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The stability of functional activity in *dunaliella* cells against the acute doses of UV-B irradiation, modified by synthetic antioxidants

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Abstract

In this work have been presented the results of influence investigations of various concentrations by synthetic antioxidants 2,6di-*tret*-butyl cresol (BHT) and 2, 6 di-*tret*-butyl phenol on the population in *Dunaliella salina* IPPAS D-294 cells.
The bioproductivity, synthesis dynamics of carotenoid amount, endogen activity in catalase and POL in the presence of various concentrations of synthetic antioxidants in intensive culture have been determined.
It was identified that, the modification of cells by synthetic antioxidants within 24 hours in intensive culture decreases amount of synthesized carotenoids and POL process increases catalase activity.
It became clear that the population of *Dunaliella* cells, modified by synthetic antioxidants shows higher functional stability against the influence of further various acute doses of UV-B irradiation.

Keywords: green microalgae *Dunaliella,* synthetic antioxidants, bioproductivity, biosyntheses of carotenoid amount, catalase activity, POL process, functional stability against UV-B irradiation

1. Introduction

In alive organisms happen a lot of processes of radical oxidations, therefore occur noticeable life important transformations, including the synthesis of new biologically active units, regulation of biological cycle and system, formation of functional activity of organisms.
Anumberof free radicals of organisms important for life are regulated with the help of enzyme system of antiradical protection. On the other side, excess accumulation of free radicals, balance disorder among forming and cancelling radicals lead to the development of oxidizing stress, which followed by the injury of biological molecule, lipid oxidation, modification of protein and DNA [1-3]. Antioxidants play an important role in the regulation of occurring free-radical changes in organisms, able to connect the content of unpaired electron unites with the formation less active or fully non-active radicals, therefore antioxidants and the investigation of antioxidation features of unites has got wide spread lately [4-6].
Lately new approaches began to develop rapidly, linking chemistry and biology by antioxidants, expressing important problem-the dependence of biological activity of antioxidants, their features as inhibitors of radical reactions. Purposefully were synthesized non-toxic antioxidants of various structures, mainly derivative screened phenols [7, 8] useful at biological investigations of hydroxy derivative heterocyclic hydrocarbons and screened phenols their homologous series derivatives-antioxidants. At the same time has been carried out investigations in models of antiradical activity in synthetic antioxidants with peptide radicals, arising under UV-irradiation [9].
There are very little information on the synthetic antioxidant influence and their antiradical features in green algae. Due to that, the purpose of our work was the investigation influence of various concentrations in synthetic antioxidants with 2, 6 di-*tret*-butyl cresol (BHT- classic synthetic antioxidant) and 2, 6 di-*tret*-butyl phenol on the growth, activity of endogen antioxidant systems of *Dunaliella* algae and their UV-protection activity in cells.

2. Materials and methods

As theinvestigation method was used halophylic green algae *Dunaliella salina* IPPAS D-294, taken from the saline lake in Masazir located in the north-easten part of Baku in Azerbaijan. The algae were grown at 27°C temperature in glass photoreactors (250ml), in the installation for growing unicellular algae. The source of UV-irradiation was mercury-vapor lamp SVD-120, equipped with color filter UFS-2.Mineral medium contained (g/l): NaCI – 87,5 (1,5 M); KNO_3 –5,0; KH_2PO_4-1,25; $MgSO_4$ –50; $FeSO_4$-0,009 microelement solutions (mg/l)- $Ca(NO_3)_2$ •H_2O- 735; H_3BO_3 - 735; $ZnSO_4$ •$7H_2O$- 615; $(NH_4)MoO_4$- 100; $MnCl_2$•$4H_2O$- 180. The cell suspension in photoreactors was irradiated by white light (16 Wt/m^2) within 24 hours and permanently purged with the mixture (air+ 1, 5% CO_2) at 25°C temperature. The cells were cultivated within 24 hours, in intensive-accumulated cultivation regime and was irradiated day and night. The culture growth was determined periodically by counting cell number in Qoryayev chamber under the microscope or by nephelometric measurement of optic suspension density in photoelectrocolorimeter.
The content of pigments in cellular extracts (100 % acetone) was measured in spectrophotometer and counted on base of Wettshtain coefficient [10].
To measure the photosynthetic cell activity, of grown algae were precipitated by centrifugation 3000 rev/min. within 10 min. at room temperature and transferred into newly-made mineral medium. The suspension density in cells was led to 10^{6}cells/ml (optic density OD=0,8). The speed of oxygen evolution in cells was measured in polarographic installation, using platinum electrode Klark, lightining the suspension in

