http://pubs.rsc.org/en/Content/ArticleLanding/2014/TB/c4tb00840e#!divAbstract
http://pubs.rsc.org/en/Content/ArticleLanding/2014/TB/c4tb00840e#!divAbstract
http://pubs.rsc.org/en/Content/ArticleLanding/2014/NR/c3nr06040c#!divAbstract

The following products are now available through IOLITEC:

Magnetite, highly uniform Nanospheres (1mg/mL in Chloroform)

DP-1111-HP [1309-38-2] Fe3O4/CHCl3

APS: 12 ± 2 nm
PM: nanospheres
Appearance: dark brown/black

1 mL	49.00 €
5 mL	149.00 €
10 mL	239.00 €
20 mL	399.00 €

Danger

Packaging in glass bottle - Produced by MagnnPro, LLC

Magnetite, highly uniform Nanocubes (1mg/mL in Chloroform)

DP-1112-HP [1309-38-2] Fe3O4/CHCl3

APS: 12 ± 2 nm
PM: cubes
Appearance: dark brown/black

1 mL	49.00 €
5 mL	149.00 €
10 mL	239.00 €
20 mL	399.00 €

Danger

Packaging in glass bottle - Produced by MagnnPro, LLC

Magnetite, highly uniform Nanospheres + amino groupes (1mg/mL in Water)

DP-1113-HP [1309-38-2] Fe3O4/H2O

APS: 12 ± 2 nm
PM: nanospheres
Appearance: dark brown/black

1 mL	139.00 €
5 mL	399.00 €
10 mL	699.00 €
20 mL	1199.00 €

Warning

Packaging in glass bottle - Produced by MagnnPro, LLC

Magnetite, highly uniform Nanocubes + amino groupes (1mg/mL in Water)

DP-1114-HP [1309-38-2] Fe3O4/H2O

APS: 12 ± 2 nm
PM: cubes
Appearance: dark brown/black

1 mL	139.00 €
5 mL	399.00 €
10 mL	699.00 €
20 mL	1199.00 €

Warning

Packaging in glass bottle - Produced by MagnnPro, LLC

6 Science & Applications

Interesting Articles summarized by Boyan Iliev (BI), Maria Ahrens (MT), Sven Sauer (SS), Frank Stiemke (FS), Kai Schütte (JW), Sandra Baumann (SB), and Thomas J. S. Schubert (TS).

Pro-fragrant ionic liquids with stable hemiacetal motifs: water-triggered release of fragrances

H. Q. N. Gunaratne, P. Nockemann, K. R. Seddon, *Chem. Commun.* **2015**, *51*, 4455.

In the past 10 years or so ionic liquids have managed to sneak into quite a lot of different applications starting from solvents and catalysts to additives for polymers and lubricants or electrolytes for electrochemical devices. One field in which the "new" ionic liquids (Cetylpyridinium or benzalkonium chloride are per definition ILs, and have been known for quite some time now, but have not been referred to as ionic liquids) have had big difficulties getting into cosmetic products, but with this paper, we believe the activation energy for this process has been further lowered.

The idea the authors from QUILL have is to attach perfume raw materials (PRMs) such as alcohols to an ionic liquid through an easily cleavable group, such as a hemi-acetal. Usually such alcohols are incorporated into pro-fragancies as esters, and the release of the fragrance is achieved through a lipase enzyme, or by changing to a higher pH. The greatest benefit of using a hemiacetal is that the release trigger is neutral water, as can be found in human sweat. The benefit of using an ionic liquid is the stable non-volatile matrix it presents, which allows the fragrance to be released only through the addition of water, thus allowing for a simple and almost quantitative release.

The particular ionic liquid used in this study, **4-formyl-1-methylpyridinium iodide** is currently available from IOLITEC as a custom synthesis (**CS-1436-HP**), but will soon be added to our standard catalogue of over 300 ionic liquids. IOLITEC has a long history of reasonably priced high quality custom synthesis ILs and development of specialized IL-based solutions for its customers. We would be glad to help you find the right ionic liquids for your application. For further information or a quote please do not hesitate to contact us.

