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THE RELATION BETWEEN THE ELECTRIC RESPECTIVE MAGNETIC ENERGIES BY WHICH THE DRUGS OPERATE

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ABSTRACT. In a recent communication we have shown a new method for classifying the drugs. There are three classes of drugs, corresponding to three electric schemas: (1), (1^{*}) and (1^{**}). As criteria of classifying we have proposed the Thomson radial frequency of the series(1^{*}), respective parallel(1^{**}) circuit [1]. Consider a drug $D \in \left(1^{**}\right)$. The relation between the electric and magnetic energies is: $\left(E_D\right)_E, \max = R^2 \left(E_D\right)_B, \max \frac{C_p}{L_p}\left(\omega_1\right)$. Similar, for a drug $D \in \left(1^{*}\right)$ results: $\left(E_D\right)_E, \max = R^2 \left(E_D\right)_B, \max \frac{C_s}{L_s}\left(\omega\right)$ By ω_1 is denoted the resonance radial frequency. The *indexes p, s* indicate that the pseudo-capacitance, respective the pseudo-inductance are arranged in parallel, respective in series. The electric, respective magnetic energies take the maximum values.The drugs belonging to the class $\left(1^{**}\right)$, act both by magnetic and electric energy, i.e., they are superior as compared with those belonging to the class(1^{*}). This conclusion remains valid for the *antioxidant(A.O.)* respective *pro-oxidant(P.O.) drugs*, because the A.O-drugs $\in$ [$J^{**}_{A,O}$ drugs] $\in \left(1^{**}\right)$ and P.O-drugs $\in$ [$J^{*}_{P,O}$ drugs] $\in \left(1^{*}\right)$ belong to sub-classes of the classes(1^{*}), (1^{**})**.**

Keywords*: drug, multi-electrode, Thomson radial frequencies, antioxidant, pro-oxidant capacity*

INTRODUCTION

Bonciocat et al., have shown, in a series of papers, the faradaic current density of an electrode redox reaction occurring with combined limitations of charge transfer and non-stationary linear semi-infinite diffusion, is the solution of an integral equation of Volterra type [2-6]. By solving this equation, new methods of direct and cyclic voltammetry have been developed [7-17]. Very recently has been shown that the Electrochemical Impedance Spectroscopy method may have important applications in the drug research [18-23].

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Let's consider a drug $D \in \left(I^*\right)$. From the significance of the radial Thomson frequency $\omega_{Th,p} = \left[L_p(\omega_1) C_p(\omega_1)\right]^{-1/2}$ it results:

$$L_p(\omega_1)\, C_p(\omega_1) = \frac{1}{\omega_{Th,p}^2} \tag{1}$$

and from the physical significance of the criterion:

$$J^{**} = \frac{\left[\omega_{Th,p}\right]_0^2}{\left[\omega_{Th,p}\right]_0^2 - \omega_1^2} \qquad \text{results:}$$

$$L_p(\omega_1) C_p(\omega_1) = \frac{1}{\left[\omega_{Th,p}\right]_0^2} = \frac{1 - J^{**}}{\omega_1^2\, J^{**}} \tag{2}$$

We shall use the notations:

$$a = \frac{1}{\left[\omega_{Th,p}\right]_0^2}; \qquad b = \frac{1 - J^{**}}{\omega_1^2\, J^{**}} \tag{3}$$

as well as:

E_D = energy contained in a drug D

$(E_D)_E$ = electric energy contained in a drug D

$(E_D)_B$ = magnetic energy contained in a drug D

Then:

$$(E_D)_E = \frac{1}{2} C_p V^2 = \frac{1}{2} C_p (RI)^2 = \frac{1}{2} R^2 C_p I^2 = \frac{1}{2} R^2 \frac{a}{L_p} I^2 =$$

$$= \frac{1}{2} R^2 \frac{b}{L_p} I^2 = \frac{R^2}{2} \frac{C_p}{L_p} \frac{b}{C_p} I^2 \tag{4}$$

respective:

$$(E_D)_B = \frac{1}{2} L_p I^2 = \frac{1}{2} \frac{a}{C_p} I^2 = \frac{1}{2} \frac{b}{C_p} I^2 \tag{5}$$

and thus:

$$E_D = \frac{1}{2} \frac{b}{C_p} I^2 \left(1 + C_p \frac{R^2}{L_p}\right) \qquad (E_D)_E / (E_D)_B = R^2 \frac{C_p}{L_p} \tag{6}$$