thermostated volume, saturating the intensity by white light (100 Wt/m^2).

In order to measure the catalase activity in cells, the suspension precipitated by centrifugation (3000 rev/min.). The sediment was transferred into a mortar with 0,5g $CaCO_3$, was added 5 ml distilled water and triturated into homogeneous mass. Then gained mass quantitatively transferred into a glass with 50 ml capacity till the mark and infused with periodic shaking 3-4 hours. Within that time happens enzyme extraction in plant material. After infusion the suspension was filtered in dry glass. Catalase activity was measured by gazometric method, which based on determination of volume after adding into the aqueous extract of plants, containing catalase, hydrogen peroxide [11].

The evaluation degree of lipid peroxidation (POL) was carried out by the method of determining MDA content in *Dunaliella salina* cells – method based on the reactions with thiobarbituric acids. The cell suspension (35 ml) was centrifugated at 3000 rev/min. within 10 minutes. The resulting sediment was homogenized in 20 ml 0,1% TCA. Homogenate was centrifugated at 3000 rev/min within 10 minutes. To the 1 ml supernatantwas added 4 ml 20% TCA, containing 0,5% TBA. The mixture was heated in water bath at 95°C within 30 minutes and immediately cooled in running water. After centrifugation of mixture at 3000 rev/min within 10 minutes, was determined optic density of supernatant at 532 nm [12].

3. Results and discussion

It is known that, characterizing strain of unicellular algae resulting dependence change significantly by culture conditions. Herewith significant values are the growth optimization, accumulation of biomass and photosynthetic culture productivity of microalgae for the complete identification of their high potential biosynthetic activity. Based on carried investigations on *Dunaliella salina* IPPAS D-294 algae was obtained optimal value of temperature, light intensity, the content of CO_2 in air mixture, the content of NaCI in mineral medium. On optimal conditions (temperature 27°C, light intensity 16 Wt/m^2,the content of CO_2 in air mixture 1,5%, mineral medium containing 1,5 M NaCI) the growth of cells in 250 ml glass photoreactors and filing by air mixture with 25°C temperature in intensive-accumulative regime of cultivation within 24 hours showed that, optimal density of cell solution increases 3,5-4 times. Such tendency of population growth continued and also at following variants of control suspension cultivation.

In any alive organisms every moment occur a great number of processes of radical oxidation, due to thatwere performed substantial part of important vital transformations, including the synthesis of new biological active units, transformation of substances in cascade reaction series, regulation of biological cycle and system, implementationof functional activity of organs and etc.The amount of vital necessary free radicals of organism is regulatedwith the help of enzyme system of antiradical defense. Substantially reduce of oxidative stress and its effects can be with the help of exogenic synthetic antioxidants, among which an important place is assignedby the space of hindered phenols, particularly BHT and its derivatives.