Lithium bis(pentafluoroethylsulfonyl)imide (Li BETI) (BI, TS)

Lithium bis(pentafluoroethylsulfonyl)imide (KI-0016-HP), big brother of the well-known Lithium bis(trifluoromethylsulfonyl)imide (KI-0001-HP), is back! Among the main advantages of LiBETI are its ultra-hydrophobicity and stability of the ionic liquids that are derived from it.

Not only the ionic liquids based on this anion, but also the Li-salt can come in handy in quite a few quite useful applications, where it can perform even better than the corresponding less fluorinated amides. Such an example is its use as base for solvate ionic liquids with glyme, which finds application as potential electrolytes for lithium sulfur batteries, among others. The main benefit in this case is that BETI is able to suppress the dissolution of Li_2S_x effectively while being electrochemically stable in Li −S cells.[3] The authors also report, that although bis(fluorosulfonyl)imide, is a popular anion for electrochemical applications, is not suitable in this case since it reacts with the polysulfides on the electrode.

Another electrochemical application, where BETI surpassed BTA was in a solid polymer electrolyte for lithium batteries[4]. The authors showed that although the BETI-based system showed lower ionic conductivity, the lithium transference numbers for BETI within the solid electrolyte were actually higher.

And last, but not least, it has been shown[5], that BETI-based electrochemical systems show better stability, due to the better passivation of Aluminum current collectors by BETI compared with BTA.

If you want to try something new, now is your chance: Li BETI in a purity of over 99% is available from stock in amounts of 25 g to 5 kg and more.

[3] K. Ueno, J-woo Park, A. Yamazaki, T. Mandai, N. Tachikawa, K. Dokko, M. Watanabe, *J. Phys. Chem. C* **2013**, *117*, 20509.
[4] A. Fisher, M. Khalid, M. Widstrom, P. Kofinas, *J. Elchem. Soc.* ,**2012**, *159*, A592
[5] M. Morita, T. Shibata, N. Yoshimoto, M. Ishikawa, *Electrochim. Acta*, **2002**, *47*, 2787.

High performance of symmetric micro-supercapacitors based on silicon nanowires using N-methyl-N-propylpyrrolidinium bis(trifluoromethyl-sulfonyl)imide as electrolyte

D. Aradilla, P. Gentile, G. Bidan, V. Ruiz, P. Gómez-Romero, T. J.S. Schubert, H. Shin, E. Frackowiak, S. Sadki, *Nano Energy* (2014), **9**, 273-281. http://dx.doi.org/10.1016/j.nanoen.2014.07.001

During the last years extensive research has been done on the field of energy storage. One area many researchers are dealing with is nanostructured materials. Especially, silicon nanowires (SiNWs) have attracted great attention. In this context, Gentile et al. reported about the use of N-methyl-N-propyl-pyrrolidinium bis(trifluoromethylsulfonyl)imide (PMPyrr BTA) as electrolyte in symmetric micro-supercapacitors based on nanostructured SiNWs electrodes at a very high cell voltage of 4V. Due to the astute combination of diverse key features such as the huge electrochemical window of PMPyrr BTA, high surface area of SiNWs and tremendous compatibility of electrode and electrolyte, the device showed excellent values in terms of power density (182 mW cm-2) and specific energy (0.19 mJ cm-2). Furthermore, an exceptional stability with a capacity loss of only 25% after 8x106 galvanostatic charge-discharge cycles was obtained. All in all, this study showed that SiNWs can be a promising alternative material to carbon electrodes and this SiNWs based device can be also of high interest for different electronic technological applications.

7 Tech-Transfer – from science to applications

Since our foundation in 2003, IOLITEC was a technology driven company. Over the past years IOLITEC was involved in numerous R&D-projects. Many of them were in close co-operation with companies others were joint projects in a consortium, funded by the German Federal Ministry for Education and Science or by the European Union.

It's quite obvious that we are not in the position to talk about our projects with other companies, while the opposite is true for our funded projects: In the latter case it is highly appreciated to inform our customers about our R&D-activities and to establish a technology transfer.

Interested? If you are interested in our future activities you are cordially invited to contact us via science@iolitec.de.

