MS14-2-9 Crystallographic studies of the magnesium nitrate salt-hydrate eutectic system
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Abstract
The advent of large-scale renewable energy sources has led to a growing requirement for energy-storage technologies whereby energy is stored at times of high production and low demand[1]. An important technology is thermal energy storage as 42% of the UK's energy demand is associated with heating and cooling. Phase-change materials (PCMs) enable the storage of thermal energy due to the material's high latent heat of fusion. A material of particular interest for PCM applications is magnesium nitrate. While it has been studied extensively for this purpose in the hexahydrate form[2], the low temperature eutectic composition has a melting temperature of approximately -31.5 °C [3], which is suitable for refrigeration applications. Such hydrates provide high cooling capacity at a composition for which the components crystallise at the temperature corresponding to the lowest melting point of the system. However, these PCMs suffer from several issues that must be overcome before integrating into cooling systems. Salt-hydrate eutectic systems frequently sub-cool[4] – a phenomenon whereby a material cools below its freezing point without crystallisation occurring.
Using the technique of 3-layer calorimetry, we have observed separate crystallisation events for each component (salt-hydrate and ice), suggesting that the phases sub-cool independently to different temperatures despite being at the eutectic composition. Using powder X-ray diffraction (PXRD) the low-temperature hydrate composition (suspected to be the nonahydrate) of the system has been studied, to gain structural and phase evolution information. Furthermore, a metastable magnesium nitrate hydrate (suspected to be the tetrahydrate) has also been studied. By solving the crystal structure of these low-temperature hydrates, we can begin to identify ways of eliminating the issue of sub-cooling through the use of heterogeneous nucleating agents. This will enable us to use these PCMs in energy-storage applications.

References
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