In figure 1 has been presented the growth dependence of population in *Dunaliella salina* IPPAS D-294 cells at various concentrations 2,6 di-*tret*-butyl cresol (BHT) (1) and 2,6 di-*tret*-butyl phenol (2) in mineral medium. As seen in the figure, the presence of BHT and 2,6 di-*tret*-butyl phenol in the medium visibly influence on the culture growth. Thus, at concentrations 25 mkM and 50mkM in mineral medium of BHT the cell differentiation increases up to 2,5% and 4,5% respectively, but in the presence of 2,6 di-*tret*- butyl phenol 3% and 5% compared to control suspension. So, BHT and 2,6 di-*tret*-butyl phenol at low concentrations mkM 50 mkM are comparable with the activity of usual phytohormones. At concentrations 150-350 mkM in mineral medium the growth stimulating influence of BHT and 2,6 di-*tret*-butyl-phenol in mineral medium visibly decreases. By increasing the content of BHT and 2,6 di-*tret*-butyl-phenol in mineral medium it orderly (500 mkM) gets reverse sign, was observed the reduction (15%) and (10%) of growth culture within 24 hourly cultivation in intensive- accumulative regime.Expressed growth stimulating BHT activity and 2,6 di-*tret*-butyl-phenol at low concentrations in mineral medium make those antioxidants perspective and effective resources being available and reliable regulation (activation) of culture growth in *Dunaliella salina* IPPAS D-294 cells.

In order to identify functional activity of *Dunaliella salina* IPPAS D-294 in cell modification within 24 hours at various concentrations of synthetic antioxidants BHT and 2,6 di-*tret*-butyl-phenol in mineral medium showed that BHT and 2,6 di-*tret*-butyl-phenol investigated range reduces the photosynthetic oxygen evolution of cell suspension.

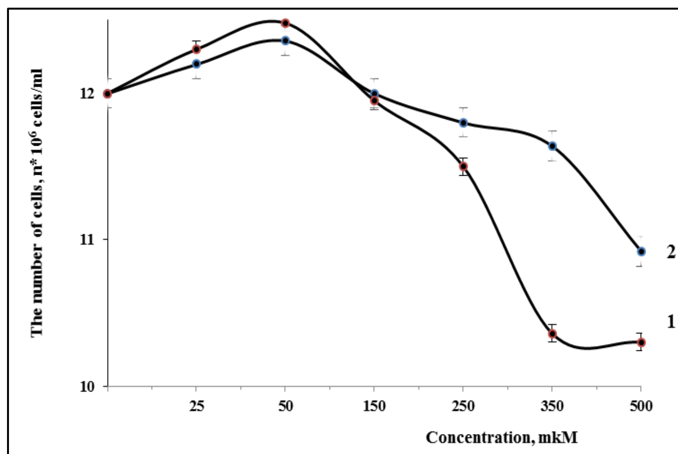

Fig 1: The dependence of population growth in *Dunaliella salina* IPPAS D-294 cells at various concentrations 2,6 di-*tret*-butyl cresol (BHT) (1) and 2,6 di-*tret*-butyl phenol (2) in mineral medium. Temperature 27°C, light intensity 16 Wt/m^2

In fig. 2 have been presented the data of photosynthetic oxygen evolution in *Dunaliella salina* IPPAS D-294 cells, grown at various concentrations of 2,6 di-*tret*-butyl cresol (BHT) (1) and 2,6 di-*tret*-butyl phenol (2) in mineral medium. As seen in the figure, photosynthetic oxygen evolution in *Dunaliella salina* IPPAS D-294 cells, by modification (growth within 24 hours in intensive regime of cultivation) by different concentrations of BHT (25-500mkM) despite of growth stimulation at low concentrations 25mkM and 50 mkM (fig.2, curve 1) greatly suppressed already at concentrations 25mkM (20%). The cell modification by BHT high concentration 50-150 mkM suppresses cell function to 30-32%, and in 350-500 mkM to 35-37%

