Quantised Charging of Metal Clusters in an Ionic Liquid

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Quantised charging of nanometre-sized metal particles has been the focus of intense research over the past decade, as efficient synthetic routes have become increasingly available. The most prominent place is occupied by so-called monolayer protected clusters (MPCs), as they are sufficiently robust to be purified to the narrow size dispersion required to resolve individual charge states. As ionic liquids hold great promise also for technological applications, we discuss under which conditions quantised charging of metal clusters can be observed in this unconventional medium.

Next, we demonstrate that depending on the composition of the ionic liquid, the dynamics of the charging process may differ over more than an order of magnitude. In particular, it is shown that the ionic liquid behaviour is not a linear combination of its composing ions’ properties, but is dominated by specific interactions.

Finally, we present first-time evidence that also ligand-free metal clusters can be brought to display quantised charging. This is also the first report of quantised charging for particles dispersed in an ionic liquid, as previous work has been concerned with particle films.

The ca. 1.1-nm diameter Au clusters were generated directly in the ionic liquid 1-butyl-3-methylimidazolium tetrafluoroborate (BMImBF$_4$) by thermal decomposition of KAuCl$_4$. Experimental observations are discussed, and density functional theory (DFT) calculations are employed to relate the behaviour to the structure of the ionic liquid surrounding the clusters (see Figure).