Ionic Liquids Today

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Photo: © IOLITEC, T. J. S. Schubert, 2012.

>>> Ionic Liquids for Energy Storage

>>> High-Tech-Fluids from 3M

>>> Task-Specific-Ionic-Liquids

Content:

1 Editorial

Over the past decade we saw in the business of ionic liquids a number of changes: Companies founded and disappeared, but, more important, a lot of different people and characters. Within these changes, there remained just of few people as a constant at the companies: Roland Kalb from Proionic, Marc Uerdingen, PhD, from Merck (until 2007 Solvent Innovation), Uwe Vagt, PhD, from BASF, and of course Tom Beyersdorff, PhD, and myself.

As we were recently informed, *Marc Uerdingen* quit in 2012 Merck KGaA, to move back in the region of Cologne, where he was born and where still the centre of his life is located. For me as a colleague from early Solvent Innovation times, I have to stress that he was a fantastic colleague with a deep and broad knowledge about chemistry, and, no surprise about ionic liquids. Even when I quit Solvent Innovation to found IOLITEC and we became suddenly competitors, he remained a good friend to me, though we both fought sometimes in the same field. Marc works of course still as a chemist, but the ionic liquids scene loses one of the men with the deepest knowledge about ionic liquids science and applications.

Another job change hits from my very personal view the ionic liquids scene in a similar way, but of course IOLITEC more directly: *Tom Beyersdorff*, IOLITEC's first full time chemist, who entered the company in 2004, has quit IOLITEC at the end of August 2012. I take the risk to say, that nearly everyone who met Tom and who worked with him in different business situations liked his combination of competence always together with his generally friendliness and overall positive attendance. Tom left IOLITEC for similar reasons as Marc, since the centre of his life is now Munich.

This should not even sound like an obituary for Marc and Tom. Maybe both of them are getting bored at their new jobs and re-enter the exciting world of ionic liquids, soon. It would be definitely a big benefit for our field!

Sincerely Yours,

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

2 Ionic Liquids for Energy Storage – An Overview

By Thomas J. S. Schubert.

2.1 Introduction

The production of energy will be with no doubt one of the major challenges over the upcoming decades. In this context, electricity generated from renewable resources such as wind and photovoltaic plays already an important role, which will surely increase in the near future. Nevertheless, since wind is not blowing and the sun is not shining all the time, electricity has to be buffered or better stored somewhere until there's a demand.

Without the claim of being complete, I'll focus and summarize on those concepts, where ionic liquids might be involved in the near future.

2.2 Concepts

Pump storage hydro power stations

A solution that is already realized are *pump storage hydro power stations*, using overcapacities from renewable energies to pump water to a higher level. On demand the kinetic energy of the water can be transformed back into electricity. Though the overall degree of efficiency is up to 70%, there are e.g. in Germany only a few regions where these stations can be installed (5 of them are already). But it has to be added that in Germany the opposition against such projects is also a political problem. In terms of the degree of efficiency this technology marks the state of the art - but unfortunately we don't see any demand for ionic liquids!

Batteries

Another interesting concept is the use of batteries for electric powered cars: As long as a car is not driving, which is the case for 22-23 hours a day in average, it can be used to store electricity. This idea can also be embedded in a more general concept of a "smart grid", which is promoted e.g. by Siemens.[1]

[1] See also http://www.siemens.de/elektromobilitaet/elektromobilitaet.html .

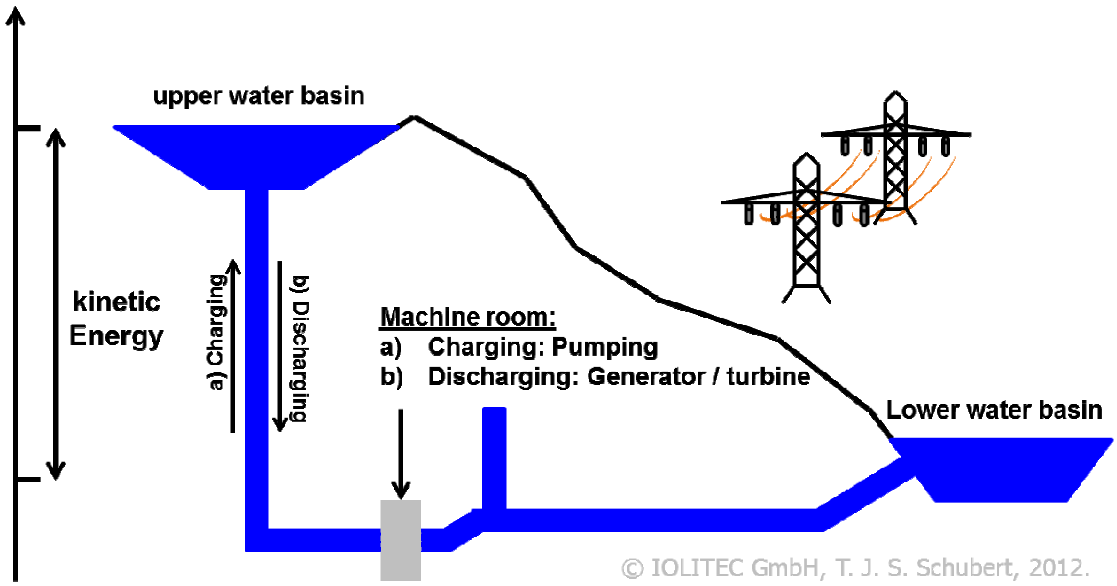

Fig. 2-1. Principle of a Pump storage.

Another interesting point is that old batteries from e-cars, having only 70% of the original performance, can be used in their "second life" also to store energy, e.g. for the consumption of electricity generated from PV in private houses. Though at present the automotive industry is concentrating to install existing battery technologies in e-cars, energy density, charging-speed, and the number of charge-discharge cycles will be the major challenges for better batteries in the future, if e-mobility will find its way to success.

Photo: © IOLITEC, T. J. S. Schubert, 2012.

Fig. 2-2. "E-cars: Using their batteries to store energy from renewables?

In this context, next to novel electrode materials, separators, and conducting salts, the electrolyte might be also a part to look a little bit closer. A battery seems to be simple, but in terms of electrochemistry it is a real complex device. One of the most important challenges for a successful development of novel battery concepts is to understand the processes at the interfaces, in particular at the solid electrolyte (SEI), which might led to interesting results if ionic liquids are involved. As a consequence, it is not useful to expect that the replacement of a common electrolyte from an existing Lithium-ion-battery by an ionic liquid leads directly to an overall better performance. In novel concepts of batteries one has to take into consideration the advantages of ionic liquids, e.g. low vapor pressure and high thermal stability, and to develop them not independently, but together with all other parts of a battery.

As a consequence, the use of ionic liquids for battery applications is still at the level of fundamental research, but with an interesting outlook for the next generations of batteries. We'll keep you involved!

Sabatier Process

The final technology that should be highlighted in this overview is the synthesis of methane from hydrogen, generated by the cleavage of water, and CO_2 from power stations, better known as *Sabatier process*. The necessary electricity is taken from overcapacities of renewable energies, in particular from wind and solar energy. The advantage of this approach is that the resulting methane can be stored directly inside the gas net, which is readily available in industrial countries.