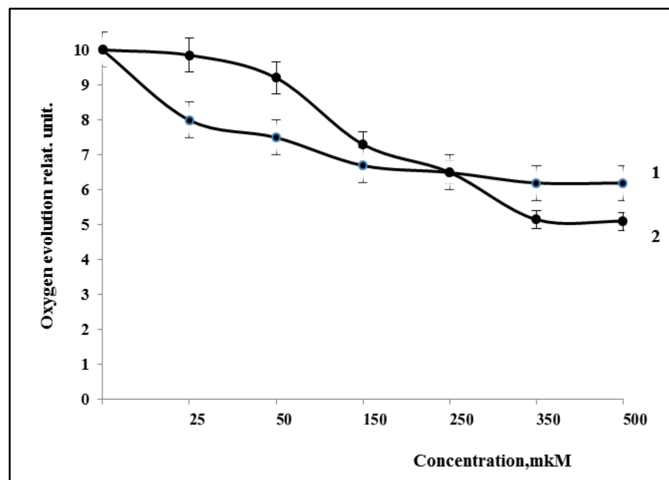

Fig 2: Photosynthetic oxygen evolution of *Dunaliella salina* IPPAS D-294 cells, grown at various concentrations of cresol (1) and 2,6 di-*tret*-butyl phenol (2) in mineral medium.
Temperature 40 °C, light intensity 100 Wt/m^2.

we identified regulating growth and development of algae, BHT influence compared with the influence of 2,6 di-*tret*-butyl phenol, which on the structure identical to BHT, however the group of methyl also seemed to be effective antioxidants, physiological active. This unit has analogous BHT influence: growing in the presence of 25 mkM and 50 mkM 2,6 di-*tret*-butyl phenol on optimal conditions was observed the stimulation of algae growth in intensive cultivation (fig.1, curve 1).

Beginning with concentration 150 mkM and higher, was observed the suppression of cell bioproductivity during 24 hourly cultivation. Such, in the presence of 2, 6 di-*tret*-butyl phenol in mineral medium at various concentrations by growth indication it influences as antioxidant, analogous BHT. It is not excluded that, synthetic antioxidant 2,6 di-*tret*-butyl cresol (BHT) and
new 2,6 di-*tret*-butyl phenol imitate and also perform the role of growth regulating agent.

In fig.2 were presented the results of photosynthetic oxygen evolution in (curve 2) *Dunaliella salina* IPPAS D-294 cells, grown at various concentrations 2,6 di-*tret*-butyl phenol in mineral medium. As seen in the figure the concentration 2,6 di-*tret*-butyl phenol (25-500 mкM) leads to the suppression of functional activity of *Dunaliella* cells. In this case the observing suppression of function 2,6 di-*tret*-butyl phenol much differs from antioxidant BHT, so at concentrations 25mkM and 50mkM the suppression of functional activity in cells are insignificantly 2% and 5% respectively. The increase of concentration 150 mkM and higher leads to the acute suppression 28% and 48% (350 and 500 mkM) of photosynthetic oxygen evolution in cells, which wasn't observed in BHT investigations. Though, plant cells usually have high- level antioxidative activity and as usual, contain a great number of antioxidants of various chemical nature, we wanted to investigate, at which degrees, used synthetic antioxidants in growth medium during 24 hourly cultivation can influence on the endogenic low molecular (carotenoids) and high molecular (catalase) antioxidants, and also on the process of lipid peroxidation.

In table 1 have been presented the growth indications, pigment formation, catalase activity, and amount of MDA formation in *Dunaliella* cells in control and also during processing the cells by antioxidant 2, 6 di-*tret*-butyl cresol (BHT) at various concentrations during 24 hourly cultivation. As seen in the schedule, the modification of cell suspension by BHT at concentrations 25 mkM and 50 mkM leads to the increase of endogen catalase activity to 60%. The increase of BHT concentration 150-500 mkM decreases a little the catalase activity 58%, but it remains higher compared to control cells. The modification of cell suspension by BHT leads to acute decrease of carotenoid biosynthesis, so at concentrations 25 mkM 82%; 50 mkM 62%; 150mkM 69%; 250 mkM 66%; 350 mkM 50%; 500 mkM 45%. At the same time with the carotenoids are suppressed chlorophyll synthesis «a» and «b».The evaluation of intensity processes of lipid peroxidation (POL) was also conducted in conditions of cell modification of synthetic antioxidants by BHT on the stage of development of algae in intensive-accumulative regime of cultivation. The intensity indications of peroxidation processes of lipids in cells, defining in content MDA, at low concentrations 25 mkM and 50 mkM remained in higher level of control, but with increasing the concentration of synthetic antioxidant decreased to minimum level 33% at 500 mkM.

