

Photoinduced reaction of excited triplet 9,10-anthraquinone quenched by antioxidant vitamin C

Sha Chen, Xian-Jun Cao, Yi Luo, Guang-Lai Zhu, and Xin-Sheng Xu*

Institute of Atomic and Molecular Physics, Anhui Normal University, Wuhu 241000, China

Received 18 March 2014; Accepted (in revised version) 17 June 2014

Published Online 8 August 2014

Abstract. The quenching of the photoinduced excited triplet of 9,10-anthraquinone ($^3\text{AQ}^*$) by Vitamin C (VC) has been studied in ethylene glycol-water (EG- H_2O , EG/ H_2O =9/1, v/v) homogeneous by using time-resolved electronic paramagnetic resonance (TR-EPR) and laser flash photolysis techniques. According to the chemically induced dynamic electron polarization (CIDEP) and transient absorptive spectra, the reaction intermediates and the reaction mechanism have been analyzed. The rate constant for the quenching of excited triplet $^3\text{AQ}^*$ by VC has been measured. The results indicate that $^3\text{AQ}^*$ can capture hydrogen atom not only from ethylene glycol molecule but also from VC. The strong CIDEP signal of VC monoanion radical indicates that the quenching of VC to $^3\text{AQ}^*$ is obvious. The rate for the quenching of $^3\text{AQ}^*$ by VC is nearly diffusion-controlled.

PACS: 76.30. -V, 82.20.-W

Key words: 9,10-anthraquinone, Vitamin C, time-resolved electron paramagnetic resonance (TR-EPR), transient absorptive spectrum, chemically induced dynamic electron polarization (CIDEP)

1 Introduction

Biologic quinones such as 1,4-benzoquinone (PBQ), duroquinone (DQ), 1,4-naphthoquinone (NQ) are widely distributed in biological systems and play important physiological roles as redox carrier in processes such as photosynthesis, oxidative phosphorylation and mitochondrial electron transport [1,2]. However, these biologic quinones are photosensitive. The excited triplet quinones produced by UV light irradiation may produce serious damage to biological tissues in the skins of human. On the one hand, the excited triplet quinones may abstract hydrogen atom from protein, nucleic acid and lipid components

*Corresponding author. *Email address:* xxsheng@mail.ahnu.edu.cn (X. S. Xu)

of cells directly [3]. On the other hand, the excited triplet quinones may oxidate nucleic acid and lipid components of cells by sensitizing ground state oxygen $^3\text{O}_2$ to yield highly oxidative singlet oxygen $^1\text{O}_2$ indirectly [4,5]. Just for these reasons, the photoinduced reaction of the excited triplet biological quinones quenched by antioxidant have been paid much interest in recent years.

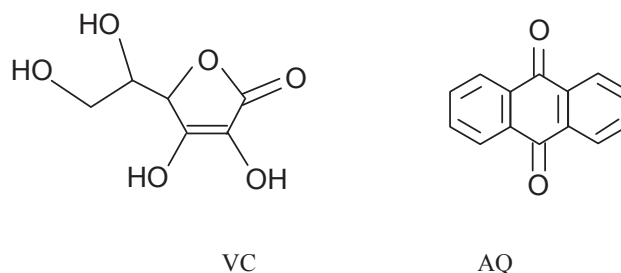


Figure 1: Molecular structures of VC, AsH^- and AQ.

Vitamin C (VC, ascorbic acid, AsH_2 , Fig. 1) is one kind of naturally available biological antioxidants contained in vegetables and fruits. There have many reports that VC functions synergistically with Vitamin E (α , β , γ and δ -Tocopherols, TocH) in the biological antioxidation protection process by reducing tocopheroxyl radical Toc^\bullet and to reproduce TocH in vivo [6-9]. However, the direct reactions of the excited triplet $^3\text{DQ}^*$ and ectogenic 9,10-anthraquinone ($^3\text{AQ}^*$) and quenched by VC have also been reported [10,11].

9,10-anthraquinone (AQ, Fig. 1) is one classical quinone molecule with three benzene ring. Many important drugs which collectively called anthracenediones include 9,10-anthraquinone derivatives. Photoinduced excited triplet 9,10-anthraquinone ($^3\text{AQ}^*$) may capture electron from electron donor such as triethylamine to produce 9,10-anthraquinone anion radical $\text{AQ}^{\bullet-}$ and triethylamine cation [12]. Excited triplet $^3\text{AQ}^*$ also can abstract hydrogen atom from hydrogen donor such as ethylene glycol (EG) to produce neutral 9,10-anthraquinone radical AQH^\bullet and ethylene glycol ketyl radical [13]. In addition, stable radical 2,2,6,6-tetramethylpiperidoxyl (TEMPO) is also an effective quencher of photoinduced $^3\text{AQ}^*$ [14]. However, the photoinduced reaction of antioxidant VC to quench $^3\text{AQ}^*$ have not been reported up to now.

Time-resolved electron paramagnetic resonance (TR-EPR) and transient absorptive spectrum techniques are both powerful tools for detecting and identifying short-lived intermediate radicals directly in photophysical and photochemical reactions. The chemically induced dynamic electron polarization (CIDEP) signal observed by TR-EPR and transient absorptive spectrum observed by laser flash photolysis can provide significant information about photochemical reaction mechanisms and reaction dynamics. In the present work, we will report the photoinduced reaction mechanism and reaction dynamics for $^3\text{AQ}^*$ quenched by antioxidant VC in EG homogeneous solution by using TR-EPR method combined with laser flash photolysis. The reaction intermediates and reaction