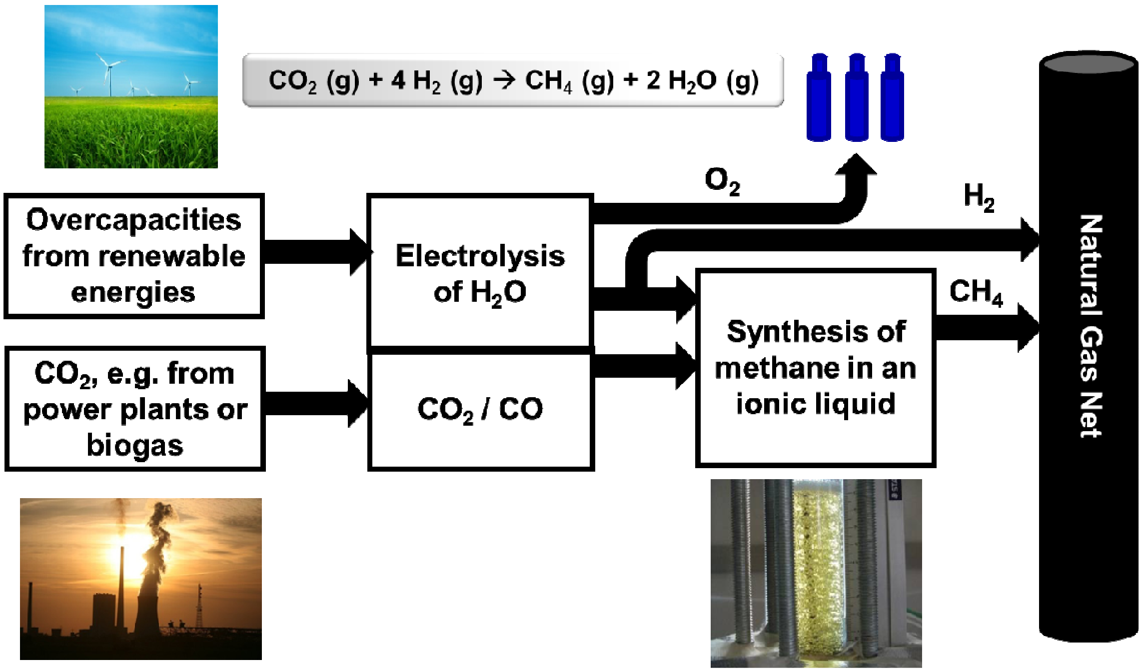

Fig. 2-3. Using the Sabatier-process to store energy inside the natural gas net.

Ionic Liquids are used in this approach as thermally stable reaction medium: The thermal stability has to be at minimum 280 °C, the solubility for hydrogen and oxygen should be as high as possible, the solubility of methane should be of course as low as possible. Together with partners from Universities and from industry IOLITEC develops this technology in a project funded by the German Federal Ministry of Education and Research. IOLITEC's part is of course the development of a suitable ionic liquid!

Balance Wheels

A completely different approach is to store electric energy in a fast spinning wheel, a so called *balance wheel*. One of the major advantages of this technology is that the energy uptake and release is fast, so the system can react fast on alternating changes in the supply of electricity from renewable resources. Since the energy is stored mechanically in the rotation, the overall efficiency is limited by friction. The friction caused by the air reduces the efficiency so significantly that these wheels are often designed to be used in vacuum to reduce such energy losses. As a consequence, a lubricant that is used under vacuum conditions should have a ultralow vapor pressure.

As you can imagine, here come ionic liquids into the game: The research concerning the use of ionic liquids as lubricants is already established started approximately 10 years ago, but over the past years the research concerning the use of ionic liquids as lubricants for vacuum applications became more and more popular.

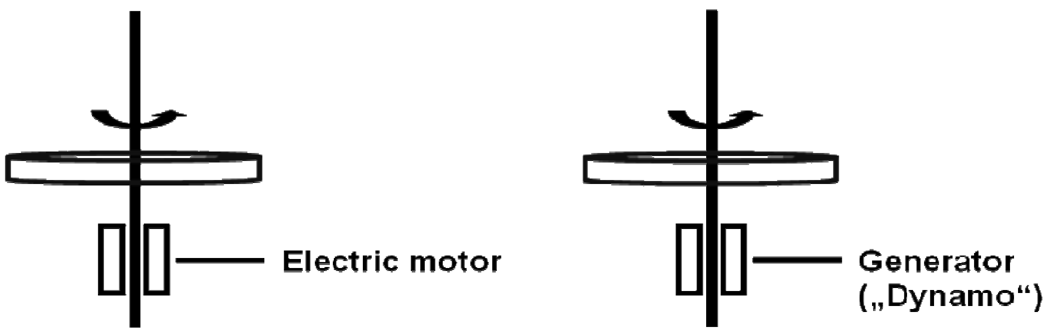

Fig. 2-4. Charging (left) and discharging (right) of the balance wheel.

In a joint project, funded by the German Federal Ministry of Education and Research, together with other partners, IOLITEC focuses on the development of novel ionic liquids that are suitable lubricants for this and related technologies.

Interested? If you want to know more about the status of our current activities in these exciting but also important technologies, please do not hesitate to contact us! (science@iolitec.de).

3 News from IOLITEC Inc.

By Frank M. Stiemke

A quite turbulent half a year lies behind IOLITEC Inc.: Dr. Tom Beyersdorff, who was President of IOLITEC Inc. since 2010, has left IOLITEC after nearly 2.5 successful years in middle of August 2012 and went back to Germany (see also Editorial). In the following 1.5 months our US-customers were served from the Headquarters in Germany until I was able to continue our operations at Tuscaloosa. In this transition phase, I hope, only a very few customers experiences greater delays or difficulties in their supply of Ionic Liquids, thanks to my great colleagues in Germany. Since October 1st, IOLITEC Inc. is back to full operation in the U.S.

At the end of September I moved from Germany to Tuscaloosa and became the new President of IOLITEC Inc. By education I'm organic chemist. I was already working at IOLITEC's headquarters since 2008, where I was not only involved in R&D-projects dealing with ionic liquids but although in sales and marketing of nanomaterials based on IOLITEC's the IL-dispersion-technology. For me it is a great opportunity to go to the U.S. evolving our business. Though Tom Beyersdorff left a big gap, I try my best to answer your questions, serve your needs in ionic liquid supply and help you to conduct and to enhance your fundamental research and applied science.

You will have the first chance to meet me personally at the SMARTCOATINGS Conference in Orlando, Florida, February 20th -22nd, where I will give a talk about metal deposition from Ionic Liquids.

As many of you might already know, IOLITEC offers custom synthesis of all patent free ionic liquids and I would be glad to receive your inquiries for non catalog products, too.

Please direct all inquiries to:
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4 High tech fluids by 3M

By Sven Sauer.

3M and IOLITEC started cooperation on 3M™ Novec™ and 3M™ Fluorinated™ Products

IOLITEC and 3M had and have already a fruitful business in the field of fluorinated raw materials for the production of ionic liquids. Since March 2012 this cooperation was further deepened and expanded into the area of fluorinated liquids (3M™ Novec™, 3M™ Fluoriniert™). Starting in 2012, IOLITEC is now in the position to offer functional materials on behalf of 3M, which amend our portfolio of ionic liquids and nano-materials in a perfect way.

In the next few sections we will provide an overview of the unique physical-chemical properties and possible technical applications of those materials.

General properties

The fluorinated compounds from 3M have some unique properties: In table 1 the major physical data for the Novec™ and Fluoriniert™ materials are summarized. The materials are in contrast to ionic liquids non-conductive with a very high dielectric strength about 40 kV at a distance of 0.1 ″ making them to one of the best known liquid insulators. Depending on the used Novec™ or FC™ fluid, the boiling point varies from 34 °C up to 128 °C and the pour point from -138 °C up to -38 °C. This wide range of being in the liquid phase opens a large window of possible applications in different temperature areas. The compounds are thermally stable up to 150 °C (Novec™ 649 up to 350°C). The viscosities of the materials are around 1 cP at room temperature making them, in combination with a very low surface tension, suitable candidates as diluents. They are non-flammable and chemically inert even under extreme conditions like fast temperature changes. The liquids are non-corrosive and would be compatible to every metal and most of the used plastics in industrial applications. Additionally, they are not declared as dangerous good for transport and storage and they are almost non-toxic. Regarding the environmental impact the fluorinated compounds show in contrast to FCKW and other halogenated compounds no ozone depleting properties with an "ozone depleting potential" (ODP) of 0. In addition, the "global warming potential" (GWP) is low and for some materials 60 or less. The fluorinated materials from 3M are environmental friendly and safe to handle.

Table 1. Physical Data of 3M™ Novec™ materials.