Table 1: The growth indications, pigment formation, catalase activity and the amount of MDA formation in *Dunaliella* cells in control and during processing cells by antioxidants 2, 6 di-*tret*-butyl cresol

	Growth, OD		**Catalase activity, mкMH_2O_2 ml^{-1} min^{-1}.**				**The amount of pigments, mg/l.**			**The content of MDA, mol/graw weight**
			5	*10*	*15*	*20*	*Ca*	*Cb*	*Ccar*	
K	0,3	1,20	0,4	0,9	1,1	1,2	3,46±0,05	1,73±0,05	1,34±0,1	$1{,}9 \cdot 10^{-3}$±0,05
O_1	0.3	1,23	0,6	1,2	1,7	2,0	3,0±0,05	1,5±0,05	1,1±0,1	$1{,}26 \cdot 10^{-3}$±0,05
O_2	0.3	1,25	0,65	1,15	1,6	2,0	2,95±0,05	1,45±0,05	0,83±0,1	$1{,}2 \cdot 10^{-3}$±0,05
O_3	0.3	1,20	0,65	1,1	1,55	1,9	2,47±0,05	1,33±0,05	0,93±0,0	$1{,}18 \cdot 10^{-3}$±0,05
O_4	0.3	1,15	0,65	1,3	1,7	1,9	2,62±0,05	1,4±0,05	0,89±0,1	$1{,}13 \cdot 10^{-3}$±0,05
O_5	0.3	1,04	0,6	1,2	1,65	1,9	2,67±0,05	1,27±0,05	0,67±0,1	$0{,}88 \cdot 10^{-3}$±0,05
O_6	0.3	1,03	0,35	1,1	1,55	1,9	2,39±0,05	1,09±0,05	0,60±0,1	$0{,}63 \cdot 10^{-3}$±0,05

Note: optic density*OD=0,8:* Temperature 27°C, light intensity 16 Wt/m^2; C-control; O_1-treatment2,6 di-*tret*-butyl cresol (25 mkM); O_2-treatment2,6 di-*tret*-butyl cresol(50 mkM); O_3-treatment2,6 di-*tret*-butyl cresol(150 mkM); O_4-treatment2,6 di-*tret*-butyl cresol(250 mkM); O_5-treatment2,6 di-*tret*-butyl cresol(350 mkM); O_6-treatment2,6 di-*tret*-butyl cresol (500 mkM);

So, the modification by various concentrations by BHT, the suspension of *Dunaliella* cells during 24 hourly cultivationleads to the changes of endogen antioxidant systems, which effect on the functional activity and bioproductivity of algae.

The second synthetic antioxidant 2,6 di-*tret*-butyl phenol was also investigated on the range of concentration 25-500 mkM in the growth medium within 24 hourly cultivation of algae suspension.

In table 2 were presented the growth indications, pigment formation, catalase activity and amount of MDA formation in *Dunaliella* cells in control and by treating cells with antioxidants 2,6 di-*tret*-butyl phenol. As seen in the schedule the modification of cells by 2,6 di-*tret*-butyl phenol with different concentrations leads to the increase of endogen catalase activity (the increase of activity 25-50%), that significantly differs from BHT influence (58-60% of all concentrations). It is necessary to note that we watch the increase of indications of carotenoid biosynthesis, in the case with 2,6 di-*tret*-butyl phenol in low concentrations 25-50 mkM (stimulating bioproductivity of algae) to 20-27%, which disagree with BHT data, where have reliable indications of suppression. The increase of concentration of synthetic antioxidant 2,6 di-*tret*-butyl phenol in mineral medium on the range 250-500 mkM decreases the synthesis of carotenoids to 20-22%. At those experiments also as at the first antioxidant BHT, chlorophyll biosyntheses «a» and «b» are suppressed.

