

Contents lists available at ScienceDirect

Radiation Physics and Chemistry



journal homepage: www.elsevier.com/locate/radphyschem

The effect of aromatic amines and phenols in the thiyl-induced reactions of polyunsaturated fatty acids



Ivana Tartaro Bujak^a, Chryssostomos Chatgilialoglu^{b,c}, Carla Ferreri^b, Luca Valgimigli^d, Riccardo Amorati^d, Branka Mihaljević^{a,*}

^a Ruđer Bošković Institute, Division of Materials Chemistry, Radiation Chemistry and Dosimetry Laboratory, Bijenička 54, 10000 Zagreb, Croatia

^b ISOF, Consiglio Nazionale delle Ricerche, Via Gobetti 101, 40129 Bologna, Italy

^c Institute of Nanoscience and Nanotechnology, NCSR Demokritos, 15341 Agia Paraskevi, Athens, Greece

^d Department of Chemistry "G. Ciamician", University of Bologna, Via S. Giacomo 11, 40126 Bologna, Italy

HIGHLIGHTS

• LH micelles were used for the parallel study of peroxidation/cis-trans isomerization.

• Both 2-mercaptoethanol and diphenylamine alone protect LH from oxidation.

• Aminyl radicals promote thiyl-radical-induced cis-trans isomerization of LH in air.

ARTICLE INFO

Article history: Received 30 September 2015 Received in revised form 13 November 2015 Accepted 20 November 2015 Available online 23 November 2015

Keywords: PUFA Linoleic acid Antioxidant Aromatic amines Isomerization

ABSTRACT

Thiols are well known for their role in cellular redox homeostasis, while aromatic amines and phenols are the best known classes of chain-breaking antioxidants. On the other hand, thiyl radicals are known to catalyse the double bond isomerization in PUFA. We investigated the role and interplay of 2-mercaptoethanol and diphenylamine in the parallel processes of peroxidation and *cis-trans* isomerization of linoleic acid (LA) during gamma radiolysis, both in solution and micelles. Both compounds, used alone were able to protect LA from oxidation; however pro-oxidant activity and enhanced isomerization was observed when they were used together, depending on the experimental settings. Instead, α -tocopherol protected LA from both oxidation and isomerization in the presence of thiols under any tested settings. The mechanistic scenario is discussed highlighting the role of diphenylaminyl radicals in promoting thiyl-radical-induced *cis-trans* isomerization in the presence of oxygen.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Due to the crucial roles of lipids in structural and signaling activities, the control of lipid reactivity and transformations is an interdisciplinary research field extending over chemistry to biology and medicine (Chatgilialoglu et al., 2014; Halliwell and Gutteridge, 2007). In this context, the protection against their degradation under oxidative and free radical conditions is of special interest. The reactions of polyunsaturated fatty acids (PUFA) with free radicals are known to occur via two main processes: (i) lipid

E-mail address: mihozeg@irb.hr (B. Mihaljević).

http://dx.doi.org/10.1016/j.radphyschem.2015.11.018 0969-806X/© 2015 Elsevier Ltd. All rights reserved. peroxidation (Niki, 2012) and (ii) cis-trans isomerization (Lykakis et al., 2015; Ferreri and Chatgilialoglu, 2012). The mechanism and products of each process have been studied extensively and are now fairly well documented and understood. Scheme 1 shows the interplay of the two processes in the case of linoleic acid moiety and the corresponding main products. The initial step of peroxidation is hydrogen abstraction from the bisallylic position, which can be performed by a variety of radicals, followed by the reaction with oxygen. Conjugated diene hydroperoxides having the *trans,cis* double bond geometry are the initial stable products (Yin et al., 2011). In free radical isomerization, the addition-elimination of a thiyl radical is enough to produce mono-trans geometrical isomers (Chatgilialoglu and Ferreri, 2005). An overall damaging potential is produced, that must be carefully considered for its consequences in a biological scenario, since peroxidation is a chain reaction (Yin et al., 2011) and isomerization is a catalytic process (Ferreri et al.,

Abbreviations: ArOH, α -tocopherol; LH, Linoleic acid; PUFA, Polyunsaturated Fatty Acids; Ph₂NO[•], diphenylnitroxyl radicals; LOOH, Lipid hydroperoxide; PB, phosphate buffer; RS[•], thiyl radicals; Ψ , volume part of the solvent in a solvent mixture

Corresponding author.





Scheme 1. Radical-based peroxidation and *cis-trans* isomerization processes of linoleic acid.

2001; Ferreri et al., 2004). In the presence of oxygen and thiols, both processes were detected for the first time in the biomimetic model of linoleic acid micelles, thus confirming the double-sworded reactivity of thiols towards unsaturated lipids (Scheme 1) (Mihaljević et al., 2011). It was demonstrated that conjugated diene hydroperoxides and mono-*trans* isomers can be formed to comparable extent.