Fluorinated Liquid Novec™	unit	Novec 7100	Novec 7200	Novec 7300	Novec 7500
Boiling Point	°C	61	76	98	128
Glas Point	°C	-135	-138	-38	-100
Molekular Weight	g/mol	250	264	350	414
Critical Temperature	°C	195	210	243	261
Critical Pressure	MPa	2,23	2,01	1,88	1,55
Vapour Pressure	kPa	27	16	5,9	2,1
Vapour Heat	kJ/kg	112	119	102	89
Density	kg/m^3	1510	1420	1660	1614
Coefficent of Expansion	1/K	0,0018	0,0016	0,0013	0,0013
Kinematic Viscosity	cSt	0,38	0,41	0,71	0,77
Absolute Viscosity	cP	0,58	0,58	1,18	1,24
Specific Heat	J/kg K	1183	1220	1140	1128
Thermal Conductivity	W/m K	0,069	0,068	0,063	0,065
Surface Tension	mN/m	13,6	13,6	15	16,2
Solubility of Water in Liquid	ppm by weight	95	92	67	45
Solubility of Liquid in Water	ppm by weight	12	<20	<1	<3
Dielectric strength, 0.1'' distance	kV	~40	~40	~40	~40
Dielectric Constant @ 1kHz	-	7,4	7,3	6,1	5,8
Volume Resistance	ohm cm	10^8	10^8	10^{11}	10^8
Global Warming Potential	GWP	297	59	210	100

Table 2. Pyhsical data of 3M^{TM} Fluoriniert^{TM} materials.

Fluorinated Liquid FC-Series	unit	FC-770	FC-3283	FC-40	FC-43
Boiling Point	°C	95	128	155	174
Glas Point	°C	-127	-50	-57	-50
Molekular Weight	g/mol	399	521	650	670
Critical Temperature	°C	238	235	270	294
Critical Pressure	MPa	2,47	1,22	1,18	1,13
Vapor Pressure	kPa	6,6	1,4	0,43	0,19
Vapor Heat	kJ/kg	86	78	68	70
Density	kg/m³	1793	1820	1850	1860
Coefficent of Expansion	1/K	0,0015	0,0014	0,0012	0,0012
Kinematic Viscosity	cSt	0,79	0,75	1,8	2,5
Absolute Viscosity	cP	1,4	1,4	3,4	4,7
Specific Heat	J/kg K	1038	1100	1100	1100
Thermal Conductivity	W/m K	0,063	0,066	0,065	0,065
Surface Tension	mN/m	15	15	16	16
Solubility of Water in Liquid	ppm by weight	14	7	<7	7
Solubility of Liquid in Water	ppm by weight	<5	<5	<5	<5
Dielectric strength, 0.1'' distance	kV	>40	>40	>40	>40
Dielectric Constant @ 1kHz	-	1,9	1,9	1,9	1,9
Volume Resistance	ohm cm	10^{15}	10^{15}	10^{15}	10^{15}

Fluorinated Liquids in Science

Having a quick look into the literature, there are a couple of interesting publications in combination with fluorinated liquids. Focusing here on the more chemical aspect the liquids could be applied in a broad area even in combination with ionic liquids. For example *Marc Shifflet* investigated the liquid-liquid equilibria of hydrofluoroethers (HFE) and 1-Ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (*J. Chem. Eng. Data*, **2007**, *52*, 2413). He describes that all hydrofluoroethers show a large miscibility gap, whereas the EMIM BTA rich side becomes more soluble in the hydrofluoroethers with decreasing boiling point of the HFE.

The application of Novec™ liquids for coating of nano materials on surfaces was shown by *Shu Yang et al.* (*Appl. Mater. Interfaces*, **2012**, *4*, 1118.). He used Novec™ 7300 to disperse fluorosilane modified silica nanoparticle and spin-coated the mixture on different surfaces. With this technique and the modified nanoparticles he was able to prepare superhydrophobic surfaces having a contact angle with water above 150° and a roll-off angle for a water droplet of less than 5°. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) images revealed that NPs formed a nearly close-packed assembly in the superhydrophobic films. In addition he reported that the coated film was highly transparent with greater than 95% transmittance in the visible region.

Fluorinated liquids could also be used for chromatography applications as alternative to hexane. *Michael Kagan* (*J. Comb. Chem.*, **2009**, *11*, 704.) demonstrated for instance the successful and effective use of Novec™ liquids in separating libraries of pyrrolobenzodiazepine derivatives by preparative HPLC.

As described in the tables above the fluorinated liquids have a very low surface tension and viscosity. This advantage could be used for measuring the porosity of nanostructured materials like membranes. *S. Cardea* (*Appl. Mater. Interfaces* **2009**, *1*, 171.) and *A. Gugliuzza* (*Appl. Mater. Interfaces* **2010**, *2*, 459.) for instance used FC and Novec™ materials to determine the void volume fraction of porous membranes by calculating the value from weight and density of the solvent adsorbed inside the open pores.

Another surprising application is the use of Novec™ 7100 as preserving agent for biologics. The Smithsonian natural history museum in Washington D.C. used the fluorinated ether to preserve a 7.31 m long calamari. The organic material was first fixed in formalin and then stored in the Novec material instead of ethanol/formalin. The advantage of Novec™ as storing liquid is the non-toxicity and non-flammability of the material. In addition, the pigments and organic materials of the biologics are not dissolved by the fluorinated liquid keeping their natural color and shape.

Furthermore, there are already a lot of established industrial applications for fluorinated liquids which are now described shortly:

Technical Applications

Solvents for coating materials and lubricants

Coating of waver ©3M

The Novec™ liquids are suitable solvents for coating materials and lubricants. Materials like silicone, fluorocarbones, FTFE and heparine could be dissolved easily and deposited on metal-, plastic- and elastomeric surfaces. Typical application fields are the coatings of injection needles, surgery instruments, filters, PVC-tubings or hard discs in computers. The fluorinated liquids have a low surface tension leading to a homogeneous surface of the coating. Since they vaporize fast the drying time after the coating process could be reduced to a minimum.

Precision Cleaning

Electronic devices and other high performance prefabricated parts need often an intensive and effective cleaning before they could be assembled in their final device. The Novec™ liquids themselves could already be used in their pure form to remove light hydrocarbon- and silicon oils. Since they have a very low viscosity and surface tension, the liquid enters even small porous materials resulting in an effective cleaning. With the addition of cleaning additives the performance of the liquids could be further increased to remove even strong impurities of silicon oils, hydrocarbon oils and fats.

Thermal management

With their good environmental, health and safety aspects in combination with their physical properties the fluorinated liquids from 3M are suitable media for cooling or heat transfer applications. With a broad liquid range and adjustable boiling points in combination with the isolative non-conductive behavior they could be used in the direct cooling of computer- or high performance electronics. One interesting application here would be as media in evaporative cooling devices. A schematic illustration of such a device is given in **Error! Reference source not found.**. The electronic component, for instance a processor, is surrounded by the non-conductive fluorinated liquid. The heat produced by the silicon chip leads to the evaporation of the surrounding media and therefore to a cooling of the device comparable to the cooling effect of sweating.

In addition to their low melting points they are very effective as tempering fluids down to a temperature of -110°C. Also an application in temperature testing devices for electronic parts would be possible. The fluorinated liquids do not interact with the used materials and could be easily removed without any residue.

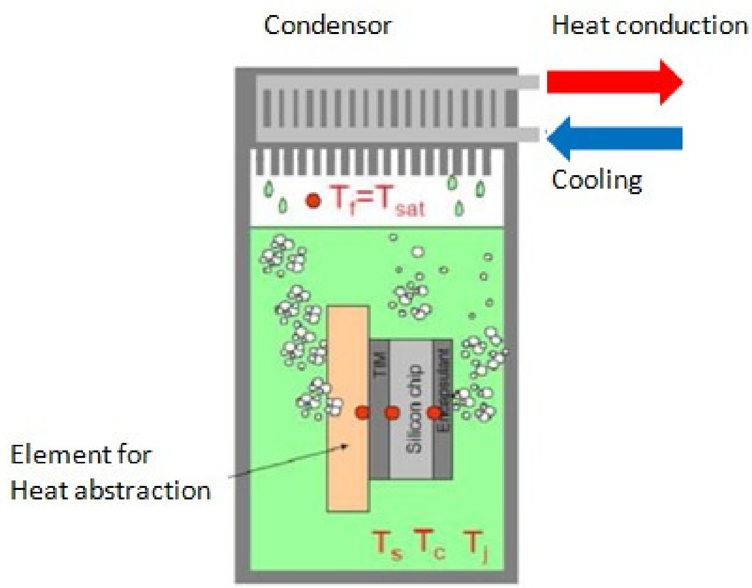


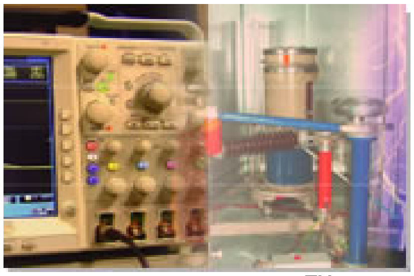
Fig. 4-1. Evaporation cooling of a silicon chip ©3M.

Liquids for voltage withstand tests

As mentioned already above the fluorinated liquids from 3M have a very high dielectric strength. Therefore they are ideal candidates for voltage withstands and other tests of electronic devices. For example the liquids are used in temperature shock tests, sensor tests, burn-in tests and Gross-Leak tests. After the testing process the liquid evaporates without any residue on the tested device.

Fire extinguishing media

Some fluorinated liquids are suitable candidates as fire extinguishing media. Novec™ 1230 (not available at IoLiTec) for instance is used as fire extinguishing media replacing by the Montreal protocol banned Halones. This fluorinated ketone does not attack the ozone layer and has the lowest global warming potential (1) among the permitted chemical fire extinguishing media. With the very high heat capacity of the resulting air/Novec™ mixture during the extinguishing process the media is able to extract large amounts of heat from the fire leading to an effective cooling of the burning material. The media could be used in the presence of people since the concentration needed for extinguishing is low and there would be no residues of the fluorinated liquid after the fire is extinguished. These properties together with the non-conductivity of the material allow the use in server centers, archives, museums and other sensitive areas where water would lead to enormous damage.



Electronic test stand, © 3M.

Available fluorinated Liquids from 3M at IoLiTec

We offer four different Novec™ liquids (7100, 7200, 7300 and 7500) and four different 3M Fluoriniert™ materials (FC-40, FC-43, FC-770 and FC-3283). All the compounds are available from 100 g up to 5 kg and in small bulk quantities.

You will find the prices for the material in our new Key Intermediates list available for download on our homepage and below at the end of this article.

Some more information about the properties and applications of the fluorinated compounds are shown on our homepage. There you can find more material available for download like brochures and applications sheets from 3M. http://youtu.be/2AObOHGsUxc

5 Task specific ionic liquids

Because of the many inquiries that we have received in the past for functionalized and task specific ionic liquids (TSIL), IOLITEC has recently acquired a license from the renowned patent of Prof. James Davis (University of South Alabama, USA). These ionic liquids contain functional groups in the side chain of the alkyl substituents thus allowing them to interact with the surrounding medium and fulfill different tasks in it. Examples for such tasks are the complexation of metal ions, used in metal extraction[2], or complexation of Li-ions, which allows for a higher specific Li-conductivity in e.g. Li-ion batteries, interaction with CO2 for carbon capture[3] and much more. We will start introducing such compounds as part of our standard catalogue, which is currently composed of more than 300 ILs, in the meantime please inquire for any substances that you might be interested in.

[2] Davis *et al, Chemical Communications*, **2001**, 135.
[3] Davis *et al*, *J. Am. Chem Soc*. **2002**, *124*, 926.

6 Selected Applications

By Boyan Iliev (BI), Hülya Sahin (HS), Maria Taige (MT), Sven Sauer (SS), Marcin Smiglak (MS), Frank Stiemke (FS), Tom F. Beyersdorff (TB) and Thomas J. S. Schubert (TS).

Ionic liquids in separations of azeotropic systems – A review (SS)

A. B. Pereiro, J. M. M. Araújo, J. M. S. S. Esperança, I. M. Marrucho, L. P. N. Rebelo, *J. Chem. Thermodynamics* **2012**, *46*, 2–28.

One of the most challenging techniques in chemical industry processes is the separation and purification of mixtures and raw materials like crude oil. Especially azeotropic systems are nearly impossible to be separated via common techniques like distillation. Since a few years the use of ionic liquids is investigated as azeotrope breakers due to their unique properties.

The authors *Pereiro* and *Rebelo* summarized in their critical review the current scientific development and progress in this field. They focused on three different techniques: liquid-liquid extraction, extractive distillation and supported liquid membranes. They compared the azeotrope braking potential of the ionic liquids with the performance of conventional solvents. In addition, they provide a systematic analysis of the influence of the structure of ILs on their azeotrope breaking capacity suggesting guidelines for selecting the most suitable ILs for the separation of specific azeotropic mixtures. One of the most used ionic liquids in this field are EMIM OTf, EMIM $EtSO_4$, BIMIM Cl, BMIM PF_6, HMIM PF_6, and OMIM PF_6. Regarding the hexafluorophosphate containing ionic liquids it should be mentioned that they are not suitable for processes containing water since they could for hydrofluoric acid in contact with water.

Heat-Assisted Electrodissolution of Pt in an Ionic Liquid (SS)

J.-F. Huang, Hao-Yuan Chen, *Angew. Chem. Int. Ed.*, **2012**, *51*, 1684 –1688.

During the last decade the demand of raw earth and noble metals increased dramatically due to their use in modern electronic devices like smartphones or catalytic processes in industry. Especially the demand of Platinum will rise in the near future since this metal plays an important role as catalyst in fuel cells. Since availability of the material is limited, scientists all over the world are looking for processes for recovery. Since Pt is one of the noblest metals, highly corrosive agents like HNO_3/HCl or strongly oxidative media (H_2SO_4/H_2O_2) are needed to dissolve the material. There are already some alternative electrochemical processes known for the dissolution of Platinum, but those methods involve the use of highly toxic electrolytes or corrosive solutions and can lead to the evolution of toxic gases.

The authors described the use of a mixture between the ionic liquid EMIM Cl and $ZnCl_2$ (75:25 mol%) that serves as a solvent system for the electrodissolution of large amounts of Pt metal. In addition, they showed that the same solvent system could be used to recover the Pt-metal directly and effectively by simple reduction at the cathode in the same system. Furthermore, the dissolution of a Pt electrode in the electrolyte was investigated at different temperatures: At a low temperature (70 °C), the anodic potential limit has been assigned as the anodic oxidation of Cl^-- ions to Cl_2, and the cathodic limit was from the reduction of the imidazolium cation and $ZnCl_4$. At higher temperatures (starting with 80°C) a fast dissolution of the Pt-electrode was observed, leading to a sharp needle at a potential larger than 1.20 V. In a further step, the dissolved Pt was then deposited as Pt/Zn alloys from the mixture. This approach of using ionic liquids as electrolytes combined with high temperatures may generally give some new impulses in electrochemistry.

Conductive Lubricating Grease Synthesized Using the Ionic Liquid

W. Wang, Y. Xia, Z. Liu, Z. Wen, *TribolLett.* **2012**, *46*, 33-42

Ionic liquids have been widely studied as base oils for lubricants or additives to lubricants or in the formulation of greases. The inherent conductivity of ionic liquid based greases offers the chance to replace expensive gold and silver particles that are commonly used as conductive stuffing in greases for electronic equipment.

In this recently published article the authors describe the formulation of conductive greases by mixing the ionic liquids OMIM BF_4 and OMIM PF_6 with PTFE micro powder as thickener. The new greases were compared to a standard PAO and showed higher thermal stabilities, lower friction coefficients and better anti-wear properties at room temperature and elevated temperatures. The tribological properties of the two greases were determined by SRV and Four-Ball tests. The authors observed stable friction coefficients up to loads of 900 N for both IL-based greases. Also, compared to PAO the two IL based greases showed a better wear resistance at higher loads.

