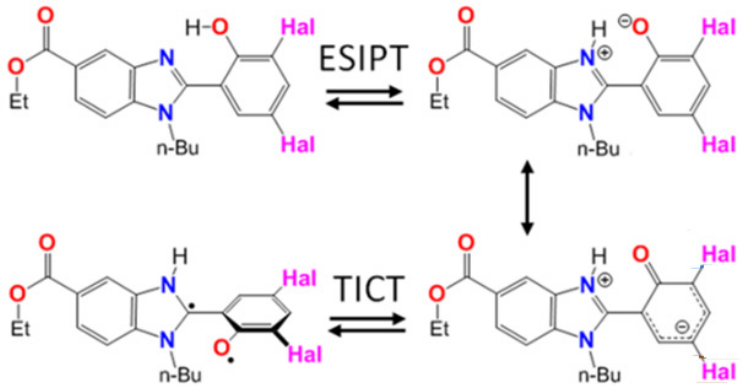

Fig. 2. *ESIPT and TICT processes in a dihalogenated compound **3e***

	Solid state	MeCN	THF	EtOH	DMSO	DMF
3a	**K**	**K (major) +** E (minor)	**E**	**E**	**E**	**E**
3b	**K**	**K (major) +** E (minor)	**E**	**E**	**E**	**E**
3c	**K**	**K (major) +** E (minor)	**E**	**E**	**E**	**E**
3d	**K**	**K (major) +** E (minor)	**E + K**	**E (major) +** K (minor)	**E**	**E**
3e	**K**	**K (major) +** E (minor)	**K**	**E + K**	**K (major) +** E (minor)	**K**

Fig. 3. *Summary of the experimental data on which form of **3a**–**3e** emits in the solid state and in five solvents of different polarity. E – enol form; K – keto form*

least one of the following conditions is satisfied. (i) Intermolecular hydrogen bonding of HBI to solvent molecules is relatively weak. This favors the formation of O–H···N intramolecular hydrogen bonds in HBI and facilitates ESIPT. (ii) A halogen atom is introduced in the *ortho*-position to the OH–group. This stabilizes the keto form and decreases the energy barrier for ESIPT due to strongly negative inductive effect. If neither of these two conditions is met, the ESIPT process is hindered and the emission originates from the enol form (Fig. 3). Compared to solution, the potential energy curve of the S_1 state has only one minimum in the solid state, which leads to barrierless ESIPT and fluorescence of the keto form. According to DFT and TDDFT calculations, twisted intramolecular charge transfer state (TICT, Fig. 2), which is often coupled with ESIPT, is thermodynamically and kinetically unfavorable in the case of HBI, resulting in moderate to high photoluminescence quantum yields for **3a**–**3e**.

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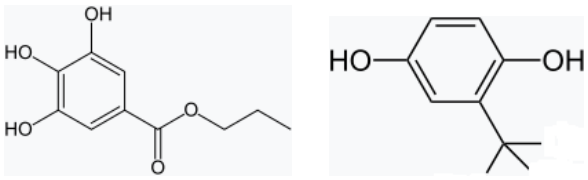
INVESTIGATION OF THE ANTIOXIDANT ACTIVITY OF FOOD ADDITIVES OF SYNTHETIC E310 AND E319

Y. O. Shishko, A. K. Manoshkina
Scientific supervisor – PhD, assistant professor, O. A. Voronova
Language expert – PhD, assistant professor, O. I. Lipskikh

National Research Tomsk Polytechnic University
Lenin Avenue, 30, Tomsk, Russia, 634050, oaa@tpu.ru

Propyl gallate (E 310) and tert-butylhydroquinone (E 319) are synthetic phenolic antioxidants, which are used for technological purposes for food production.

As food additives E310 and E319 are used in the manufacture of mayonnaise and sauces based on it, butter, margarine, gum, dry cooking mixes, mashed potatoes and instant soups, dried meat.



propyl gallate tert-butylhydroquinone

Scheme 1.

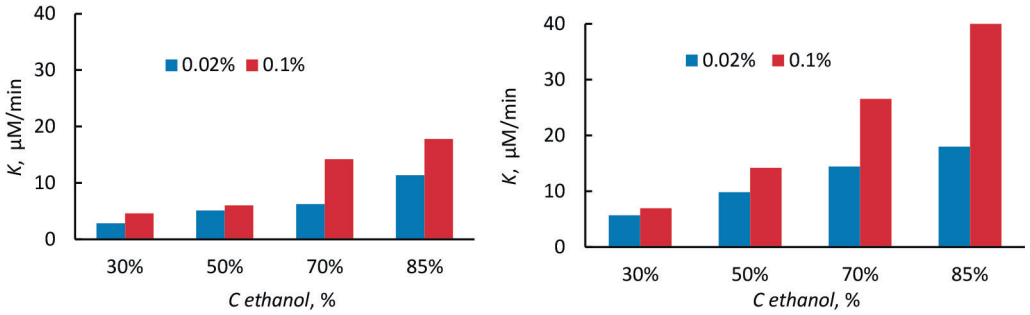


Fig. 1. *The values of the antioxidant activity of E310 and E319 with a concentration of 0.02 %, 0.1 % in water-ethanol solutions of various concentrations (30 %, 50 %, 70 %, 85 %)*

Currently, propyl gallate is a generally recognized safe antioxidant to protect oils, fats and fat-containing products from rancidity resulting from the formation of peroxides. It is used as an antioxidant in maximum concentrations of 0.1 %.

Tert-butylhydroquinone is a highly effective antioxidant for many animal dietary fats and unsaturated vegetable oils, even in the presence of iron does not cause discoloration. It is added to a wide range of products with a maximum limit of 0.1 %.

This work is devoted to the study of antioxidant activity of food additives E310 and E319 by voltammetric method.

The voltammetric method for determining the antioxidant activity of phenothiazine and its derivatives consisted in recording voltammograms of cathodic oxygen reduction electroreduction (ER O_2). In this work, the TA-2 voltammetric analyzer ("Tomanalyt", Tomsk, Russia) was used together with a PC. Voltammetric curves were recorded in a three-electrode electrochemical cell connecting to the analyzer. A working mercury-film electrode, a silver-silver chloride electrodes with saturated (Ag|AgCl|KClsat) KCl, as reference and counter electrodes were used. Water-ethanol solution of 0.1 N $NaClO_4$ in various concentrations (10 %, 30 %, 50 %, 70 %, 85 %) was used as a background solution. The food additives were studied in several concentrations (0,02 %, 0,1 %).

It is obvious that the antioxidant activity may depend both on the concentration of the substance under study and on the water-ethanol ratio in the background electrolyte. Therefore, to assess the most effective concentration of propyl gallate and ethanol concentration in the background electrolyte, the methods of experiment design was used in this work: a full factor experiment and a steep ascent method (Table 1).

Table 1. The basic characteristics of the experiment

Name of characteristic	X_1, ($C_{preservative}$, %)	X_2, ($C_{ethanol}$, %)
Zero level	0,06	50
Interval of a variation	0,04	20
Top level	0,1	70
Bottom level	0,02	30

After processing the data, it was found that the model adequately describes the process for all the studied substances. The effect of the interaction of factors is not important, and all the coefficients of the linear model are significant and have a plus sign, which means an increase in optimization criteria with an increase in the values of both factors.

It should be noted that the criterion of antioxidant activity is the relative change in the ER O_2 current, taking into account the different oxygen concentration in background solutions with different ethanol content (K, μM/min).

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