

## Sir Harold Kroto, - From astrophysics, cluster science to nanotechnology

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The 1996 Nobel Prize in Chemistry was awarded Robert F. Curl, Harold W. Kroto and Richard E. Smalley for “The discovery of carbon atoms bound in the form of a ball” [1] today known as Carbon-60 (Fullerene-  $C_{60}$ ), the “buckyball” or Buckminsterfullerene [2]. Initial evidence for their conclusion was based on experiments spanning eleven days in September 1985, working on the evaporation of graphite by laser irradiation in a helium nozzle, followed by expansion into vacuum and detection of carbon clusters by photo-ionization time-of-flight mass spectrometer [2]. The recorded spectrum was dominated by a peak for 60 carbon atoms. Before 1985 it was generally accepted that elemental carbon existed in only two ordered forms, (allotropes): diamond and graphite. Kroto had in earlier experiments synthesized long carbon chains as  $HC_7N$  in the laboratory, to investigate their microwave (rotational) spectra, and also detected such species from red giant stars using radio astronomy [3]. The goal with the new experiment was to generate even longer chains using the laser-ablation nozzle technique. The ingenious hypothesis was that the 60-carbon cluster was built up as a cage that had a truncated icosahedral form, wherein carbon atoms occupied each of 60 vertices. This form comprises 32 faces, 12 of which were pentagons and 20 hexagons. Kroto et al. [2] soon realized that such a  $C_{60}$  molecule had been proposed by Osawa in 1970 [4]. Kroto further established that the `fullerene hypothesis` could account for the main series of magic numbers in carbon-cluster distributions [5]. For examples of further experiments see Ref 1. Already from 1982 Krätschmer and Huffman had independently used an electric carbon arc technique to produce soot with the hope to explain the rather intense stellar absorption at 217 nm. The soot had been characterized using IR and UV spectroscopy [6] and also dissolved in benzene with a reddish colour with more resolved spectra and further crystallized and characterized by X-ray diffraction [7]. The first public announcement of this result, confirming the `fullerene hypothesis` occurred, during the ISSPIC-5 meeting in Konstanz, Sept 10-14, 1990 [8]. For an overview see also Ref 9.

The original discovery of  $C_{60}$  from a fundamental research strategy in astrophysics and spectroscopy had suddenly given the basis for a new field in Nanoscience and Nanotechnology. The  $C_{60}$  story with its soccer-ball structure became very popular from the entertaining lectures given by Kroto [10]. A generation of students has since been raised on the iconic structure-images of the  $C_{60}$  cluster-molecule.

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