Tribological Behavior of 1-Methyl-3-Hexadecylimidazolium tetrafluoro-borate Ionic Liquid Crystal as a Neat Lubricant and as an Additive of Liquid Paraffin

C. Zhang, S. Zhang, L. Yu, P. Zhang, Z. Zhang, Z. Wu, *TribolLett* **2012**, *46*, 49-54

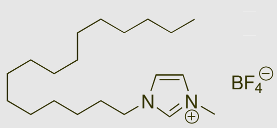
Solid lubricants such as graphite, hexagonal boron nitride (hBN) and molybdenum or tungsten disulfide (MoS_2 or WS_2) are effective lubricant additives due to the formation of lamellar structures that orient parallel to the surface in sliding direction. A similar layered organization is known for liquid crystals. These so called smectic phases are mesophases between the crystalline and isotropic liquid phase, in which the molecules align themselves in layers or planes.

It is well known that some ionic liquids form liquid crystalline mesophases upon heating. In the present publication the authors describe the use of 1-Hexadecyl-3-methylimidazozlium BF_4 (HexadecMIM BF_4) – an ionic liquid crystal (ILC) (cr 49 ^oC S_mA 180 °C is)– as a neat lubricant and additive to liquid paraffin. The authors could show that the HexadecMIM BF4 takes part in tribochemical reactions on the steel surface to form tribuchemical products such as B_2O_3, FeF_2 or FeF_3.

If HexadecMIM BF_4 is added to paraffin base oil it was found that friction and wear where reduced while the load carrying capacity was increased at both room temperature and 80^{o}C compared to the pure paraffin base oil. It was also found that HexadecMIM BF_4 shows Superior tribological properties as a pure lubricant compared to paraffin and the paraffin/HexadecMIM BF_4 system.

1-Hexadecyl-3-methylimidazolium tetrafluoroborate, >98%

IL-0097-HP	[244193-64-4]	$C_{20}H_{39}BF_4N_2$	MW 394.34



25 g	113.00 €
50 g	150.00 €
100 g	226.00 €
250 g	504.00 €
500 g	906.00 €
1 kg	1'628.00 €
5 kg	6'510.00 €

Graphene, carbon nanotube and ionic liquid mixtures: towards new quasi-solid state electrolytes for dye sensitised solar (HS)

I. Ahmad, U. Khan, Y. K. Gun'ko, *J. Mater. Chem.,* **2011***, 21,* 16990.

Since dye-sensitized solar cells (DSSCs) were developed by *Michael Grätzel* they have been widely investigated because of their potentially lower costs compared to silicon solar cells. A further advantage is that these cells operate well at diffuse light. However, the solar power conversion efficiencies of DSSCs are lower than those of classical crystalline silicon cells. Considering the highest reported efficiency for a small area DSSC (0.25 cm^2) is 11.3%, a high improvement in efficiency is required. The commonly used electrolyte is a volatile solvent with low viscosity and a high diffusion coefficient. Nevertheless, these liquid electrolytes have several disadvantages: leakage of electrolytes, corrosion of cells over time, high temperature instability, just to mention only a few. For DSSC technology, further development in the field of electrolytes is necessary.

Gun'ko et al. studied carbon based nanomaterials in ionic liquids as potential electrolytes. They prepared quasi-solid state electrolytes by incorporating graphene, SWCNTs, or a combination of SWCNTs and graphene into 1-methyl-3-propylimidazolium iodide (PMIM I). These electrolytes increased light conversion efficiencies of DSSCs moderately. By using graphene-based quasi-solid state electrolytes the efficiency increased by factor 13 (from 0.16% for pure PMIMI to 2.1%). In case of SWCNT an increase from 0.16% to 1.43% was observed. The best result (2.5%, an increase by a factor of 15) was achieved when graphene and SWCNT were mixed in PMIMI. The authors believe that this significant increase occurred, because the carbon materials act as charge transporter in the ionic liquids and as catalyst for the electrochemical reduction of I_3^-.

Graphene platelets, 6-8 nm, 99.5%

CP-0067-HP	[1034343-98-0]	C	MW 12.01
Thickness: 6-8 nm		5 g	19.00 €
SSA: 120-150 m^2/g		10 g	29.00 €
PM: -		25 g	59.00 €
Appearance: black powder		50 g	99.00 €

Warning
H 319, 335
P 261, 280, 305+351+338, 362

Packaging: Powder in PE bottle

Graphene platelets, 11-15 nm, 99.5%

CP-0068-HP	[1034343-98-0]	C	MW 12.01
Thickness: 11-15 nm		5 g	17.00 €
SSA: 60-80 m^2/g		10 g	27.00 €
PM: -		25 g	57.00 €
Appearance: black powder		50 g	97.00 €

Warning
H 319, 335
P 261, 280, 305+351+338, 362

Packaging: Powder in PE bottle

Single-Walled Carbon Nanotubes, 90%

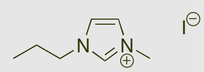
CP-0011-SG	[308068-56-6]	C	MW 12.01
OD: < 2 nm		0.5 g	69.00 €
L: < 20 µm		1 g	115.00 €
SSA: > 450 m^2/g		2 g	189.00 €
		5 g	399.00 €

Warning
H 315, 319, 335
P 261, 280, 302+352, 305+351+338, 313+332, 362

Packaging: Powder in PE bottle

1-Methyl-3-propylimidazolium iodide, >98%

IL-0025-HP	[119171-18-5]	$C_7H_{13}IN_2$	MW 252.10
		25 g	45.00 €
		50 g	60.00 €
		100 g	95.00 €
		250 g	195.00 €
		500 g	309.00 €
		1 kg	495.00 €
		5 kg	1'980.00 €



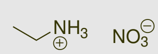
Stable and Water-Tolerant Ionic Liquid Ferrofluids (HS)

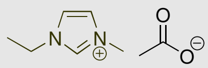
N. Jain, X. Zhang, B. S. Hawkett, G. G. Warr, *Appl. Mater. Interfaces* **2011**, *3*, 662.

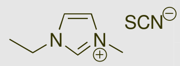
Ferrofluids are colloidal dispersions of nanoscaled magnetic particles in a carrier fluid (which is usually an organic solvent or water) and have characteristically both magnetic and fluid properties. They have numerous applications in the field of electronic devices (liquid seals), mechanical engineering (friction-reducing), medicine (contrast agents, cancer detection) and analytical instrumentation. For many applications it is necessary that the carrier liquid does not evaporate and remains stable at high temperatures. It is appropriate to use ionic liquids as carrier liquid.

Warr and co-workers successfully prepared ferrofluids in ionic liquids and in IL/water mixtures remaining stable for several months. The stability was verified by dynamic light scattering. They studied protic Ethylammonium nitrate (EAN) and aprotic ILs like Ethylmethylimidazolium acetate (EMIMOAc), Ethylmethylimidazolium thiocyanate (EMIMSCN) and Butylmethylimidazolium tetrafluoroborate ($BMIMBF_4$). Ferrofluid using bare maghemite nanoparticles could be prepared in aprotic ILs. This is due to salvation structure surrounding nanoparticles. In the protic IL, EAN, the particles sedimented within minutes. The authors indicate that a thin adsorbed polymer layer can form an effective steric barrier, whereby the sterically stabilized maghemite is stable in EAN.