Table 2: The indications of growth, pigment formation, catalase activity and the amount of MDA formation in *Dunaliella* cells in control and by treating the cells with antioxidants 2,6 di-*tret*-butyl phenol.

	Growth, OD		Catalase activity, mкMH_2O_2 ml^{-1} min^{-1}.				The number of pigments, mg/l.			The content of MDA, mol/graw weight
			5	*10*	*15*	*20*	*Ca*	*Cb*	*Ccar*	
K	0,3	1,2	0,4	0,9	1,1	1,2	3,25±0,05	1,59±0,05	1,17±0,1	1,9*10^{-3}±0,05
O_1	0.3	1,22	0,45	0,8	1,2	1,5	3,1±0,05	1,5±0,05	1,4±0,1	1,8*10^{-3}±0,05
O_2	0.3	1,24	0,45	0,9	1,5	1,8	3,19±0,05	1,95±0,05	1,49±0,1	1,6*10^{-3}±0,05
O_3	0.3	1,2	0,45	0,9	1,4	1,8	2,93±0,05	1,45±0,05	1,2±0,1	1,38*10^{-3}±0,05
O_4	0.3	1,18	0,4	0,8	1,5	1,7	2,72±0,05	1,32±0,05	0,93±0,1	1,2*10^{-3}±0,05
O_5	0.3	1,16	0,45	0,9	1,5	1,7	2,89±0,05	1,65±0,05	0,91±0,1	1,2*10^{-3}±0,05
O_6	0.3	1,09	0,35	0,8	1,4	1,7	3,0±0,05	1,51±0,05	0,93±0,1	0,75*10^{-3}±0,05

Note: optic densityOD=0,8:Temperature 27°C, light intensity 16 Wt/m^2; C-control; O_1-treatment by 2,6 di-*tret*-butyl phenol(25 mkM);O_2-treatment by 2,6 di-*tret*-butyl phenol(50 mkM);O_3- treatment by 2,6 di-*tret*-butyl phenol(150 mkM); O_4-treatment by 2,6 di-*tret*-butyl phenol (250 mkM); O_5- treatment by 2,6 di-*tret*-butyl phenol(350 mkM);O_6- treatment by 2,6 di-*tret*-butyl phenol(500 mkM);

The (POL) indications, defining by content MDA, at low concentrations 25 mkM and 50 mkM remained below the level of control 95% and 84% respectively, but the increase of concentration of synthetic antioxidant decreased to the level 39% at 500 mkM.

The main aim in investigations was the explanation of stability limits of population in control *Dunaliella* cells, and also in cells modified by synthetic antioxidants 2,6 di-*tret*-butyl cresol and 2,6 di-*tret*-butyl phenol with concentrations 25 and 50 mkM against the influence of various acute doses of UV-B irradiation.

In figure 3 have been presented the results of photosynthetic oxygen evolution irradiated by various acute doses of UV-B light in control *Dunaliella* cells and in cells modified within 24 hours at intensive cultivation with 25 mkM and 50 mkM 2,6 di-*tret*-butyl cresol. As seen in the figure, in control cells, irradiated by acute doses 2,2*10^{3}Erg/mm^2 functional activity strongly suppressed 30-32%.

The following increase of acute UV-B irradiation doses 3, 75* 10^{3}Erg/mm^2 leads to the deeper suppression (40%) of the cell (photosynthetic oxygen evolution) function (fig.3, curve 1). Acute doses 6* 10^{3}Эрг/ mm^2 significantly didn't increase the suppression of synthetic oxygen evolution compared to doses 3, 75* 10^{3}Erg/mm^2, but manifested some stability.The cells modified by 2, 6 di-*tret*-butyl cresol in concentration 25 mkM under the influence of acute doses of UV-B irradiation 2, 2* 10^{3}Erg/mm^{2}show high functional stability 95-96%. The increase of acute doses to 3, 75* 10^{3}Erg/mm^2 didn't effect on functional activity of modified cells. Acute doses of UV-B irradiation 6* 10^{3}Erg/mm^2 greatly reduced (77%) photosynthetic oxygen evolution of modified cells (fig.3, curve 2).

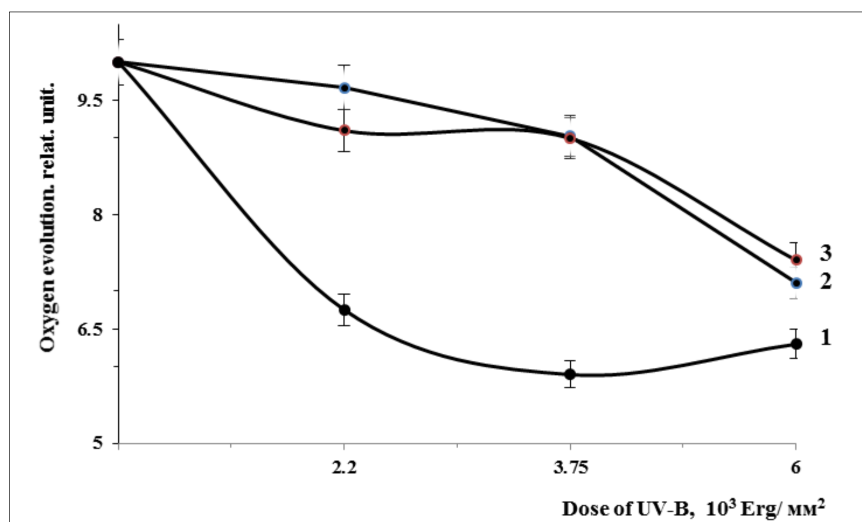

Fig 3: Photosynthetic oxygen evolution in *Dunaliella salina* IPPAS D-294 cells, irradiated by various acute doses UV-B light: **1-** control cells; **2-** cells, modified by 2,6 di-*tret*-butyl cresol concentration 25mkM; **3-**cells, modified by 2,6 di-*tret*-butyl cresol in concentration 50 mkM. Temperature 40°C, light intensity 100 Wt/m^2

The increase of synthetic antioxidant concentration (50 mkM) BHT during cell modification showed that the stability of functional activity is saved on high level at low acute doses 2,2* 10^3Erg/mm^2 UV-B irradiation, then suppression character is saved (fig.3, curve 3), as in concentration 25 mkM.

The investigation, carried out with antioxidant 2,6 di-*tret*-butyl phenolshowed that, this synthetic antioxidant demonstrates tread role under the UV-B light influence.

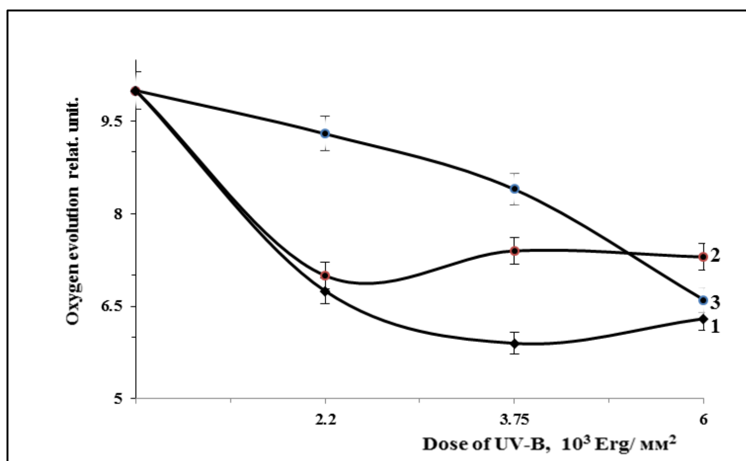

Fig.4. Photosynthetic oxygen evolution in *Dunaliella salina* IPPAS D-294 cells, irradiated by various acute doses of UV-B light: **1**- control cells; **2-** cells, modified by 2,6 di-*tret*-butyl phenol in concentration 25mkM; **3-** cells, modified by 2,6 di-*tret*-butyl phenol in concentration 50mkM. Temperature 40°C, light intensity100 Wt/m^2

In figure 4 were presented the results of photosynthetic oxygen evolution in *Dunaliella* cells, irradiated by various acute doses of UV-B light. As seen in the figure, the function of control cells under the influence of UV-B acute dose on the range 2,2* 10^3Erg/mm^2 – 6* 10^3Erg/mm^2 as in the fig. 3 is strongly suppressed (fig.4, curve 1).

The modification of cells by 2,6 di-*tret*-butyl phenol in concentration 25mkM showed that this synthetic antioxidant at this concentration demonstrates weak tread function in the functional cell activity.

At acute dose 2,2* 10^3Erg/mm^2 of UV-B irradiation the protection of functional cell activity is weakly manifested (on the control cell level), but the increase of doses to 3,75* 10^3Erg/mm^2 and 6* 10^3Erg/$mm^2$is watched some functional stabilities differing from control cells (fig.4 curve 2). The increase of antioxidant concentration to 50 mkM markedly has risen the tread function of 2,6 di-*tret*-butyl phenol. Modification of cells at this concentration noticeably increased the functional cell stability,where are watched smooth decrease of functional activity under the increase of acute dose of UV-B irradiation (fig.4, curve 3).

Thus, the functional protection of cells by synthetic antioxidant 2,6 di-*tret*-butyl cresol and 2,6 di-*tret*-butyl phenol at low concentrations (stimulating growth of cell population fig.1) protect the functional activity of cells unequally. Probably, protective function (antioxidant activity) of 2,6 di-*tret*-butyl cresol (BHT -classic synthetic antioxidant) increase the tread function of 2,6 di-*tret*-butyl phenol.

4. Reference

1. Gate L, Ba GN, Tew KD, Tapiero H. Biomed. Pharmacother. 1999; 53:169-180
2. Namiki M. Crit. Rev. Food Sci. Nutrition. 1990; 29:273-300.
3. Mates M. Toxycology, 2000; 153:83-104.
4. Khasanov VV, Rijova GL, Malseva EV. Methods of antioxidant investigations, Chemistry of raw plant materials, 2004; 3:63-75.
5. Shishkina LN, Burlakova EB. Natural and synthetic antioxidants as radioprotectorsChemical physics, 1996; 15(1):43-53.
6. Magerramov AM, Magerramov MM, Makhmudova Kh. A, Quseynova AR, Ali-zadeh GI *et al*. Photosynthetic activity of *Synechococcus Sp.PCC7942* cells modified by synthetic antioxidants under UV-C illumination. Reports. AN Azerb. 2003, 1-2,.
7. Magerramov AM, Guseynova AR, Ali- zadeh GI, Nadjaphly MH, Makhmudova Kh A, Allakhverdiev MA. Protection of cells *SynechococcusSp.PCC7942*by synthetic antioxidants under UV-C illumination at chronic doses in intensive culture. Reports. AN Azerb. 2003, 3-4.
8. Ershov VV, Nikiphorov GA, Volodkin AA. Spatially-hindered phenols. M., Chemistry, 1972, 351.
9. Burlakova EB. Bioantioxidants. Russ. Chem. j. LI, 2007; 1:3-12
10. Gavrilenko VF, Ladigina ME, Khandobina LM. A large practicum on plant physiology. High school, 1975, 392.
11. Pleshkov BP. Practicum on plant biochemistry.M. 1976, 255.
12. Heath RL, Packer L. Archieves of Biochem. And Biophys. 1968; 125:189-198.