Biological Activity of C60,70 Fullerenols

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Contributor: Ekaterina Sushko

The simplest bioassay based on a bioluminescent system of coupled enzyme reactions was used to study toxic and antioxidant effects of a water-soluble fullerene derivative, fullerenol, with 10-12 oxygen groups (F10-12) at the enzymatic level. Toxic and antioxidant characteristics of F10-12 were compared to those of homologous fullerenols with a higher number of oxygen groups: F24-28 and F40-42. An active role of reactive oxygen species (ROS) in the bioeffects of F10-12 was demonstrated.

fullerenol toxicity antioxidant activity reactive oxygen species bioluminescent assay

1. Introduction

Fullerene is a nanosized carbon structure with potential drug delivery applications. The simplest bioassay based on a bioluminescent system of coupled enzyme reactions was used to study toxic and antioxidant effects of a water-soluble fullerene derivative, fullerenol, with 10-12 oxygen groups (F10-12) at the enzymatic level. It should be noted that the entry aimed to elucidate the physicochemical processes underlying the toxic and antioxidant effects of F10-12.

2. Current Insights

F10-12 suppresses bioluminescence of the enzymatic assay at concentrations >0.002 gL-1. This suppression is associated with inhibition of chemical and biochemical processes by nano-compounds, being a characteristics of the fullerenol toxicity. Antioxidant characteristics of F10-12 were revealed in model solutions of organic and inorganic oxidizers, which suppressed bioluminescence intensity by 50%. Bioluminescence activation was considered as fullerenol' antioxidant effect, it was observed in these solutions under the low-concentration exposure to F10-12 (<0.002 gL-1) and was validated statistically, thus confirming ability of fullerenols to mitigate toxic effects of oxidizers.

Comparison of the toxic and antioxidant characteristics of F10-12 to those of homologous fullerenols with a higher number of oxygen groups (F24-28 and F40-42) on the fullerene’s carbon cage did not reveal a simple dependency on the number of oxygen groups: fullerenol F24-28 demonstrated lowest toxicity and highest antioxidant activity. It is likely that the higher efficiency of the fullerenol–solvent interactions of F24-28 and its related solubility in water affects the properties of F10-12. This result contributes to the predictive criteria for the selection of fullerene derivatives of optimal reactivity, which is highly important for biomedical applications.

Reactive oxygen species (ROS) were considered as active particles responsible for inhibiting (toxic) and activating (antioxidant) effects in the bioassay system. An active role of ROS in the bioeffects of F10-12 was demonstrated. Toxic and antioxidant effects of F10-12 were related to the ROS content in the enzyme solutions. Correlations between toxic/antioxidant characteristics of F10-12 and ROS content were evaluated. We found that both types of effects are concerned with a decrease in ROS content under the addition of the fullerenol: noticeable ROS decay results in the toxic effect, i.e. bioluminescence inhibition, while slight ROS decay in the solutions of the model oxidizer mitigates the toxic oxidizer's effect making the bioluminescent intensity closer to control and, hence, revealing an antioxidant property of the fullerenol. Preliminary we demonstrated an increase in ROS content in water solutions at oxidizer addition, with 1,4-benzoquinone taken as an example.

We should emphasize that both the lack and an excess of ROS can produce an analogous deleterious effect. The results reveal a complexity of ROS effects in the enzymatic assay system.