Equations(6) lead to the following conclusions:

$\frac{C_p}{L_p}R^2 \langle 1 \quad \rightarrow (E_D)_E \langle (E_D)_B$ i.e., the drug acts firstly by magnetic field

$\frac{C_p}{L_p}R^2 = 1 \quad \rightarrow (E_D)_E = (E_D)_B$ i.e., the drug acts equally by electric and magnetic fields

$\frac{C_p}{L_p}R^2 \rangle 1 \quad \rightarrow (E_D)_E \rangle (E_D)_B$ i.e., the drug acts firstly by electric field

$R^2 \to 0 \quad \rightarrow (E_D)_E = 0$ i.e., the drug acts by magnetic field

$R^2 \to \infty \quad \rightarrow (E_D)_B = 0$ i.e., the drug acts by electric field

The last two conclusions of eqs.(6) show that these two classes of electrochemical cells needed to obtain the Nyquist diagrams. In the class(A) enter the cells adequate to analyze the drugs effects which act by their magnetic fields, while in the class(B) enter the cells adequate to analyze the drugs effects which act by their electric fields.

Therefore:

A) Pt | $K_3Fe(CN)_6$ / $K_4Fe(CN)_6$, (10^{-3}M), Drug, O_2 physically dissolved, KCl (in excess)

The presence of KCl (in excess) assures a value R_{sol} very small.

B) Pt | $K_3Fe(CN)_6$ / $K_4Fe(CN)_6$, (10^{-3}M), Drug, O_2 physically dissolved, KCl (absent)

Absence of KCl assures a value R_{sol} very great. It is very important to mention that the researches made with the 6 drugs and two mixtures of drugs have used cells of type (A) in order to obtain the Nyquist diagrams.

Therefore, the six drugs and two mixtures of drugs investigated, have proved to be antioxidant drugs and the criterion J^{**} have served to estimate their efficiency.

THEORETICAL SECTION

Further let's establish the relation between the quantities **a** and **b**.

For this, we shall elucidate the quantity **b,** by explaining the criterion J^{**} (see eq.(7) below).

It thus results:

$$\frac{1}{J^{**}} = 1 - \frac{\omega_1^2}{\left[\omega_{Th,p}\right]_0^2} \tag{7}$$

i.e.,

$$-\frac{1-J^{**}}{J^{**}}=\frac{\omega_1^2}{\left[\omega_{Th,p}\right]_0^2} \tag{7'}$$

from where:

$$b=\frac{1-J^{**}}{\omega_1^2\,J^{**}}=-\frac{\omega_1^2}{\omega_1^2\left[\omega_{Th,p}\right]_0^2}=-\frac{1}{\left[\omega_{Th,p}\right]_0^2} \tag{8}$$

Therefore the two quantities **a** and **b** are the one the opposite of the other.

Further using eqs.(4), (5), (6) one gets the conclusions:

$$\left(E_D\right)_B=\frac{1}{2}\frac{b}{C_p}I^2;\quad \left(E_D\right)_E=\frac{1}{2}R^2\frac{C_p}{L_p}\frac{b}{C_p}\,I^2 = 0 \text{ (because R = 0)}$$

$$E_D=\frac{1}{2}\frac{b}{C_p}I^2\left(1+R^2\frac{C_p}{I_p}\right) = \left(E_D\right)_B \text{ (because R = 0)}$$

