

ELECTRONIC AND BIOLOGICAL BEHAVIOR OF FULLERENE-DERIVED STARBURST CONJUGATED MACROMOLECULES

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Application of photodynamic therapy (PDT) for tumor destruction has been studied extensively as an alternative approach to radio- and chemotherapy against malignant cells. The most commonly used sensitizers for clinical PDT practices are Photofrin II, an enriched active fraction of hematoporphyrin derivatives, and disulfonated aluminum phthalocyanine (AlPcS₂). Photoactivation of hematoporphyrin leads to the formation of singlet oxygen and the cell cytotoxicity. Involvement of superoxide radicals in the cell cytotoxicity was also indicated other than singlet oxygen. Photogenerated triplet C₆₀ intermediate is involved in the energy transfer process that converts the ground-state triplet oxygen molecules into the excited molecular singlet oxygen ¹O₂. This type of activated photosensitizers often induce severe oxidative damage to the structure of lipids, proteins, and nucleic acids, which are associated as major components of subcellular plasma membrane, mitochondria, cytoplasmic organelles, lysosomes, enzymes, and DNA. Therefore, structural decomposition and rapid deterioration of biological functions lead to vascular disruption of the cell and direct tumor cell death.

Molecular C₆₀ and its derivatives are electronegative compounds. Direct chemical bonding of an electron-donating conjugated organic molecule on the fullerene cage forms a molecular charge-transfer complex, when activated, with A–D array. Application of multiple conjugate donors bound on one C₆₀ molecule leads to a starburst complex with an A–(D)_n coordination. These hyperstructures may exhibit improved inter- and intramolecular solid-state properties and be useful as electroactive and photoactive starburst macromolecular materials. Photoinduced intramolecular electron-transfer from electron-donating arms of these starburst molecules to the central C₆₀ core was found to be highly efficient upon irradiation. The resulting structural interconversion can be followed by change of the optical absorption of the products. Utilization of unique electronic phenomena on these photoexcitable fullerene-based macromolecules in the generation of reactive oxygen species (ROS) under physiological conditions allows their potential biomedical application as potent photodynamic therapeutic agents.