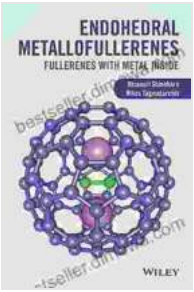
Endohedral Metallofullerenes: Fullerenes With Metal Inside

The world of fullerenes, also known as buckyballs, took a captivating turn with the discovery of endohedral metallofullerenes. These remarkable structures are formed when metal atoms are encapsulated within the hollow interiors of fullerene cages. This unique combination of carbon and metal has opened up a realm of novel materials with extraordinary properties and promising applications.

Structure and Bonding

Endohedral metallofullerenes consist of a metal atom or cluster nestled inside a fullerene cage. The fullerene cage is composed of carbon atoms arranged in a spherical or ellipsoidal shape, forming a hollow cavity. The metal atom or cluster is trapped within this cavity, stabilized by electrostatic interactions between the metal and the inner surface of the cage.



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4 out of 5

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Enhanced typesetting	: Enabled
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The bonding between the metal and the fullerene cage is complex and can vary depending on the size and type of metal atom or cluster. In some cases, the metal atom forms covalent bonds with the carbon atoms of the cage, while in other cases, the interaction is more ionic in nature.

Unique Properties

Endohedral metallofullerenes possess a unique set of properties that distinguish them from both pure fullerenes and metal clusters. These properties arise from the synergistic combination of the metal atom or cluster with the fullerene cage.

- **Enhanced Stability:** The encapsulation of metal atoms within the fullerene cage provides enhanced stability compared to free metal clusters or isolated fullerenes. This stability is attributed to the protective environment provided by the fullerene cage, which shields the metal atom or cluster from external influences.
- **Tunable Electronic Properties:** The presence of metal atoms or clusters inside the fullerene cage alters the electronic properties of the material. By varying the type and number of metal atoms, the electronic bandgap, conductivity, and other electronic properties can be tailored for specific applications.
- **Magnetic Properties:** Endohedral metallofullerenes containing magnetic metal atoms or clusters exhibit interesting magnetic properties. The interaction between the metal atom or cluster and the fullerene cage can lead to ferromagnetism, antiferromagnetism, or even superparamagnetism.
- **Optical Properties:** The incorporation of metal atoms or clusters can modify the optical properties of endohedral metallofullerenes. These

materials often exhibit unique absorption and emission spectra, making them promising candidates for optoelectronic applications.

Synthesis and Characterization

Endohedral metallofullerenes are typically synthesized using methods that involve the encapsulation of metal atoms or clusters within preformed fullerene cages. One common approach is the Krätschmer-Huffman method, where a carbon arc is generated in the presence of metal-containing precursors. The high temperatures and reducing atmosphere promote the formation of endohedral metallofullerenes.

Characterizing endohedral metallofullerenes requires specialized techniques to identify and quantify the encapsulated metal atoms or clusters. Mass spectrometry, X-ray crystallography, and nuclear magnetic resonance (NMR) spectroscopy are commonly used for this purpose.

Applications

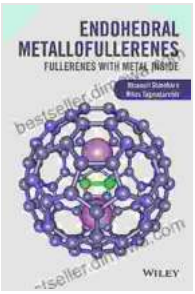
The unique properties of endohedral metallofullerenes have sparked interest in various fields, including materials science, chemistry, and physics. Some potential applications include:

- **Catalysis:** Endohedral metallofullerenes have shown promise as catalysts for a range of chemical reactions. Their unique electronic and structural properties make them efficient and selective catalysts for various organic and inorganic reactions.
- **Energy Storage:** The ability to tune the electronic properties of endohedral metallofullerenes makes them promising candidates for

energy storage applications. They have been explored for use in batteries, supercapacitors, and fuel cells.

- **Biomedicine:** Endohedral metallofullerenes have shown potential in biomedical applications, such as drug delivery and imaging. Their ability to encapsulate and protect drugs or imaging agents makes them attractive therapeutic and diagnostic tools.
- **Electronics:** The tunable electronic properties of endohedral metallofullerenes make them promising materials for electronic applications. They have been explored for use in transistors, sensors, and optoelectronic devices.

Endohedral metallofullerenes represent a fascinating class of materials that combine the unique properties of fullerenes with the versatility of metal atoms or clusters. Their enhanced stability, tunable electronic properties, and potential applications in various fields make them an exciting area of research and development. As research continues, we can expect to uncover even more remarkable properties and applications of these intriguing materials.



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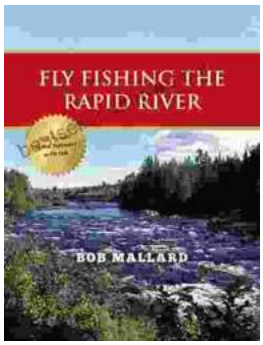

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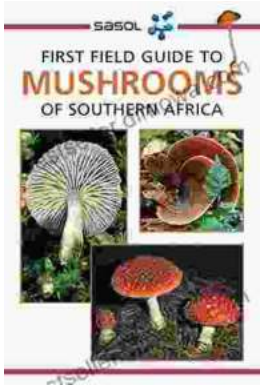

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