From eq.(8) results:

$$\lim_{J^{**}\to-\infty} b=-\frac{1}{\omega_1^2} \tag{8'}$$

and from the expression (3) of **a**:

$$\lim_{[\omega_{Th,p}]_0\to\omega_1} a = \frac{1}{\omega_1^2} = -\lim_{J^{**}\to-\infty} b \tag{8''}$$

i.e., the relation $b=-a$ remains for the limiting values to which the quantities **a** and **b** tend corresponding to the resonance Thomson radial frequency:

$$\omega_1=res\;\omega_{Th,s}\left[\alpha_{D_i}^{*}\left(\omega_1\right)=0\right] = res\;\omega_{Th,p}\left[\alpha_{D_i}^{**}\left(\omega_1\right)=0\right]$$

when the two drugs $D_i\in\left(1^{*}\right)$ respective $D_i\in\left(1^{**}\right)$ have maximum therapeutic effects.

Using the relation (8) results:

$$\frac{b}{a}=\frac{1-J^{**}}{\omega_1^2\,J^{**}}\cdot\left[\omega_{Th,p}\right]_0^2 = \frac{1-J^{**}}{\omega_1^2\,J^{**}}\omega_1^2\left[1-\alpha_D^{**}\left(\omega_1\right)\right] =$$

$$\frac{1-J^{**}}{J^{**}}\left[1-\alpha_D^{**}(\omega_1)\right] \tag{9}$$

i.e.,

$$\frac{b}{a}\left[\alpha_D^{**}(\omega_1)=0\right]=\frac{1-J^{**}}{J^{**}}=-1$$

i.e., for :

$$J^{**}=-\infty \qquad \rightarrow \qquad J^{**}[\ \alpha_D^{**}(\omega_1)=0] = -\infty \tag{9'}$$

but also:

$$J^{**}[\ \alpha_D^{**}(\omega_1)=0] = \infty \tag{9''}$$

i.e.,

$$|J^{**}[\ \alpha_D^{**}(\omega_1)=0\ ]| = \infty \tag{9'''}$$

The relation (9''') is general, i.e., it is valid irrespective of the values that quantities ***a*** and ***b*** may have.

The magnetic energy content in a drug $D\in\left(1^{**}\right)$

We shall use the eqs.(8') and (8'') to express the magnetic energy content in a drug $D\in\left(1^{**}\right)$ corresponding to resonance Thomson radial frequency.

It thus results:

$$\lim_{[\omega_{Th,p}]_0\rightarrow\omega_1}(E_D)_B = \lim_{[\omega_{Th,p}]_0\rightarrow\omega_1}\left(\frac{1}{2}\cdot\frac{a}{C_p}I^2\right) = \frac{1}{2}\cdot\frac{I^2}{C_p}\lim_{[\omega_{Th,p}]_0\rightarrow\omega_1} a = \frac{1}{2\omega_1^2}\cdot\frac{1}{C_p}I^2 \tag{10}$$

or:

$$\lim_{J^{**}\rightarrow-\infty}(E_D)_B = \lim_{J^{**}\rightarrow-\infty}\left(\frac{1}{2}\cdot\frac{b}{C_p}I^2\right) = \frac{1}{2}\cdot\frac{I^2}{C_p}\lim_{J^{**}\rightarrow-\infty} b = -\frac{1}{2}\cdot\frac{I^2}{C_p}\cdot\frac{1}{\omega_1^2} = -\frac{1}{2\omega_1^2}\frac{I^2}{C_p} \tag{10'}$$

the two limiting values being one the opposite of the other, i.e.,

$$\lim_{[\omega_{Th,p}]_0\rightarrow\omega_1}(E_D)_B = -\lim_{J^{**}\rightarrow-\infty}(E_D)_B \tag{10''}$$

Therefore one may write:

$$\left|\lim_{[\omega_{Th,p}]_0\rightarrow\omega_1}(E_D)_B\right| = \left|\lim_{J^{**}\rightarrow-\infty}(E_D)_B\right| = \frac{1}{2\omega_1^2\,C_p}I^2 \tag{11}$$

$$[\omega_{Th,p}]_0 \rightarrow \omega_1 \qquad J^{**} \rightarrow -\infty$$

and afterwards, expressing the pseudo-capacity $C_p(\omega_1)$ in function of the Warburg pseudo-capacity $C_W(\omega_1)$.

