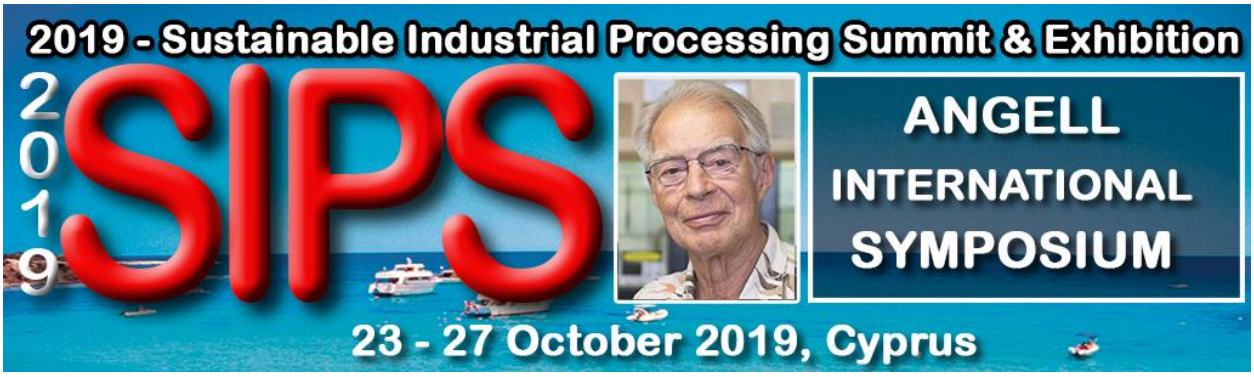

C. Austen Angell, Ph. D., D.I.C. Biography

Austen Angell was born in Canberra, Australia's capital city, first child of Herbert Raleigh and Kate Rosalind Angell. Canberra was very small, only 15,000 people, when he graduated from High School, so he went to Melbourne University for tertiary education. After B. Sc. and M. Sc. degrees, an opportunity to study high temperature molten salt Chemistry in the laboratory of John Bockris at the University of Pennsylvania arose, and was taken up. The intention was to return to Australia to write up the research for a Melbourne PhD. However, this plan was sidelined when a post-doc offer from London University's Imperial College, to work with Bockris' star student, John Tomlinson, came along. After 2.5 years working on diffusion and conductivity in metal-molten salt solutions, punctuated with a 6-month break driving a Volkswagen beetle across Africa from Liberia to Sudan and back to the UK via Egypt, Syria, Turkey and so on, he wrote a PhD thesis that was awarded the biennial Armstrong Medal for research at Imperial College.

He then returned to Australia, Melbourne University, as an instructor and started working on the glass-forming molten salts that he had heard mentioned at the first Faraday Discussion on Molten Salts which he attended (with advisor Tomlinson) immediately on return from the African adventure. He was lucky that mixed calcium nitrate-potassium nitrate melts supercool easily and formed beautiful glasses near the eutectic composition, and he was able to make diffusion and conductivity measurements on the supercooled liquid that showed the now-well-known curvilinear Arrhenius plots of most glass-formers. They were precisely fitted by the Cohen- Turnbull equation that had been "in the air" at the Faraday Discussion. These results were startling to the US molten salt community and his return to the US, as a post-doctoral fellow with Dieter Gruen, at Argonne National Laboratory, was soon followed with an invitation to present ideas on glass-formers at a Gordon Research Conference on Molten Salts (1967) - which was a great experience. These are the most scientifically profitable conferences of all, with their heavy emphasis on invited speakers and much discussion, public and private. With Dieter Gruen, he learned about transition metal spectroscopy and ionic solvent effects on cation coordination numbers, and enjoyed the color changes that accompany the increasing coordination numbers promoted by decreasing temperature approaching the glassy state. This experience proved invaluable in the later writing of Chapter 6 in a 1976 book entitled "Glass Structure by Spectroscopy", that was largely the work of star student and general spectroscopist (and first author) Joe Wong. It has been cited well over 1000x.

