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Bioactivities and Animal Clinical Studies of Fat-Soluble Carbon-60: A Minireview

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ABSTRACT

Carbon-60 (fullerene) is a football-shaped carbon compound composed of 60 carbons with a molecular weight of 720. The discovery of carbon-60 earned three scientists the 1996 Nobel Prize in Chemistry. Carbon-60 is an inorganic form of carbon. While most inorganic carbons are typically biologically inert, Carbon-60 stands out due to its existence as distinct molecules rather than extended arrays of atoms. Owing to its antioxidant properties, carbon-60 has found application in cosmetology and dermatology. However, its low solubility in water (<10−11 g·l−1) has limited its study and medical application. Therefore, concerns have arisen regarding the dispersion of fat-soluble carbon-60 in aqueous solutions or human body fluids. Our research demonstrated that carbon-60 oil exhibits a more potent antioxidant effect compared to water-soluble vitamin C in aqueous solutions, whereas fat-soluble vitamin E shows no antioxidant effects in such solutions. In vitro studies involving cellular and animal models have suggested that carbon-60 oil effectively inhibits the pro-inflammatory actions of human neutrophils in cell culture media and reduces level of inflammatory marker of C-reactive protein in the blood of beagle dogs. C-reactive protein in the blood mainly serves as a marker for cardiovascular and cerebrovascular inflammation, possibly promoting such inflammation. Some research indicates that oral administration of carbon-60 oil to mice extends their lifespan and effectively treats colitis. In summary, this review discusses, in the context of carbon-60, recent advancements in antioxidant activity, skin inflammation, colitis treatment and potential use for treatment of C-reactive protein related diseases. This review is essential for understanding the future potential of carbon-60 as an oral drug for treating colitis and cardiovascular and cerebrovascular inflammatory diseases.

Keywords: Carbon-60 Oil; Fullerene; Fat Solubility; Lifespan; Drug Delivery; Antioxidant; Anti-Inflammation; Colitis; C-Reactive Protein; Cardiovascular and Cerebrovascular Diseases

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Carbon, with the chemical symbol C and atomic number 6, is classified within group 14 of the periodic table [1]. Carbon atoms exhibit diverse bonding capabilities, resulting in the formation of various carbon allotropes. Well-known allotropes include graphite, diamond, amorphous carbon, and fullerenes. Carbon-60 (C-60), also called fullerene, comprises 60 carbon atoms arranged in a football-shaped structure, with a molecular weight of 720 (https://en.wikipedia.org/wiki/Buckminsterfullerene). In 1996, three scientists were awarded the Nobel Prize in Chemistry for their pioneering discovery of C-60 [2-4](https://www.sesres.com/unlocking-the-mysteries-of-carbon-60-discovery-and-implications/). C-60 is an inorganic form of carbon. However, inorganic forms of carbon exhibit limited biological activity and minimal clinical applications in humans. Research has shown the therapeutic potential of liposoluble C-60 in addressing inflammatory skin diseases, cancers, and intestinal diseases owing to its robust antioxidant properties [5]. C-60 holds promise for applications in the fields of cosmetics, medical devices, and medicine [6,7]. In 1992, the Journal of the American Chemical Society highlighted the

potent free radical scavenging abilities of C-60 fullerene and first introduced the concept of the "free radical sponge." Studies and recent patents have demonstrated the robust scavenging ability of fullerene against reactive oxygen species and its remarkable potential as a biological antioxidant, advocating its utilization as an active ingredient in the preparation of cosmetic formulations [8].

Therefore, given its vital effects on skin health, hair follicle growth, and anti-aging, markets in Japan, United States, and China have incorporated C-60 into cosmetic formulations to treat, prevent, and protect against skin damage [9-14]. Our previous patent application showed the efficacy of fat-soluble C-60 oil in alleviating itching caused by mosquito bites [15,16], suggesting its ability to effectively penetrate human skin. Previous study also suggest C-60 as a viable alternative for the treatment of allergic and inflammatory conditions [17]. Our previous study demonstrated the efficacy of orally administered fat-soluble C-60 oil in treating colitis in mice [18]. Relevant patents and additional studies have further supported the role of fat-soluble C-60 oil in colitis treatment in mice [19-22]. Fat-soluble C-60 is insoluble in water but soluble in edible oil at concentrations ranging from 1–4 g/L. Various studies have underscored the antioxidant and anti-inflammatory properties of fat-soluble C-60 [23-28]. Investigating the transmission pathways of fat-soluble C-60 in aqueous solutions or human bodily fluids constitutes an intriguing research avenue [29-36]. Our previous study elucidated that fat-soluble C-60 oil disperses in aqueous solutions, producing a potent antioxidant effect [5]. Fat-soluble C-60 oil exerts a more robust antioxidant effect compared to vitamin C in aqueous environments [5]. Similarly, even a small volume of fat-soluble C-60 oil effectively inhibits the proinflammatory effects of human neutrophils in cell culture media [5]. Conversely, fat-soluble vitamin E fails to produce antioxidant effects in aqueous solutions. These studies were the first to propose the hypothesis that fat-soluble C-60 could disperse in aqueous solutions or human bodily fluids [5].

Researchers at the Chinese Academy of Sciences discovered the efficacy of fat-soluble C-60 in treating central nervous system diseases [37], suggesting its direct entry into the central nervous system [5] and subsequent anti-inflammatory effects [37]. French scientists conducted related research, wherein they orally administered C-60 oil to mice once a week, thereby almost doubling their lifespan [38]. Our previous research yielded notable findings: oral administration of fat-soluble C-60 oil significantly reduces the levels of the inflammatory marker C-reactive protein in the blood of beagle dogs [5], suggesting its entry into tissues and organs, thereby producing anti-inflammatory effects. C-reactive protein in the blood serves as a marker for cardiovascular and cerebrovascular inflammation and may promote such conditions [39]. These findings collectively suggest that oral administration of fat-soluble C-60 oil may offer therapeutic or preventive benefits for cardiovascular and cerebrovascular inflammatory diseases [5,39-41]. In summary, orally administered fat-soluble C-60 enters tissues and cells in the body, thereby lowering the inflammatory marker C-reactive protein levels and treating inflammatory diseases in humans. It is expected to serve as a therapeutic agent for skin inflammation, colitis, cardiovascular and cerebrovascular inflammation, as well as central nervous system inflammation. C-60 demonstrates potential as a versatile anti-inflammatory drug for managing systemic inflammatory diseases.

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