“Glass is frozen beauty” - A Memorial Issue in Honor of C. Austen Angell (1933–2021)

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Published in:
Journal of Non-Crystalline Solids: X

Publication date:
2022

Document Version
Publisher's PDF, also known as Version of record

14 (2022) 100096

Contents lists available at ScienceDirect

Journal of Non-Crystalline Solids: X

journal homepage: www.sciencedirect.com/journal/journal-of-non-crystalline-solids-x

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This special issue is devoted to celebrating the scientific career of Charles Austen Angell who passed away March 12, 2021. In this issue, former students, post-docs and close collaborators of Austen have come together to commemorate his remarkable career with a collection of contributions spanning a stunningly broad range of topics in the physical chemistry of glasses and liquids that collectively reflect Austen's wide and deep contributions to so much of the literature of glasses and supercooled liquids. The number of articles and the breath of scientific themes addressed in this issue serve as a testament to the unparalleled impact Austen had on the scientific community over a career lasting more than 60 years.

His passion, curiosity and tireless enthusiasm for science were only matched by his remarkable ability to listen and engage with students and colleagues. As one of the most influential scientists in the fields of glass, water, molecular and ionic liquids, and batteries, Austen has mentored and inspired generations of researchers across the world. In his academic life, he worked tirelessly to establish the "big picture" of the nature of glass, glass forming liquids, and the glass transition and as evidenced in the many contributions within and beyond this volume, it must be readily agreed that he has achieved substantial progress. Indeed, contributions to this special issue originate from more than fifteen different countries including his homeland Australia.

Austen had a unique talent for bridging multiple fields of science and engineering and for connecting communities for the benefit of scientific advancement and discovery. He was widely recognized for his aptitude at explaining deep concepts and bringing innovative viewpoints to solve issues across disciplines. His seminal contributions have made lasting impact and refashioned many of these fields for years to come. The breadth of his scientific contributions is exemplified by the five broad topical areas covered in this special issue:

- Liquid fragility and liquid dynamics
- Amorphous water and liquid anomalies
- Ionic liquids, electrolytes and applications in energy
- Glass transition and relaxation
- Structure of glasses and liquids

The first topical area is liquid fragility and liquid dynamics. The concept of liquid "fragility" that is so simply and clearly illustrated in the "Angell plot" is likely Austen's most impactful achievement, transcending the fields of physics, chemistry, biophysics, physical chemistry, material sciences among many others. His visionary idea of comparing all glass-forming liquids on a single T_g-scaled master-plot and to characterize them by their approach to T_g is now a staple of glass science with deep-reaching implications in industrial glass manufacturing and continues to be an extensive source of scientific challenges for academic research. In this issue, the concept of fragility is approached and reviewed from several perspectives such as structural considerations, energy landscape features or modeling of binary mixtures.

The second topical area is amorphous water and liquid anomalies. The physics of amorphous and liquid water – the most anomalous liquid – has been the source of enduring scientific controversies for many decades, to which Austen brought much clarity throughout his career. Thanks to his many contributions, the thermodynamic anomalies exhibited by super-cooled water are now broadly associated with a liquid-liquid phase transition obscured by fast crystallization. This transition is further associated with the observation of polyamorphism in glassy water as well as other anomalous substances such as phase change materials. In this issue, the liquid-liquid phase transitions in water are investigated through modeling, structural ordering considerations, extension to aqueous solutions and analogy to phase change materials. The properties of supercooled water are also investigated including its decompression dynamics and its controversial glass transition temperature.

The third topical area is ionic liquids, electrolytes and applications in energy. The properties of ionic liquids have been a major center of interest since very early in Austen's career. Through his work with John Bockris at the University of Pennsylvania followed by his PhD thesis with John Tomlinson at Imperial College to his seminal work on battery and fuel cell electrolytes, Austen made fundamental contributions to the field that remain today as guiding principles to current research in solid electrolytes. These advances have deep practical importance in a world where energy conversion is rapidly transitioning towards electrified and carbon-neutral technologies. In this issue, ionic transport in glasses, polymers, plastic crystals and solvents is investigated and reviewed for battery and fuel cell applications. Ionic liquids are also investigated as another form of energy storage through phase change materials.

The fourth topical area is the glass transition and relaxation. Austen was undoubtedly one of the most prolific and influential glass scientists of his generation. His seminal paper "Formation of Glasses from Liquids and Biopolymer(s)" has been cited more than 5000 times. He became "hooked on glass-formers" through the study of simple mixtures of calcium and potassium nitrates that readily vitrify, but went on to investigate all types of glasses. He made fundamental contributions to each field including metallic glasses, oxide glasses, covalent network glasses, molecular glasses, polymers and biopolymers and metal oxide framework glasses. In this issue, the theory of glass formation is investigated through elastic models, and glassy relaxation is investigated through hyperquenching-annealing-calorimetry, concentration fluctuations, surface diffusion and molecular reorientation.

https://doi.org/10.1016/j.nocx.2022.100096

Available online 13 April 2022

The fifth topical area is the structure of glasses and liquids. Structure-property relationships is one of the main tenets of material science and Austen provided one of the most extensive accounts of glass structures in his monograph with Joe Wong "Glass Structure by Spectroscopy". One of his main quests was to identify a structural origin to fragility. To this end, Austen applied many techniques from neutron diffraction to nuclear magnetic resonance to the study of glass structures. In this issue, the structure factor of binary mixture is investigated in the context of liquid-liquid phase transitions; the structure of aluminosilicates is investigated by Brillouin spectroscopy, the local structure of water is investigated by X-ray spectroscopy and the structural properties of liquid crystals is studied by modeling.

Overall, this collection of articles exemplifies Austen's unbounded and expansive enthusiasm for scientific research and its far-reaching impact on the past, present and future of liquid and glass science. While Austen clearly put his intellectual mark on all these diverse fields of study and infused them with his wisdom, he did much more: as evidenced by the creative outpouring in these articles, he inspired generations of scientists to join him in his quest. We wish to thank all the authors of these outstanding contributions who made this special issue a wonderful tribute to Austen.

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