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Effects of hydroxylated benzaldehyde derivatives on radiation-induced reactions involving various organic radicals

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ABSTRACT

In the present paper, the effects of hydroxylated benzaldehyde derivatives and gossypol – the known natural occurring compound – on formation of decomposition products resulting from radiolysis of ethanol and hexane in deaerated and oxygenated solutions were studied. The obtained data enabled the authors to make conclusions about the effects produced by the structure of the compounds under study on their reactivity towards oxygen- and carbon-centered radicals. It has been found that 2,3-dihydroxybenzaldehyde, 4,6-di-tert-butyl-2,3-dihydroxybenzaldehyde and 4,6-di-tert-butyl-3-(1,3-dioxane-2-yl)-1,2-dihydroxybenzene are not inferior in efficiency to butylated hydroxytoluene – the industrial antioxidant – as regards suppression of the radiation-induced oxidation processes occurring in hexane. The derivatives of hydroxylated benzaldehydes were shown to have a significant influence on radiation-induced reactions involving α-hydroxyalkyl radicals.

1. Introduction

Free-radical reactions are known to play an important role in functioning of a living organism. Activation of these reactions causes damage to biomolecules, leading to numerous pathologic conditions, including cancer, arthritis, cataract, ishaemia, epilepsy and various forms of dememtia (Evans et al., 2004; Halliwell and Gutteridge, 2007). Therefore, it is important to investigate the processes of such kind in order to find out the means to influence them. Among substances of natural origin, effective regulators of free-radical processes are aromatic compounds containing carbonyl and hydroxygroups in their structures, such as curcumins (Brinkevich et al., 2012), phenylpropanoids (Samovich et al., 2013), pyridoxine (Lagutin and Shadyro, 2005), etc.

Gossypol (yellow pigment of cotton seeds) possesses marked antiviral and anti-tumor properties (Wang et al., 2009; Keshmiri-Neghab and Goliae, 2014), and is characterized by the ability to inhibit free-radical processes (Li et al., 2000; Dodou et al., 2005; Wang et al., 2008; Ilkevich et al., 2009). The antioxidant properties of gossypol and its derivatives are mainly due to their ability to neutralize peroxide radicals (ROO•) (Wang et al., 2008) being formed during the action of ionizing radiation or free-radical agents on organic compounds in the presence of oxygen. There is no information in the literature about possible influence of gossypol and its analogues on homolytic processes involving carbon-centered radicals. Biological and antioxidant activity of gossypol and its structural analogues are deemed to be associated with 2,3-dihydroxybenzaldehyde included in its structure (Baram and Ismailov, 1993). This gave us reasons for conducting examination of the reactivity of gossypol and its structural analogues towards organic radicals of various types.

2. Experimental section

2.1. Chemicals

Benzaldehyde (I), 2-hydroxybenzaldehyde (II), 2,3-dihydroxybenzaldehyde (III), 2,3-dimethoxybenzaldehyde (IV), (+/–)-gossypol (IX), butylated hydroxytoluene (X), (+/–)-meso-2,3-butanediol (2,3-BD), n-hexane, n-dodecane, hexanol-2, hexanol-3, hexanone-2 and hexanone-3 purchased from Sigma-Aldrich were used in this study without further purification. Compounds (V–VIII) were synthesized according to procedures described in (Shadyro et al., 2016) (Table 1). The degree of purity of all compounds used in this study was not less than 97%. Ethanol (96% v/v) was purified by sorption on "Wolfen Zeosorb LA" ceolite followed by fractional distillation on a rectifying column of 3 m height.

2.2. Preparation of samples for irradiation

In order to investigate reactivity of the derivatives of hydroxylated

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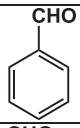
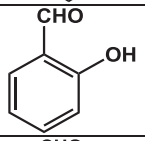
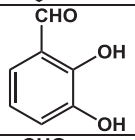
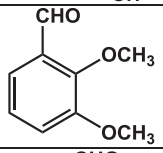
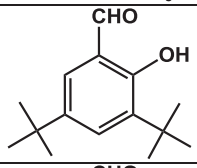
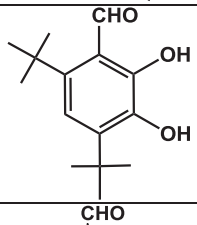
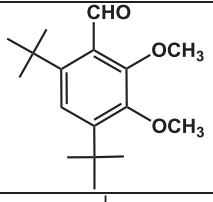
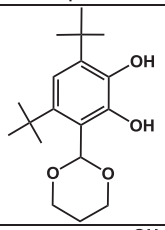
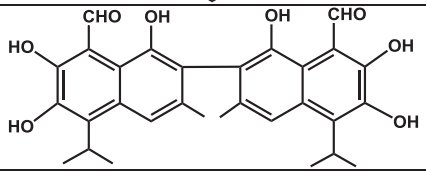
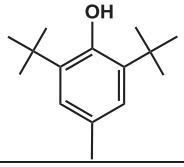
Table 1
The test compounds examined in this study.

No.	Structure	Name
I		Benzaldehyde
II		2-Hydroxybenzaldehyde (salicylic aldehyde)
III		2,3-Dihydroxybenzaldehyde
IV		2,3-Dimethoxybenzaldehyde
V		3,5-Di-*tert*-butyl-2-hydroxybenzaldehyde
VI		4,6-Di-*tert*-butyl-2,3-dihydroxybenzaldehyde
VII		4,6-Di-*tert*-butyl-2,3-dimethoxybenzaldehyde
VIII		4,6-Di-*tert*-butyl-3-(1,3-dioxane-2-yl)-1,2-dihydroxybenzene
IX		2,2'-Bis-1,6,7-trioxy-3-methyl-5-isopropyl-8-aldehydonaphtyl (gossypol)
X		2,6-Di-tert-butyl-4-methylphenol (butylated hydroxytoluene)