Table 6-1: IOLITEC's Projects funded by the European Union

Project Acronym		**IOLITEC's R&D**
DIACAT	EU	Solvent for Catalysis
SCAIL-UP	EU	Electrolyte for Aluminum Deposition
BACCARA	EU	Electrolyte for Supercapacitors
NEST	EU	Electrolyte for Supercapacitors
IOLICAP	EU	Solvent for CO_2-Capture

EU-Project: Scaling-up of the aluminum process from ionic liquids: "SCAIL-UP"

Duration: 36 months **Start date:** 01.11.2013 **End**: 31.10.2016

Funding Agency: European Commission, the Seventh Framework Programme FoF.NMP.2013-10: (Project no. 608698)

Partner: *MAIER S. Coop.* (Spain, Coordinator), *IK4-CIDETEC* (Spain), *Consorzio INSTM* (Italy), *Turbocoating S.p.A.* (Italy), *Ionic Liquids Technologies GmbH* (Germany), *C-Tech Innovation Ltd* (United Kingdom)

Project target: Overcoming barriers in up-scaling of ionic liquid-based aluminum electrodeposition by designing and developing an industrial scale pilot plant in order to replace costly and more hazardous processes by a new manufacturing industrial process for the automotive and aeronautic sector.

Current project status: The design of the pilot plant has been completed and the pilot plant facility is currently built. Furthermore, the suitable ionic liquid-based electrolyte has been identified and is currently produced on a 200 L scale. Optimization of the AL-deposition conditions for the pilot plant scale is ongoing. The recycling process of the used electrolyte and the Life-cycle assessment (LCA) is currently under evaluation. The project is on schedule.

For further information please visit the project website http://scailup.eu/ or contact us directly at science@iolitec.de .

EU-Project: Diamond materials for the photocatalytic conversion of CO_2 to fine chemicals and fuels using visible light: "DIACAT"

Duration: 48 months **Start date:** 01.07.2015 **End**: 01.07.2019

Funding Agency: European Commission, Horizon 2020 program: H2020-EU.1.2.1. (Project no. 665085)

Partner: *Julius-Maximilians Universität Würzburg.* (Germany, Coordinator), *Commissariat à l'énergie atomique et aux énergies alternatives, CEA* (France), *Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., FhG-IAF* (Germany), *University of Oxford* (United Kingdom), *Uppsala Universitet* (Sweden), *Helmholtz-Zentrum Berlin für Materialien und Energie* (Germany), *Ionic Liquids Technologies GmbH* (Germany), *GABO:mi Gesellschaft für Ablauforganisation: milliarium mbH & Co. KG* (Germany)

Project target: Development of a new technology to produce fuels and fine chemicals from carbon dioxide by direct photocatalytic conversion of CO2 using visible light and man-made diamant catalysts, which possess unique electronic properties. The approach utilizes the unique property of a diamant-electrode to generate solvated electrons upon light irradiation in solutions (e.g. in water and ionic liquids), which can be used for the intended chemical reactions.

Current project status: The project just started off with a kick-off meeting in Würzburg, Germany, July 23th -24th. The internal database and project website are in the process of being set up and nearly finished. Scientific work has started with testing of (commercially) available materials.

For further information please visit the project website http://www.diacat.eu/ or contact us directly at science@iolitec.de.

EU-Project: Battery and superCapacitor ChARActerization and testing: "BACCARA"

Duration: 36 months **Start date:** 01.10.2013 **End**: 30.09.2016

Funding Agency: European Commission, ENERGY.2013.7.3.3 (Project no. 608491)

Partner: *Commissariat à l'énergie atomique et aux énergies alternatives (CEA)* (France, coordinator), *Centre national de la recherche scientifique (CNRS)* (France), *Technion-Israel Institute of Technology* (Israel), *Hutchinson GMBH* (Germany), *VARTA Micro Innovation GmbH* (Austria), *IOLITEC Ionic Liquids Technologies GMBH* (Germany)

Project target: Improving the performance of Li-Batteries and supercapacitors by deep understanding of interfaces and interphases evolution within the electrode in cycling. The goal is to control and then optimize the negative electrode/electrolyte interface (active material morphology and functionalization, electrode formulation, electrolyte formulation) by investigating structural, chemical and morphological changes during electrochemical cyclability with focus on Silicon nanopowders and graphene as active or additive materials using a network of classical and advanced techniques of characterization including large scale instruments like synchrotron and neutron beam.

