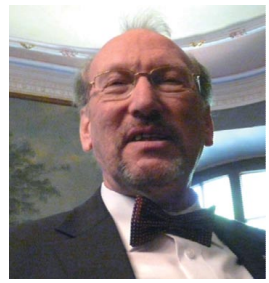
f-Element Chemistry



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Just like the mocking mystery of the Cathedral of Cologne in the morning mist of a later-on beautifully sunny day in December 2009, the rare-earth elements "perplex us in our researches, baffle us in our speculations, and haunt us in our very dreams. They stretch like an unknown sea before us – mocking, mystifying, and murmuring strange revelations and possibilities". This quote from Sir William Crookes dates back to 1887, roughly a century after the first rare earth was discovered in a quarry at Ytterby, a beautiful little town near Stockholm, Sweden. It took until 1949 to discover the last of the rare-earth elements, the radioactive promethium, and it needed Moseley's law and modern atom theory to make sure that group three of the periodic table of the elements contains four non-f elements (Sc, Y, La, Ac), fourteen 4f elements (lanthanoids, Ce–Lu) and fourteen 5f elements (actinoids, Th–Lr), a total wealth of 32 elements. Although thorium and uranium were known since 1828 and 1789, respectively, and were believed to belong to groups 4 and 6 in the early periodic tables, most of the actinides were produced and separated during or after the second World War as a result of the race for the atomic bomb.

Fascinating history

The rare-earth elements (Sc, Y, La, Ce–Lu) are by no means rare. Large deposits have been found in the earth's crust. A major challenge for almost 150 years was the separation of the elements as they all exhibit – in the oxidation state +3 – very similar chemistry. This is a consequence of the electronic configuration of the lanthanoids, $(Xe)6s^2 5d^1 4f^n$ (with $n = 1$ for cerium and 14 for lutetium), where the 4f electrons act more or less like core electrons and, thus, all the lanthanoids have three valence electrons. This general property is important for a great number of applications, for example in phosphors, magnets, and catalysts. Solid-state chemists and – especially in recent years – coordination chemists have also explored oxidation states lower (and higher) than +3. Although many salt-like and (half)metallic divalent halides and chalcogenides have been synthesized and characterized together with a plethora of cluster complexes with endohedral main-group and transition-metal atoms, the lower-valent chemistry of rare-earth elements still "murmurs strange revelations and possibilities", both in synthesis and physical/electronic structures. Actinide chemistry appears to be much less developed subject to its handicap of little (Th, U) and extreme radioactivity. This is unfortunate since the chemistry of the lanthanides and the actinides is by no means alike. Especially the first half of the actinoids behave like transition metals, as "d metals".

Different chemistry for lanthanides and actinides

There is one major conference covering more or less the 32 group 3 elements each year throughout the world, the (US) Rare Earth Research Conference, the (European) International Conference on f Elements (ICfE) and the (Australasian) International Conference on Rare Earth Development and Application (ICRE), held in this sequence. In 2009, the 7th ICfE (www.icfe.de) was held in late August in Cologne, Germany, sponsored by the University of Cologne, the European Rare Earth and Actinide Society (ERES), and the German Chemical Society (GDCh). It attracted almost 300 scientists from all continents; the scientific program consisted of 14 plenary and 63 session lectures as well as 148 poster presentations. *The* social highlight was a boat ride on the river Rhine on a beautifully sunny day, up the river to Bonn and back to Cologne, whilst enjoying the great panorama of the city at night, with live music (Nothing In Common) and the conference dinner. In the award session, the LeCoq de Boisbeaudran award was presented to Professor Claude Piguet (Genève) and the Terrae Rarae 2009 award to Professor Jean-Claude Bünzli (Lausanne). Both awardees have not only contributed oral presentations to ICfE-7, but also contribute to the present issue of EurJIC.

International conferences on the f elements

During a visit to Wiley-VCH in May 2009, Dr. Karen Hindson, Editor of this Journal, suggested that we assemble a cluster issue on f-element chemistry, associated with the Cologne meeting. We have tried to cover the whole tremendously broad field, both rare-earth and actinide element chemistry and physics, basic research (synthesis, structures, characterization) in all areas such as solid state and intermetallics, classical coordination chemistry in conventional and unconventional solvents as well as metallorganics and organometallics and, of course, more applied research, covering luminescence, magnetism, and catalysis in the wide size range from nanoparticles to large crystals.

My guest editorship of this cluster issue was an easy task. Almost all the work was done by the authors and by the reviewers, and I am grateful to all who have contributed. What is left for me is to be proud to be a member of a community of scientists who are dedicated to f-element chemistry and physics. I definitely hope that this issue will stimulate further excellent research in this area; let these elements haunt us in our very dreams.

The next occasions to present your research are the up-coming meeting this August in Beijing (6th ICRE), the 26th RERC in June 2011 in Santa Fe, New Mexico, and the 8th ICfE in Udine, Italy, in 2012.