After Argonne, the possibility of a faculty position at Purdue University came up, and his application was successful. The appointment came at about the same time as Sputnik galvanized the US to the scientific challenge of the Soviet Union, and brought a flood of research money and talented students to the American scientific scene. With students like Joe Wong, Ed Sare, Joe Tucker, and Bob Bressel, Angell studied glass-forming aqueous solutions and came up against the anomalous and paradoxical behavior of pure water in its supercooled domain. This subject came alive when Robin Speedy arrived as a post-doc from New Zealand, and took on the measurement of the compressibility of supercooled water. He showed that this property increases according to a power law as water is supercooled (opposite of all other molecular liquids), and predicts a singularity at -45ºC. What can it mean? The scientific world is still debating the idea introduced by Poole, Sciortino and Stanley, in 1991, that there is a *second* liquid phase of water that becomes thermodynamically preferred at low temperatures for any pressure above a second critical point, the pressure of which is not too far from ambient so that the critical fluctuations can still dominate the behavior. Before this can be proven, the fast crystallization of water will have to be overcome. In the meantime, second liquid phases of less important liquids that do not crystallize so readily are starting to show up, and the subject is in an exciting stage of development with implications far beyond the purely academic interest driving their initial study. For instance, there is currently increasing evidence that the behavior of exotic Phase Change Materials (PCMs), that are finding application in durable, super-fast switching digital recording technology, is linked to liquid metal-to-semiconductor transitions that occur in the supercooled liquid, shortly below the melting point.

After some 20 years at Purdue studying molecular and ionic glass-formers, and battery electrolytes, (and popularizing the concept of liquid fragility), Angell moved to Arizona State University in the Phoenix valley where the Materials Chemistry interests run high. This is where Omar Yaghi and Michael O'Keeffe collaborated to establish the elegant science of the MOF crystalline materials that have become so popular in the past twenty-five years. Another science that has bloomed in the same time period, with the same exponential growth in publications, has been that of ambient temperature ionic liquids, based on combinations of large organic cations with smaller inorganic anions. This science had languished for decades but took off with the simultaneous publication, by Cooper, and Wilkes, and their respective coworkers, of air- and water-stable examples, mainly based on fluorinated anion components. These greatly expanded the synthetic applications of ionic liquids, as non toxic alternative solvents for chemical syntheses being pioneered by Seddon, Welton and Wasserschied. Angell's student, Douglas MacFarlane, is now a recognized world leader in this field, entirely on his own merits, however Angell's history in the area was honored with the introductory lecture for the first Faraday Discussion on Ionic Liquids held in Belfast in 2011. It was exactly 50 years since the first Faraday discussion on Molten Salts which planted the seeds of excitement in the mind of the eager young listener mentioned in the second paragraph of this piece. In this 50 year interval he has not only been a speaker at many more Gordon Conferences, but has been the elected Chairman, responsible for scientific

content, at three of them [Molten Salts and Metals (1977), Water and Aqueous solutions (1980), and Chemistry and Physics of Liquids (1997)].

After 30 years at ASU, and many technological Society recognitions [Morey (ACerS, 1991) Hildebrand (ACS, 2004), Turnbull (MRS 2005) and Bredig (ECS, 2010) awards, topped recently by the Otto Schott award for Applied glass Science, 2018], Angell is still active in research, working with a smaller but still innovative group who have just introduced a new solid state, single-ion-conducting lithium electrolyte, and a new criterion for assessing when effective proton transfer has been achieved in the formation of true (fully ionic) protic ionic liquids. His latest push is for ionic liquids of high deprotonating capacity, i.e., high basicity ionic liquids as opposed to the superacidic versions he had earlier described. The range of proton activities that should be available in ionic liquids is truly staggering, some 60 orders of magnitude in Angell's thinking.

He is truly grateful for a rich life in science, in its milieu of enthused, and pleasantly competitive, national and international colleagues. His ~540 publications have been influential if one can judge from his H index (average of Google scholar and web of Science values) of over 100. He has some 15 patent certificates hanging on the walls of his student office and quite a few others waiting for hang-space or in process. His efforts have been recognized by a special issue of J. Phys. Chem. in 1999, and honor symposia in 1998 (Pisa), 2008 (Vancouver), and 2014 (Bengaluru). He especially wishes, in his turn, to emphasize his good fortune in, and gratitude to, the many talented and indefatigable younger scientists with whom he has had the good fortune to work in his laboratory over the years.
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