Current project status:

The initial problems with the stability of the electrolytes have been overcome, and now a promising carbonate electrolyte as well as mixed carbonate/IL electrolytes have been identified and tested. The results show that in most cases stable cycling at low to middle capacities is possible. Aged and cycled silicon negative electrodes in carbonate electrolyte have been successfully prepared for interface characterizations. A stable and eco-friendly novel grafted graphene/graphene supercapacitor has been optimized at the lab scale. All project goals until now have been reached.

For further information please visit the project website http://project-baccara.eu/ or contact us directly at science@iolitec.de.

EU-Project: Novel IOnic LIquid and supported ionic liquid solvents for reversible CAPture of CO_2: "IoLiCAP"

Duration: 48 months **Start date:** 01.12.2011 **End**: 30.11.2015

Funding Agency: European Commission, FP7-ENERGY-2011-1.(Project no. 283077)

Partner: *National Center for Scientific Research "DEMOKRITOS",* (Greece, coordinator), *Friedrich-Alexander-Universität Erlangen Nürnberg,* (Germany), *SCIENOMICS SARL*, (France), *IOLITEC Ionic Liquids Technologies GMBH* (Germany), *The University of Manchester* (United Kingdom), Technische Universiteit *Eindhoven (Netherlands), Public Power Corporation* S.A. (Greece), *N & K Konstantinos Goliopoulos ATE*, (Greece), *The Petrolium Institute* (United Arab Emirates), *ENDITECH Anonymos Eteria Meletes KE Efarmoges,* (Greece).

Project target: Development of a pilot plant for the capture of post combustion CO_2 (PCC) with the help of new solvents like ionic liquids (ILs). Detailed molecular modeling of sorbate/sorbent interactions should assist the development and evaluation of novel Task Specific Ionic Liquid (TSILs) for - in short-term- replacing the alkanolamines in currently existing PCC installations and - long-term - a novel CO_2 capture process, based on hybrid absorption bed/membrane technology that will incorporate TSIL modified porous materials and membranes. Ionic Liquid membranes are examined as candidates for CO_2/N_2 separation with focus on the optimization of the stability, selectivity and production cost of TSIL membranes.

Current project status: The project is close to its end and a large number of Ionic Liquids were synthesized and evaluated for their thermos-physical and physicochemical properties, absorption capacity and toxicity. Because of price, availability, performance, stability and ease of regeneration the best candidates for the pilot plant are currently tricyanmethide-based ionic liquids. A mixture of 200kg of three different ILs was produced by IOLITEC using continuous micro flow reactor technology with excellent yields and purity and sent to Greece for the incorporation in the pilot plant, which is currently being built.

For further information please visit the project website http://www.iolicap.eu/ or contact us directly at science@iolitec.de.

EU-Project: Nanowires for Energy STorage: "NEST"

Duration: 48 months **Start date:** 01.11.2012 **End**: 30.04.2016

Funding Agency: European Commission, FP7-ENERGY-2012-1-2STAGE. (Project no. 309143)

Partner: *Atomic Energy and Alternative Energies Commission (CEA) - Institute for Nanoscience and Cryogenics (Inac)* (France, coordinator), *Consejo Superior de Investigaciones Científicas (CSIC)* (Spain), *Fraunhofer-Institut für Angewandte Festkörperphysik (FHG IAF)* (Germany), *Hutchinson* (France), *IOLITEC Ionic Liquids Technologies GmbH* (Germany), *Poznan University of Technology* (Poland).

Project target: Development of (micro) supercapacitors able to work in severe conditions and for energy autonomous devices based on Diamond coated silicon nanowires and nanotrees electrodes using protonated aqueous or ionic liquid electrolyte with a large electro-chemical window and good conductivity. Ionic liquids will be used for enhanced thermal stability and enlarged operating voltage (around 3.5 V) or aqueous electrolytes (low viscosity and better conductivity) for low cost and high power specification.