γ-Iron(III)oxide powder, 99%, Maghemite			
NO-0053-HP	[1309-37-1]	Fe_2O_3	MW 159.69
APS: 20-40 nm		25 g	25.00 €
SSA: 40-60 m²/g		100 g	59.00 €
PM: spherical		500 g	225.00 €
Appearance: red brown powder		1 kg	375.00 €
	Warning H 315, 319, 332, 335 P 261, 305+351+338		
Packaging: Powder in PE bottle			

Ethylammonium nitrate, >97%			
IL-0043-SG	[22113-86-6]	$C_2H_9N_2O_3$	MW 108.11
		25 g	41.00 €
		50 g	58.00 €
		100 g	93.00 €
		250 g	198.00 €
		500 g	336.00 €
		1 kg	572.00 €
		5 kg	2'289.00 €

1-Ethyl-3-methylimidazolium acetate, >95%			
IL-0189-TG	[143314-17-4]	$C_8H_{14}N_2O_2$	MW 170.21
		25 g	60.00 €
		50 g	75.00 €
		100 g	115.00 €
		250 g	175.00 €
		500 g	265.00 €
		1 kg	395.00 €
		5 kg	1'580.00 €

1-Ethyl-3-methylimidazolium thiocyanate, >98%			
IL-0007-HP	[331717-63-6]	$C_7H_{11}N_3S$	MW 169.25
		25 g	45.00 €
		50 g	60.00 €
		100 g	85.00 €
		250 g	175.00 €
		500 g	295.00 €
		1 kg	495.00 €
		5 kg	on request

Oxygen Electrode Rechargeability in an Ionic Liquid for the Li-Air Battery (MT)

C. J. Allen S. Mukerjee, E. J. Plichta, M. A. Hendrickson, K. M. Abraham *J. Phys. Chem. Lett.* **2011**, *2*, 2420-2424.

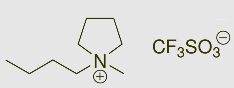
E-Mobility is a promising mobility concept for the future. The range one can drive with one battery load will surely decide about the assertion of this technology in future. This depends directly on the energy storage density of the battery. At the moment, lithium-ion batteries are very often used as power source for e-mobiles. A much higher gravimetric energy storage density can theoretically be obtained with lithium-air batteries.

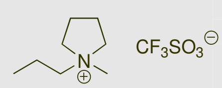
Abraham et al. published a very interesting study about the mechanism of oxygen reduction reactions and oxygen evolution reactions on glassy carbon and gold electrodes in 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide in the absence or presence of lithium bis(trifluoromethylsulfonyl)imide. They were able to show that ionic liquids are promising electrolytes for rechargeable lithium air batteries. In addition, the electrode material and the presence of lithium salt has a strong influence on the rechargeability of the oxygen electrode. *Abraham et al.* found that the oxidation overpotential for Li^+- and H^+-stabilized peroxides and superoxides is higher than for the $EMIM^+$-stabilized peroxides and superoxides. Therefore, the presence of lithium ions changes the mechanism of the oxygen reduction reaction. In the presence of lithium bis(trifluoromethylsulfonyl)imide a repeatedly cycle of the oxygen electrode on gold was possible without much loss in capacity.

Electrodeposition of selenium from 1-butyl-1-methyl-pyrrolidinium trifluoromethanesulfonate (MT)

A. Abdel Aal, F. Voigts, D. Chakarov, F. Endres *Electrochimica Acta* **2012**, *59*, 228-236.

Semiconductor thin films like selenium thin films are useful for optoelectronic applications. Unfortunately, the electrodeposition of selenium from aqueous solution leads to the formation of amorphous selenium, which cannot be used for optoelectronics due to its insulating properties. *Endres et al.* now reported a procedure for the electrodeposition of crystalline, semiconducting selenium from a mixture of 1-butyl-1-methylpyrroldinium trifluoromethylsulfonate and water under open air conditions. They were able to show that the deposition temperature strongly influences the structure of the deposited selenium. The deposition at room temperature led to the formation of an amorphous, film of red selenium film, while the desired crystalline, film of grayish selenium was obtained by electrodeposition at temperatures above 70 °C on gold substrates. Even though the process of the selenium deposition depends on multiple parameters such as the deposition temperature and time as well as the substrate, the possibility to deposit crystalline selenium thin films under open air conditions makes it to an interesting process for the industrial deposition of selenium thin films.

1-Butyl-1-methylpyrrolidinium trifluoromethanesulfonate, 99%			
IL-0113-HP	[367522-96-1]	$C_{10}H_{20}F_3NO_3S$	MW 291.33
		25 g	137.00 €
		50 g	181.00 €
		100 g	276.00 €
		250 g	570.00 €
		500 g	937.00 €
		1 kg	1'533.00 €
		5 kg	on request

1-Methyl-1-propylpyrrolidinium trifluoromethanesulfonate, 99%			
IL-0162-HP	[---]	$C_9H_{18}F_3NO_3S$	MW 277.31
		25 g	155.00 €
		50 g	207.00 €
		100 g	315.00 €
		250 g	665.00 €
		500 g	1'076.00 €
		1 kg	1'759.00 €
		5 kg	on request

Growth of single-crystal copper sulfide thin films via electrodeposition in ionic liquid media for lithium ion batteries

Y. Chen, C. Davoisne, J.-M. Tarascon, C. Guery, *J. Mater. Chem.,* **2012***, 22,* 5295.

Transition metal chalcogenides, such as ZnS, CuS, CdS and MoS_2 are popular due to their excellent physical and chemical properties. Among them, copper sulfides are of great interest with potential applications ranging from energy storage to photovoltaic fields.

Covellite CuS shows good electrical conductivity (10^{-3} S/cm), a high theoretical capacity (560 mAh/g) and flat discharge curves when cycled versus Li^+/Li^0, and has therefore long been investigated as cathode material for lithium ion batteries. One of the best methods for its synthesis is electrochemically.

Ionic liquids are superior media showing key advantages that enable them to overcome the limits imposed by common aqueous or organic electrodeposition media, such as wide electrochemical window (up to 5 V) and extremely low vapor pressures, which allow operation at temperatures well above 100 °C. By exploiting the ability of ionic liquids to solubilize molecular sulfur at the melting point, the authors report the electrodeposition of CuS in an EMIM BTA (1-ethyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide) electrolytic bath containing Cu $(BTA)_2$ salt and elemental sulfur.

Single-crystal and preferentially oriented covellite CuS thin films with flake morphology have been thus successfully obtained. SEM images show the flakes, around 50 nm thick and 1 mm wide stacked face to face and oriented perpendicularly to the substrate. Transmission electron microscopy image also shows that the electrodeposited CuS flakes have smooth surfaces, and the same diffraction pattern had been collected for more than 10 flakes taken randomly.

The mechanism by which such films grow is shown to be nested in the successive chemical reaction of electrochemically plated copper and dissolved sulfur in the ionic liquid bath; such behavior was rationalized by comparing the Nernst reduction potentials of both Cu and S. Li/CuS coin cells using single crystal thin film deposits after carbon coating as the positive electrode have been also tested and show a discharge capacity of 350 mAh/g with capacity retention of 54.4% after 20 cycles.

Doped butylmethylpyrrolidinium–dicyanamide ionic liquid as an electrolyte for MnO_2 supercapacitors

Y.-S. Li, I.-W. Sun, J.-K. Chang, C.-J. Sua, M.-T. Lee, *J. Mater. Chem.,* **2012**, *22,* 6274.

Supercapacitors, including electric double-layer capacitors (EDLCs) and pseudocapacitors, are considered promising candidates for effective energy storage due to their high power density, long cycle life, and low maintenance cost. Pseudocapacitors, whose capacitance is mainly attributed to the continuous and reversible redox reaction of electrode materials, have higher energy density than that of EDLCs and thus have become increasingly attractive. MnO_2 is a favorable pseudocapacitive material because of its satisfactory charge storage performance, natural abundance, and environmental benignity.

Appropriate doping of Na DCA (0.01 M) in BMPyrrDCA (1-Butyl-1-methylpyrrolidinium dicyanamide) electrolyte can increase the specific capacitance, specific energy, and specific power of the MnO_2 electrode. The authors attribute this to the participation of the doped Na^+, along with the intrinsic DCA^-, in the insertion/deinsertion pseudocapacitive reaction, causing extra redox sites in the oxide (and thus an improved capacitance). In the doped IL electrolyte, the MnO_2 electrode shows a specific capacitance of 100 F/g at 25 °C. Owing to a wide operation potential range of 3 V, the obtained energy and power capabilities predominately outperform those found in conventional aqueous electrolytes. By increasing the temperature to 50°C, an even higher performance (125 F/gin 3 V) of the electrode can be achieved in the IL.

