Molecular Maracas: Investigating the potential of Li@C₆₀ as a multi-state molecular switch

Henry J. Chandler¹, S. Abass Nanoh¹, Minas Stefanou², Eleanor E. B. Campbell², Renald Schaub¹

¹University of St Andrews, School of Chemistry, North Haugh, St Andrews, KY16 9ST, UK
²The University of Edinburgh, School of Chemistry, David Brewster Road, Edinburgh, EH9 3FJ, UK

hjc6@st-andrews.ac.uk

A potential end-point in the miniaturization of electronic devices lies in the field of molecular electronics, where molecules perform the function of single components like transistors [1] and switches [2]. This idea has been around for decades [3] but recent years have shown real progress in the field. A molecular switch is defined as a molecule that displays stability in two or more states (e.g. “on” and “off” involving conductance, conformation etc.) and upon application of a field, electric or otherwise, undergoes a reversible change such that the molecule is altered. Previous work has shown electric field induced multi-state molecular switches with up to four distinct states [4]. Here we report on a novel system using lithium endohedral fullerenes (Li@C₆₀) that has the potential to display up to twenty.

By using an ultra-high vacuum, low temperature scanning tunnelling microscope (UHV LT-STM) to apply an electric field to single molecules, we are able to randomly switch selected fullerenes into fourteen of these twenty available states. These states identify the position of the Li⁺ around the inside surface of the C₆₀ cage, since they preferentially stabilise closer to the hexagonal faces. Each state can then be analysed and discriminated between using a mixture of constant current scanning tunnelling microscopy (cc-STM) and dz/dV scanning tunnelling spectroscopy (STS).

Figure 1; cc-STM scan parameters; -2.5 V, 0.1 nA, a-e) cc-STM images illustrating 5 of the distinct electronic levels of the Li@C₆₀ switch, f) cc-STM image after the ejection of a Li⁺ ion from the fullerene, g-l) graphs showing the dz/dV spectra for the corresponding STM images, the spectrum in l is identical to that of a C₆₀. This is proof that the fullerene exhibited in a and g is now empty, m-s) ball and stick models of the corresponding states of the Li@C₆₀ when adsorbed to the Au(111) surface as illustrated.

References: