



Ionic liquids as tunable materials in (bio)analytical chemistry

Jared L. Anderson¹ · Kevin D. Clark¹

Received: 27 April 2018 / Accepted: 2 May 2018 / Published online: 17 May 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

Ionic liquids (IL) are a unique class of non-molecular ionic solvents that possess a multitude of customizable properties. They are often composed of bulky and asymmetric nitrogen or phosphorus-containing cations paired with organic or inorganic counter anions. One of the most remarkable features of ILs that makes them so intensely studied is their low melting points, allowing many of them to be liquids at room temperature. This is usually accomplished by imparting asymmetry into the cation, thereby preventing the cations and anions from undergoing packing into a crystalline form. In addition, ILs possess a number of other interesting and useful physicochemical properties including extremely low vapor pressures at ambient temperatures, high thermal stabilities, wide liquid ranges, tunable viscosity, and high conductivity. In addition, ILs can be designed to possess varied solubility in water and many organic solvents, opening up a plethora of opportunities for their use in many diverse areas of research.

It has been very interesting to observe the field of ILs grow into the highly interdisciplinary field that it is today. The origin of the first true “ionic liquid” is a bit controversial, but likely dates back to the late 1800s. Many of the early compounds were high-temperature molten salts followed by inorganic and organic chloroaluminates, which became highly studied electrolytes within the electrochemistry community. Synthetic

methods used to prepare the more commonly studied water- and air-stable ILs were introduced in the 1980s. These features, coupled with the aforementioned advantageous properties of ILs, have led to their widespread use in the field of green chemistry. Many of the early IL studies were focused on understanding their effects as solvents in chemical reactions, particularly in the areas of catalysis and physical organic chemistry. As this knowledge began to quickly accumulate, a greater number of cations and anions were unveiled thereby creating an even greater portfolio of possible ILs for applications.

The highly unique and tunable physicochemical properties of ILs have attracted significant attention from the analytical chemistry community. This topical collection of articles includes articles from not only the traditional branches of analytical chemistry (i.e., spectroscopy, electrochemistry, mass spectrometry, and separation science) but also their growing use in emerging areas of bioanalysis. Several of the articles within this topical collection exploit magnetic ionic liquids (MILs) as either a magnetoactive solvent in microextractions or as a stationary phase in gas chromatography. MILs are a subclass of ILs generated by the incorporation of paramagnetic components into the IL structure. In addition to possessing the tunable physicochemical properties of conventional ILs, MILs exhibit a strong susceptibility to external magnetic fields. The paramagnetic behavior of MILs is attributed to unpaired electrons in the d or f orbitals of the metal-based cation/anion. A number of the articles within the topical collection examine ILs as stationary phases in gas chromatography for the separation of multi-component volatile compounds, water, fragrances, and essential oils. In addition, IL stationary phases are highlighted in the separation of fatty acid methyl esters using two-dimensional gas chromatography with solid-state modulation. In two mass spectrometry

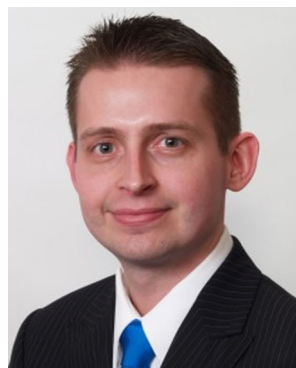
Published in the topical collection *Ionic Liquids as Tunable Materials in (Bio)Analytical Chemistry* with guest editors Jared L. Anderson and Kevin D. Clark

✉ Jared L. Anderson
andersoj@iastate.edu

¹ Department of Chemistry, Iowa State University, 1605 Gilman Hall, Ames, IA 50011, USA

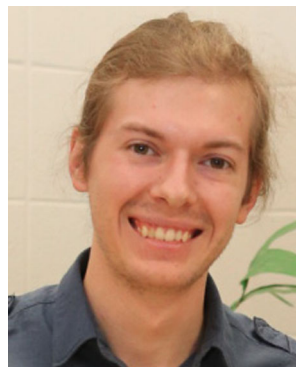
articles, ILs are exploited as MALDI MS matrices for the detection of bacterial communication molecules and virulence factors and used as additives in paired ion electrospray ionization mass spectrometry for the sensitive determination of N-blocked amino acids. Several articles discuss ILs and polymeric ionic liquids (PIL) as extraction media in sample preparation. Two articles within the topical collection involve electrochemical applications of ILs with one exploring capacitive hysteresis at the IL-polycrystalline gold interface and the other examining signal drift and calibration methods when performing amperometric gas sensing in ILs. Another article introduces a new solution phase and vapochromic detection method for amines that is based on ILs. Finally, a *Trends* article discusses the emerging role that ILs, MILs, and PILs have in the analysis of biological samples including proteins, peptides, and nucleic acids.

We would like to extend a tremendous amount of appreciation to all authors who have contributed to this topical collection. The highly diverse topics represented within this topical collection clearly show the widespread interest and impact that these unique solvents are having within the analytical and bioanalytical sciences. There is little doubt that these articles will further catalyze new interdisciplinary studies of ILs to improve existing methodologies while also enhancing our understanding of these emerging solvent systems. We would also like to thank the Editorial Office for their kind and friendly assistance in helping us organize the topical collection.



Jared L. Anderson is Professor of Chemistry in the Department of Chemistry at Iowa State University. His research focuses on the development of stationary phases for multidimensional gas chromatography, alternative approaches in sample preparation, particularly in nucleic acid isolation and purification, and developing analytical tools for trace level analysis within active pharmaceutical ingredients. He has published over 150 peer-reviewed publications and 5 book

chapters. He currently holds 6 patents and serves on the editorial boards of *Analytica Chimica Acta*, *Analytical and Bioanalytical Chemistry*, *Journal of Liquid Chromatography and Related Technologies*, *LCGC Magazine*, and *Journal of Separation Science*.



Kevin D. Clark completed his BA degree in chemistry at Gustavus Adolphus College (Minnesota) in 2012. He is a PhD candidate in analytical chemistry at Iowa State University under the supervision of Professor Jared Anderson. His research focuses on selective nucleic acid analysis and the application of magnetic ionic liquids in bioanalytical chemistry.