6 Community

IOLITEC@ Social Media

Please follow IOLITEC at Facebook or connect yourself with IOLITEC's team at LinkedIn!

Ionic Liquids @ Youtube:

As described in Thomas J. S. Schubert's overview about ionic liquid applications in the field of energy storage (chapter 2 of this newsletter), the Sabatier-process may be an interesting technology, since the energy uptake is fast and the resulting methane can be stored inside the net of natural gas, which is available and fully developed in most of the industrial countries.

The overall reaction is conducted in a gas-bubble-reactor, which was exhibited at the ACHEMA 2012:

http://youtu.be/_P-oGk2envQ

Novec™-Liquids @ Youtube:

As described in Sven Sauer's introduction of 3M's Novec™ and FC™-liquids, they are liquid insulators. The meaning of a liquid insulator becomes even more clearly, if an electronic device such as a flat screen monitor is dipped into 3M's Novec™-liquids:

http://youtu.be/2AObOHGsUxc

Missed a conference? No problem – here's our summary:

ACS National Meeting Spring 2012, San Diego/CA, USA, March 25-29, 2012 (ts)

A. Visser, N. Bridges, and R. Rogers organized for the ACS division of Industrial and Engineering Chemistry (I&EC) the session "Ionic Liquids: Science and Applications". The topics of the session

- Energetic Ionic Liquids
- Physical Properties/Physical Chemistry
- Ionic for Energy, Fuel, and Chemical Production
- Biomass and Renewables
- Advanced Electrolytes
- Molecular Modeling
- Nanomaterials
- New Materials
- Biotechnology

In addition, on Monday afternoon a symposium *in honor of Robin Rogers* was held, who became an Industrial and Engineering Chemistry Fellow.

The science presented was generally at a high level, with many active discussions. Since the meeting was also focusing on the applications, the number of participants and contribution from industry could have been a bit larger.

Furthermore, on the first day (Sunday) R. Jha organized a session named "Green Solvents and Ionic Liquids as the next Generation of Green Solvent Systems".

The program can be found at the ACS website:

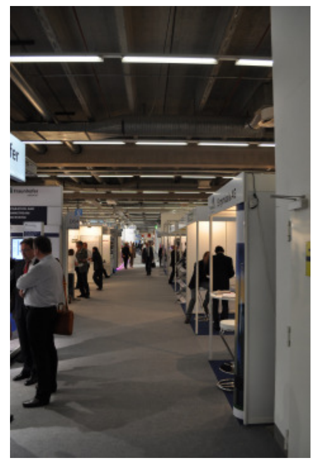
http://sandiego2012onsite.acs.org/i/57789

IOLITEC's contributions can be found at our website:

http://www.iolitec.de/en/Download-document/972-Presentation-Nano-ACS-Meeting-2012.html http://www.iolitec.de/en/Download-document/973-Presentation-ACS-Meeting-2012.html

ACHEMA 2012 Congress, Frankfurt, Germany, June 18-22, 2012 (ts)

The ACHEMA, a major fair & congress about chemical engineering takes place in Germany every three years. In June 2012 it was held in Frankfurt. Ionic liquids were also present at this event: As topic in the "Advanced Fluids" session of the accompanying congress, and of course at IOLITEC's booth, which was located at the areal of the Deutsche Bundesstiftung Umwelt e.V.



On this occasion we were proud to demonstrate 3M's NOVEC™ fluids for the first time, which are available on the kg-scale since March 2012 from IOLITEC. In this context, our exhibition object, a flatscreen monitor standing in a NOVEC™-fluid, attracted a lot of attention, since liquid insulators are out of our daily experience. Please have also a look at our video, which can be watched at YouTube: http://youtu.be/2AObOHGsUxc

At the accompanying congress, IOLITEC's CEO presented a talk at the Advanced Fluids in process engineering session about "Ionic Liquids as thermal fluids revisited" and at the Chemical Nanotechnology session about "Ionic liquids as novel dispersing agents for nanoparticles: easy- and safe-to-handle dispersions for energy applications", which can of course be downloaded here:

http://www.iolitec.de/en/Download-document/957-Presentation_Thermal_Fluids_ACHEMA_2012.html

http://www.iolitec.de/en/Download-document/956-Presentation_Nano_ACHEMA_2012.html

EUCHEM 2012, Celtic Manor, Wales, August 5th-19th, 2012 (ts)

When the usual suspicious were asked about the ionic liquid related conferences in 2012, nearly everybody agreed that the EUCHEM 2012 at the Celtic Manor Resort in Wales was maybe the scientific highlight: The balance between science, time for networking, and social events was excellent, the location very well chosen. A good indicator for a successful conference is – after all the work is done – if people are dancing at the end of the conference diner.

One of the highlights was Martin Atkins' talk about the use of ionic liquids in chemical engineering: The content of mercury in oil and natural gas leads to an enrichment of this metal in the environment. In terms of chemical engineering the separation of mercury and mercury containing compounds is a technical challenge. In his presentation, he demonstrated in which way Petronas together with the experts from QUILL managed it to develop a process in which – and it this is not a surprise – ionic liquids are used to extract the mercury out of natural gas condensate. At present this technology is under investigation in a pilot plant in Malaysia. So, maybe soon this will be another successful example of commercialized process, but in his talk a bit more "scientific meat", would have been useful, but companies are of course sometimes not allowed to tell the complete story…

The conference was closed by another great plenary lecture from Michael Grätzel about the latest stage of DSSC technology. There is no doubt that Grätzel's research had over the past years also a strong influence on the development of ionic liquids. We keep our fingers crossed for him to be become one of the next Nobel laureates!

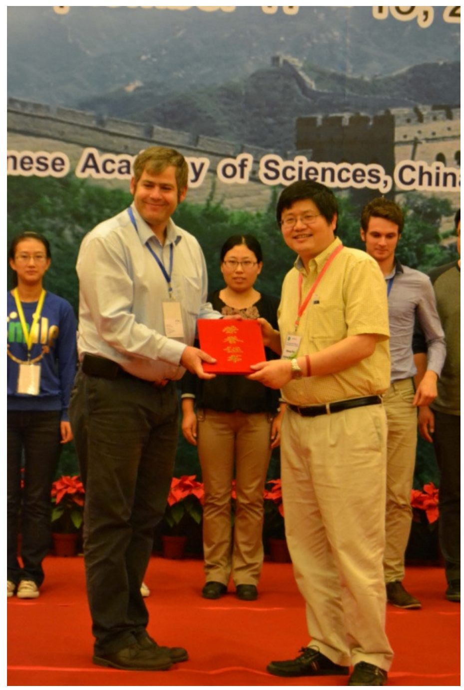
http://www.iolitec.de/en/Download-document/963-Presentation_EUCHEM2012_Nanodispersion_Lubrication.html
http://www.iolitec.de/en/Download-document/962-Thermal-Fluids-Poster-Euchem-2012.html
http://www.iolitec.de/en/Download-document/961-Sorption-Cooling-Poster-Euchem-2012.html

http://www.iolitec.de/en/Download-document/960-NanoDispersion-Lubrication-Poster-Euchem2012.html

APCIL 2012, Beijing, China, 17 – 19 September (BI)

The 3rd edition of one of biggest conferences on ionic liquids in Asia was held this year in China's capital Beijing. It had almost 300 participants from 20 countries worldwide and IOLITEC was one of them. We were able not only to present our own research results on biomass conversion, CO_2-capture and electrolyte development, but also exchange ideas over some Chinese food delicacies with many of our friends and customers.

Among the key speakers were Prof. Rogers (USA), Prof. Brennecke (USA), Prof. Ohno (Japan), Prof. Zhang (China), Prof. Wang (China). There were surprisingly many talks about biomass conversion, including those of Prof. Rogers and Prof. Wang, who also presented also a very efficient rotating packed bed pilot plant for CO_2-capturing. Another interesting topic which was quite popular was the simulation of properties for different task-specific ILs. A whole session was dedicated to separation processes, where the talks were mainly concentrated on capture of CO2 and other acidic gases from the atmosphere or desulfurization of fuels.



