Pulsed Electrical Field Impact on Cyanide Biodegradation by *Pseudomonas fluorescens*

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The impact of the pulsed electrical field on the cyanide biodegradation process was investigated in this work. In the experiment, *Pseudomonas fluorescens* bacteria was treated by the pulsed electrical field for 15 mins ($f = 100$ Hz, impulse duration is 1 ms) before adding to the solution with $\mathrm{Na[Ag(CN)_2]}$ complex, and the appropriate kinetics was described [1]. During the cyanide biodegradation process, cyanide blocks the respiratory centers (RCs) of bacteria, but simultaneously bacteria degrade cyanide using the respiratory mechanism [2]. Theoretical analysis of the cyanide biodegradation kinetics was carried out in [3].

The purpose of this work is to introduce a phenomenological model (1-2) that explains the cyanide biodegradation process in [1], and to describe the impact of pulsed electrical field on respiratory parameters of bacteria.

$$\frac{dn}{dt} = -\left(\gamma_0 + \gamma_1 C\right) n + \left(g_0 + g_1 n\right)\left(1 - n\right) - a\left(1 - C\right) \tag{1}$$

$$\frac{dC}{dt} = -\alpha n \frac{C}{C + C_m} \tag{2}$$

where n is a relative number of active RCs that can degrade cyanide, C is a cyanide concentration in the solution, $\gamma(C) = \gamma_0 + \gamma_1 C$ is the rate of RC deactivation for low cyanide concentrations, γ_0 and γ_1 are constants. $g(n) = g_0 + g_1 n$ is the rate of RC activation, g_0 and g_1 are constants. α is the maximum rate of the cyanide destruction, C_m is the Michaelis constant, a is the rate of RCs deactivation caused by by-product generation in the solution. Note that the system (1-2) is already normalized.

During the analysis of the dependence of absorbed oxygen on cyanide concentration from [4], we identified the following relations: $\alpha / C_m = g_1 + g_0/D^2 - \frac{\gamma_1}{AB}$ and $C_m = \frac{2}{B}\left(g_1 + g_0/D^2 - \frac{\gamma_1}{AB}\right) / \left(2\frac{\gamma_1}{AB} - 2\frac{g_0 A}{D^3} - g_1 - \frac{g_0}{D^2}\right)$, where A, B and D are constants. Thus parameters responsible for the rate of cyanide biodegradation are dependent on the parameters related to the respiratory activity of bacteria. In addition, we found that $\gamma_0 = g_1 - g_1 D - g_0 + g_0/D$. For other parameters, we identified the dependencies on the voltage of the pulsed electrical field (Fig 1). g_1 and γ_1 have linear dependence on voltage. Parameter a is not dependent on voltage. Also, we applied the aforementioned model and results to the cyanide biodegradation experiment in [4] after the re-normalization.

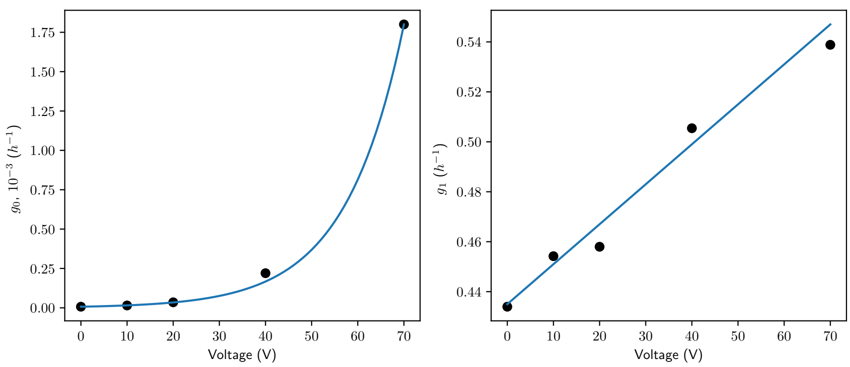

Figure 1: Dependencies of the system parameters on the voltage of pulsed electrical field

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[2] Harris R.E., Bunch A.W., Knowles C.J. Microbial cyanide and nitrile metabolism. *Sci. Prog., Oxf.,* **71**: 293 (1987).

[3] Podolska V.I., Ermakov V.N., Yakubenko L.N., *et al.* Effect of low-intensity pulsed electric fields on the respiratory activity and electrosurface properties of bacteria. *Food Biophysics*, **4**, 281 (2009).

[4] Yakubenko L.N., Podolska V.I., Vember V.E., Karamushka V.I. The influence of transition metal cyanide complexes on the electrosurface properties and energy parameters of bacterial cells, *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. **104**, 11 (1995)