$$\left|\lim(E_D)_B\right| = \left|\lim(E_D)_B\right| = \frac{1}{2\omega_1^2 \cdot \dfrac{C_w(\omega_1)}{\alpha_D^{**}(\omega_1)}} I^2 = \frac{\alpha_D^{**}(\omega_1)}{2\omega_1^2 C_W(\omega_1)} I^2$$

$$[\omega_{Th,p}]_0 \rightarrow \omega_1 \qquad J^{**} \rightarrow -\infty$$

$$\alpha_D^{**}(\omega_1) \langle 1 \tag{11'}$$

It remains to establish the values which must be putted in eq.(11') instead of the quantities $\alpha_D^{**}(\omega_1)$ and $C_w(\omega_1)$.

For this purpose we shall use the relation :

$$1 - \frac{1}{\alpha_D^{**}(\omega_1)} = m = \frac{R_{sol} + A_{ct} - \left(R_{sol} + A_{ct}^{**}\right)}{R_W^{**}(\omega_1)} = \frac{R_{sol} + A_{ct} - \left(R_{sol} + A_{ct}^{**}\right)}{0.446\, B_d^{**}} \tag{12}$$

where by B_d^{**} we have noted the ω independent part of a Warburg diffusion resistance $R_w^{**}(\omega_1)$ given by the relation [18, 19] :

$$R_W^{**}(\omega_1) = \frac{B_d^{**}}{2\omega_1^{1/2}} = 0.446\, B_d^{**} \qquad \text{(because } \omega_1 \text{ = 1.256 s}^{-1}\text{)}.$$

The expressions of the three quantities which enter in the last part of eq.(12) are:

$$R_{sol} + A_{ct} = \left[\ \mathrm{Re}(\omega_2) - \frac{\mathrm{Re}(\omega_1) - \mathrm{Re}(\omega_2)}{0.122}\ \right] \tag{13}$$

$$R_{sol} + A_{ct}^{**} = \left[\ \mathrm{Re}^{**}(\omega_2) - \frac{\mathrm{Re}^{**}(\omega_1) - \mathrm{Re}^{**}(\omega_2)}{0.122}\ \right] \tag{13'}$$

$$B_d^{**} = 20.6\ \left[\mathrm{Re}^{**}(\omega_1) - \mathrm{Re}^{**}(\omega_2)\right] \tag{13"}$$

where $\mathrm{Re}(\omega_1)$, $\mathrm{Re}(\omega_2)$ respective $\mathrm{Re}^{**}(\omega_1)$, $\mathrm{Re}^{**}(\omega_2)$ represent the *mean values* of the abscissa of the first two points:

$$P_1(\omega_1) = P_1\left(1.256\ s^{-1}\right) \qquad P_2(\omega_2) = P_2\left(1.582\ s^{-1}\right)$$

respective,

$$P_1^{**}(\omega_1) = P_1^{**}\left(1.256\ s^{-1}\right) \qquad P_2^{**}(\omega_2) = P_2^{**}\left(1.582\ s^{-1}\right)$$

of the Nyquist diagrams: $-\mathrm{Im}(\omega)$ vs $\mathrm{Re}(\omega)$, respective $-\mathrm{Im}^{**}(\omega)$ vs $\mathrm{Re}^{**}(\omega)$ made for the reference dielectrode (DRR), respective multi-electrode $(ME)_D^{**} = (DRR)$ containing the drug $D \in (1^{**})$.

Once **the value m** estimated, using eq.(13), the first part of eq.(12) leads to the estimation of $\alpha_D^{**}(\omega_1)$ by equation:

$$\alpha_D^{**}(\omega_1) = \frac{1}{1-m} \tag{14}$$

It remains to estimate the Warburg pseudo-capacity $C_W(\omega_1)$.