Phenols are very efficient antioxidants with fairly well-known chemistry and mechanisms (Valgimigli and Pratt, 2012). We were interested in extending the investigation to other common antioxidants, such as aromatic amines. They are also well known protective agents against PUFA peroxidation, whereas their role in protecting against PUFA isomerization has remained unknown until present. Diphenylamine has been largely used as antioxidant in food products in several countries, particularly to preserve the "fresh aspect" of fruits and vegetables during storage and transportation. However, its use has been banned in the EU due to its significant toxicity (Leisso et al., 2013). Albeit relevant, free radical chemistry associated to amine toxicity is still not completely understood (Beland and Kadlubar, 1985; Benigni and Passerini, 2002). Aiming at filling this gap of knowledge we have investigated the combined role of Ph₂NH and HOCH₂CH₂SH in the radical stress induced to linoleic acid (LH) under diverse biomimetic conditions. The results highlight the role of diphenylaminyl radicals as "promoters" of the *cis–trans* isomerization in the biomimetic model systems consisting of the micellar solution of LH in the presence of thiols and molecular oxygen, contributing to a better understanding of complex interactions related to free radical stress and antioxidant control, as well as of the mechanisms of aromatic amines toxicity.

2. Materials and methods

Unless otherwise noted, solvents and chemicals were of the highest grade commercially available (Aldrich, Fluka, Sigma) and were used as received.

Initially y-irradiation of phosphate buffered air-equilibrated or N₂O-saturated solutions Ψ (EtOH: H₂O)=(1:1) (pH 5) containing 0.5 mM of LH and TWEEN[®]-20 (a non-ionic surfactant soluble in ethanol/water), in the presence and absence of HOCH₂CH₂SH was studied (Mihaljević et al., 2011). After 100 Gy of irradiation, lipid components were extracted with a solvent mixture Ψ $(CH_2Cl_2:MeOH) = (2:1)$, deaerated and analyzed for quantitative determination of LOOH by the spectrophotometric ferric thiocyanate method, as described earlier (Mihaljević et al., 1996). In parallel the analysis of trans fatty acid formation at 100 Gy was carried out by GC, after treatment of the lipid extracts with an ethereal solution of CH₂N₂ in order to transform quantitatively the free fatty acid into the corresponding methyl ester. In the absence of thiol no trace of trans fatty acid was detected. By replacing TWEEN[®]-20 with another non-ionic surfactant Brij 35, similar results were obtained (Mihaljević et al., 2011).

Next, model system containing mixed surfactant micelles and buffer was prepared by slow solubilization of LH in non-ionic surfactant micelles previously formed by mixing TWEEN -20^(B) or Brij 35 and NaH₂PO₄ (PB), pH 6.5. The composition of the investigated systems was typically 0.5 mM LH, 0.28 mM TWEEN-20 and 5 mM PB (pH~5). Gamma radiolysis of the solutions with typical composition and in the presence of 2.8 mM HOCH₂CH₂SH and/or 83 μ M Ph₂NH, which was added prior to irradiation, was performed. It should be pointed out that solubility of Ph₂NH in micellar solutions is much lower than in homogeneous solutions so its concentration had to be reduced to 83 μ M.

Radiolysis was performed at room temperature using panoramic ⁶⁰Co source at dose rate 2.4 and 274.8 Gy min⁻¹. The "transit time" (the time during the movement of the source to and from irradiation position) was 2.2 s, corresponding to the transit irradiation dose of about 0.10 Gy at the dose rate of 2.4 Gy min⁻¹ and 10 Gy at the dose rate of 274.8 Gy min⁻¹, which had to be taken into consideration at doses lower than 100 Gy. Micelles were irradiated in equilibrium with air or after saturation with N₂O. After irradiation, lipid components were extracted with a solvent mixture of Ψ $(CH_2Cl_2:MeOH) = (2:1)$, deaerated by nitrogen, and an aliquot of the sample was taken out from the lower layer for the quantitative determination of LOOH. All further analysis was carried out in three independently prepared solutions. The concentration of LOOH was determined by the spectrophotometric ferric thiocyanate method following a published procedure (Mihaljević et al., 1996), using UV/ vis spectrophotometer Varian Cary 4000. The rest of the lipid extract was used for GC analysis of geometrical isomers using the known conditions for the separation of cis and trans isomers (Ferreri et al., 2001; Mihaljević et al., 2011; Chatgilialoglu et al., 2002; Chatgilialoglu et al., 2005). In order to transform linoleic acid and its geometrical isomers into the corresponding methyl esters the reaction solutions were treated with an ethereal solution of diazomethane (Glastrup 1998). A Varian 450 gas chromatograph equipped with a flame ionization detector and a Rtx-2330 (90% biscyanopropyl/10% phenylcyanopropylpolysiloxane capillary column; Download English Version:

https://daneshyari.com/en/article/1891026

Download Persian Version:

https://daneshyari.com/article/1891026

Daneshyari.com