As we look for different properties of ILs in the literature, we always see quite big discrepancies in their values, so I personally very much enjoyed by the talk of Prof. Brennecke about the uncertainties in measurements and effects of impurities on physico-chemical properties.

As a whole, the conference was a success, IOLITEC's poster on the biomass dissolution with ILs was even awarded one the best poster presentation awards.

http://www.iolitec.de/en/Download-document/975-Presentation-APCIL-2012.html
http://www.iolitec.de/en/Download-document/965-APCIL-2012-CO2-capture-Poster.pdf.html
http://www.iolitec.de/en/Download-document/964-APCIL-2012-Biomass-Poster.pdf.html

Contributions & presentations from IOLITEC at other fairs & conferences:

18th International Colloquium on Tribology, TAE, Ostfildern, Germany, January 10 – 12, 2012

Presentation from IOLITEC's CEO Thomas J. S. Schubert "Ionic Liquids and Ionic Liquid-mediated dispersions of nanomaterials as high performance additives for lubricants"

http://www.iolitec.de/en/Download-document/958-Presentation_Tribology_Esslingen_2012.html

WILS 2012, Lisboa, Portugal, February 3, 2012

Presentation from IOLITEC's CEO Thomas J. S. Schubert "Brief overview about sorption cooling media and thermal fluids"

http://www.iolitec.de/en/Download-document/977-Presentation_Workshop_WILS_Sorption__Thermal.html

Bunsentagung, Leipzig, Germany, May 17 – 19, 2012

Plenary lecture from IOLITEC's CEO "Ionic liquids: from physical-chemical properties to applications –selected Examples"

http://www.iolitec.de/en/Download-document/979-Presentation_Bunsentagung_2012.html

ILED, Rome, Italy, May 30 - June 1, 2012

Presentation from IOLITEC's Boyan Iliev "Novel Electrolytes for Lithium Ion Batteries"

http://www.iolitec.de/en/Download-document/974-Presentation-ILED-2012.html

Lubmat, Bilbao, August 6 – 8, 2012

Presentation from IOLITEC's Maria Ahrens "Ionic Liquids and Ionic Liquid-Mediated Dispersions of Nanomaterials as High Performance Additives for Lubricants"

http://www.iolitec.de/en/Download-document/969-Presentation-Tribology-Lubmat-2012.html

ZVO Jahrestagung, Darmstadt, Germany, September 26 – 28, 2012 (Presentation in German Language)

Presentation from IOLITEC's CEO Thomas J. S. Schubert "Ionische Flüssigkeiten als Elektrolyte für die Metallabscheidung".

http://www.iolitec.de/en/Download-document/967-Praesentation-ZVO-Oberflaechentage-2012.html

Green Solvents, Boppard, October 8 – 10, 2012.

Presentation "Aspects for the use of ionic liquids as thermal fluids"

http://www.iolitec.de/en/Download-document/981-Presentation_Thermal_Fluids_Green_Solvents_2012.html

Poster "Ionic Liquids for CO_2-capture"

http://www.iolitec.de/en/Download-document/976-Green-Solvents-CO2-Poster.html

Materialica, Munich, October 23, 2012

Presentation from IOLITEC's CEO "Dispersions of nanomaterials for coating applications by novel Ionic Liquid-based Dispersion Technology"

http://www.iolitec.de/en/Download-document/978-Presentation_Materialica_Nano_2012.html

Cleantech 2012, June, 18 - 21, 2012, Santa Clara, USA

http://www.techconnectworld.com/Cleantech2012/

Clean Technology 2012 was part of the joint conferences Microtech, Biotech and Nanotech in Santa Clara. Advancements in traditional technologies, emerging technologies and clean business practices were presented for a more sustainable future.

Iolitec GmbH and Iolitec Inc presented two posters and gave two presentations:

"**Ionic Liquids as Heat Transfer Medium**"

"**Ionic Liquids as Novel Dispersing Agents for Nanoparticles: Synthesis and Stabilization of Nanomaterials - Safe-to-Handle Dispersions**"

http://www.iolitec.de/en/Download-document/955-2012_CleanTech_Nano-Dispersion_Poster.html

"**Novel Electrolytes for Lithium-Ion Batteries**"

http://www.iolitec.de/en/Download-document/971-Presentation-Electrolytes-CleanTech-2012.html

"**Ionic Liquids as Sorption Cooling Media**"

http://www.iolitec.de/en/Download-document/970-Presentation-Sorption-Cooling-CleanTech-2012.html

Upcoming Exhibitions and Conferences:

COIL-5, Algarve, Portugal, April, 21-25, 2013

By for the most established conference in the field of ionic liquids will again take place in Europe. As in 2011, IOLITEC is proud to be a sponsor of this important meeting.

http://coil-5.itqb.unl.pt/

SMARTCOATINGS 2013, Orlando, Florida, February 20 -22, 2013

Meet Dr. Frank M. Stiemke at the SMARTCOATINGS Conference, where he will give the talk "*Ionic Liquids & Nanomaterials Dispersions – Symbiosis for Coating Applications*" with the focus on metal deposition from Ionic Liquids.

http://www.smartcoatings.org/

30th Battery Seminar & Exhibit, Fort Lauderdale, March, 11-14, 2013

Dr Frank M. Stiemke will give the talk "Ionic Liquids for Novel Battery Electrolytes" at 11:00 -11:30 am, March 14.

https://powersources.net/florida/frameset.html

European Coating Show/Congress, Nürnberg, March, 18-20, 2013

During the session 5 "Printing ink", March 18, 12.00-12.30 Dr. Boyan Iliev will present "Ionic Liquids as novel Materials for Coatings, Printing Inks and Dispersion of Nanomaterials"

https://www.european-coatings.com/Events/European-Coatings-CONGRESS-2013/

MRS Spring Meeting, San Francisco, April, 1-4, 2013

Material science is more and more connected to ionic liquids. As a logical consequence, Robin Rogers (The University of Alabama) , Rico E. Del Sesto (Los Alamos National Laboratory), Sheng Dai (Oak Ridge National Laboratory), Yukihiro Yoshida (Meijo University) organized a special Symposium "Materials Applications of Ionic Liquids" during this year's MRS spring meeting.

Please meet IOLITEC Inc.'s President Frank M. Stiemke and join his oral presentation "(Functional) Coatings by Metal Deposition from Ionic Liquids" at Marriott Marquis, Golden Gate Level, Salon C2, April 3rd, 9.15-9.30 amand his poster presentations "High Performance Ionic Liquid Based Electrolytes for Energy Applications" and "Ionic Liquids & Nanomaterials Dispersions ? A Fruitful Symbiosis" at Marriott Marquis, Salon Level, Salons 7-8-9.

http://www.mrs.org/spring2013/

STLE Annual Meeting, Detroit, May, 5-9, 2013

At the Annual Meeting of the Society of Tribologists and Lubrication Engineers Dr. Frank M. Stiemke will talk about "Ionic Liquids: high performance additives for lubricants"

http://www.stle.org/events/annual/details.aspx

EnMat II - 2nd International Conference on Materials for Energy, Karlsruhe, May 12-16, 2013

IOLITEC will exhibit and present at EnMAT II. Further details can be found later on our website.

http://events.dechema.de/enmat.html

CCS 2013 - European Conference on Carbon dioxide Capture and Storage, Antwerpe, May, 27-29, 2013

IOLITEC is proud to be co-organizer of the CCS conference! Meet Dr. Gabriala Adamova and Dr. Boyan Iliev in Antwerpe and discuss with them about our latest results in IL-assisted CO_2-capture.

https://secure.vito.be/VITOEvenement/inschrijving/CCS2013/CCS-info.aspx?lang=en

ICEPE 2013 - Third International Conference on Energy Process Engineering, Frankfurt, June 3-6, 2013

Dr. Maria Ahrens will present our latest results in the development of "Novel Electrolytes for Lithium-Ion Batteries".

http://www.processnet.org/icepe2013

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

Imprint

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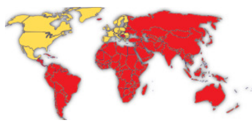

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