Current project status: The project is well advanced and due to the special Si-nanowire and protic and aprotic ionic Liquids supercaps with high cycle stability have been are ready produced. (Open access publication can be downloaded via EU-cordis website.) Currently in evaluation of supercaps systems for low temperature application is ongoing.

For further information please visit the project website http://www.project-nest.eu/ or contact us directly at science@iolitec.de.

8 Community

We define ourselves not only as a "usual chemical company", instead we like to live chemistry and scientific thinking. As a consequence, we not like just to sell materials to our customers: we would like to be part of the complete innovative processes! Social media provide an ideal and informal platform to discuss in an open-minded way.

If you are already active in one or more of these social media, please feel free to contact our experts directly or join one of the groups, were IOLITEC is involved.

RESEARCH GATE:

Please discuss with IOLITEC's experts about actual challenges in the field of ionic liquids and nanomaterials!

ResearchGate

FACEBOOK:

Please follow IOLITEC and join the Ionic Liquids Group at Facebook! In particular students

LinkedIn:

Please connect yourself to IOLITEC's team at LinkedIn! Within the Molten Salts Discussion Group, you'll meet some of our experts to discuss the hottest topics!

YouTube: Interesting Videos:

Separation of oil and tar from sand

(Penn State University, USA):

https://www.youtube.com/watch?v=sGDKxlW1ZoQ

Mechanism for electrical conduction within ionic liquids

(EPFL, Lausanne, Switzerland):

https://www.youtube.com/watch?v=NYhOb9ZB9qY

New Battery Technology using ionic liquids

(Keio University, Japan):

https://www.youtube.com/watch?v=J2WI5DdIfHk

Ionic Liquid – Time Capsule

(Peter Licence, University of Nottingham, UK)

https://www.youtube.com/watch?v=YmsZxc8AxMU

Upcoming conferences:

Batteries 2015, Nice, France, October 7th – October 9th, 2015.

Meet Iolitec's battery expert Dr. Maria Ahrens in Nice and attend her talk "*Novel Electrolytes for Batteries*" on **Thursday October 8th, 2:10 pm - 2:35 pm**:

Further information is available at:

http://www.batteriesevent.com

WORLD OF ENERGY SOLUTIONS conference, Messe Stuttgart, Germany, October 12th – 14th, 2015.

Iolitec's CEO Dr. Thomas Schubert will attend the World of Energy solutions conference and give the talk "*Ionic Liquids: Novel electrolytes for the use in next generation battery systems*" on **Wednesday, October 14th, 15:10-15:30** in session K3 "Battery systems"

Further information is available at:

http://www.world-of-energy-solutions.de/de/programm-2015.html

NANOCON 2015, Brno, Czech Republic, October 14th – 16th, 2015.

Iolitec nanomaterials is proud sponsor and exhibitor at NANOCON 2015! Meet Iolitec's nano experts at Iolitec's booth! Furthermore, Dr. Kai Schütte will give the talk "*Size Controlled Preparation of Nanoparticles and Safe-to-handle Nanoparticle Dispersions by the use of Ionic Liquids*" on **October 14th, 14:30 - 14:45**, Session A.

Further information is available at:

http://www.nanocon.eu/en//

Viennano 2015 & ÖTG Symposium 2015, Wiener Neustadt, Austria, November 24th – 25th, 2015.

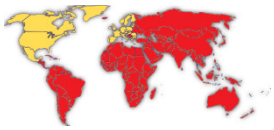
Iolitec's CEO Dr. Thomas Schubert will attend Viennano 2015 conference and give the talk "*Ionic Liquids and Ionic Liquid-Mediated Dispersions of Nanomaterials as High Performance Additives for Lubricants*" on **Wednesday, November 25th, 11:40-12:05** in session "Lubrication /(Tribo-)Corrosion"

Further information is available at:

http://www.oetg.at/oetg-events/vienanno/

Please keep us informed about other interesting events we could highlight in Ionic Liquids Today.

Contact and Order Information:



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