

Quinone-Based Compounds in Drug Discovery

Trends and Applications

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Quinones as antioxidants

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5.1 Introduction

Free radicals can be produced through normal cellular metabolism or by exposure to environmental factors. This damage can result in oxidative stress and can lead to endothelial dysfunction, lipid peroxidation, and inflammation, ultimately leading to the formation of atherosclerotic plaques (Madamanchi et al., 2005). Additionally, oxidative stress can impair the function of cardiac mitochondria and compromise myocardial contractility (Lesnefsky et al., 2001).

Oxidative stress has a dual role in cancer development. Normal cellular processes involve moderate levels of ROS, but excess production of ROS can cause DNA damage, genomic instability, and mutations that contribute to tumorigenesis (Trachootham et al., 2009). Moreover, oxidative stress can activate signaling pathways involved in cancer cell proliferation, angiogenesis, and metastasis (Gorrini et al., 2013). There have been numerous research studies that have emphasized the connection between oxidative stress and different types of cancers, including lung cancer (Hussain et al., 2013), breast cancer (Valko et al., 2006), and colorectal cancer (Grivennikova et al., 2008). In Alzheimer's, it contributes to the buildup of amyloid-beta plaques and neurofibrillary tangles, leading to neuronal dysfunction and death (Butterfield and Halliwell, 2019). In PD, oxidative stress-induced damage to dopaminergic neurons in the substantia nigra is a major factor in disease progression (Dias et al., 2013). Antioxidant therapies have shown potential in mitigating oxidative damage and slowing the progression of these diseases (Przedborski et al., 2003). Inflammatory pathways can be stimulated and tissue damage can occur due to oxidative stress, which generates reactive nitrogen species (RNS) and reactive oxygen species (ROS) and produces inflammatory cytokines. Numerous studies have found that patients with RA, IBD, and asthma exhibit heightened markers of oxidative stress.

Quinones are present in numerous natural sources such as plants, fungi, and bacteria. Quinones are naturally produced by the body during metabolism, and they possess a broad range of biological functions, such as antioxidant, antimicrobial, and anti-inflammatory properties. These compounds act as antioxidants, safeguarding cells against harm caused by free radicals. They also have antimicrobial properties and can kill or slow down the growth of microorganisms. Furthermore, they have anti-inflammatory properties that can help reduce inflammation. Quinones have numerous applications in various industries. They are used as antioxidants in food and cosmetics, as well as antimicrobial agents in wound care products. Researchers are also studying quinones for their potential use in treating cancer and other illnesses ("The biological activities of quinones," 2008).

5.1.1 Basic chemistry of quinones

Quinones are cyclic compounds with two carbonyl groups (C=O) that are separated by a carbon-carbon double bond (C=C). The carbonyl groups are conjugated, which means that they are all linked together by alternating single and double bonds. This conjugation gives quinones their characteristic properties. Quinones are typically yellow or orange. They are also soluble in organic solvents, but insoluble in water (Quinone-Wikipedia, 2023).

There are three main subclasses of quinones namely benzoquinones, naphthoquinones, and anthraquinones containing 1, 2, and 3 ring structures respectively (Quinones, 2015).

5.1.2 Benzoquinones

These are the most common type of quinones. They have a benzene ring with two carbonyl groups attached. The chemical formula for benzoquinone is $C_6H_4O_2$ (Fig. 5.1). The nucleus is a benzene ring, and the structure is a cyclic dione with two carbonyl groups.

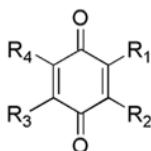


FIG. 5.1 Benzoquinone.