As one knows, for very small radial frequencies (as it is the case of the radial frequency $\omega_1 = 1.256 s^{-1}$) the Faraday impedance Z_F becomes the Warburg impedance Z_W, which in the complex plane makes an angle of 45^0 with both the real and imaginary axes. The Warburg pseudo-capacity $C_W(\omega_1)$ introduces a capacity reactance $X_{C_w(\omega_1)}$ situated in the long of imaginary axes and having the expression:

$$X_{C_w(\omega_1)} = -R_w(\omega_1)\cdot j$$

It thus results:

$$tg\left(45^0\right) = 1 = R_w(\omega_1)/X_{C_w(\omega_1)}$$

Taking into account the relation between a capacity C and her capacity reactance X_C, i.e., $C = \frac{1}{\omega|X_C|}$ it follows:

$$C_W(\omega_1) = \frac{1}{\omega_1 R_w^{**}(\omega_1)} = \frac{1}{\omega_1 \cdot 0.446\, B_d^{**}} = \frac{3.571}{B_d^{**}} \tag{15}$$

Further, introducing in eq.(11') the expressions obtained for $\alpha_D^{**}(\omega_1)$ and $C_W(\omega_1)$ results:

$$\left|\lim (E_D)_B\right| = \left|\lim (E_D)_B\right| =$$

$$\left[\omega_{Th,p}\right]_0 \to \omega_1 \qquad J^{**} \to -\infty$$

$$= \frac{\alpha_D^{**}(\omega_1)}{2\omega_1^2\, C_W(\omega_1)} I^2 = \frac{\frac{1}{1-m}}{2\omega_1^2 \cdot 3.571} \cdot B_d^{**} I^2 \cong 0.18 \frac{B_d^{**}}{(1-m)} I^2 \tag{16}$$

In The International System (S I) the magnetic energies of drugs must be expressed in J (Joule). To verify this let's fix to the first expression from eq.(16).

$\alpha_D^{**}(\omega_1)$ is a number; ω_1^2 expresses in s^{-2}; $C_W(\omega_1)$ being a capacity expresses in C/V (i.e., coulomb/ volt); I in C/s (i.e., coulomb/ second). It thus results that the quotients from eq.(16) express in $\frac{C^2/s^2}{s^{-2}\cdot C/V} = C\cdot V$ (i.e., coulomb volt), i.e., in J (Joule).

[referring to the expression: $[\frac{\alpha_D^{**}(\omega_1)}{2\omega_1^2 C_W(\omega_1)}\cdot I^2]$].

EXPERIMENTAL SECTION

From eqs.(16) results that a drug which acts by magnetic energy will have a greater therapeutic effect if its magnetic energy will be closer to the its maximum magnetic energy, corresponding to the resonance radial frequency ω_1, when:

$[\omega_{Th,\,p}] \to \omega_1$, respective the criterion $J^{**} \to -\infty$, i.e.,

$$\left|\lim\left(E_D\right)_B\right| = \left|\lim\left(E_D\right)_B\right| \cong 0.18\,\frac{B_d^{**}}{(1-m)}\,I^2 \qquad (17)$$

$[\omega_{Th,p}]_0 \to \omega_1 \qquad J^{**} \to -\infty$

where the quantities **m** and B_d^{**} are obtained by eqs.(13) and I is given in: coulomb /s = Ampere(A).

The conclusions of the experiences made with the all 6 drugs and 2 mixtures of drugs are:

- all drugs investigated belong to the class (1^{**}), more exactly to the sub-class of the antioxidant drugs $J_{A-D} \subset (1^{**})$ in accord with J^{**} criterion;

- all drugs investigated act by their magnetic energies;

- the obtained values of J^{**} criterion lead to the following sequence of their therapeutic effects, in accord with the sequence given by relation(17):

$$|J_{Am}^{**}|<|J_B^{**}|<|J_{Cf2}^{**}|<|J_{Uh+Am}^{**}|<|J_{Uh1}^{**}|<|J_{B+Am+Cf+Uh}^{**}|<|J_{Uh2}^{**}|<|J_{Cf1}^{**} \qquad (18)$$

where:

B	=	Sweedish Bitter
Am	=	Achillea millefolium
Cf	=	Calendulae flos
Uh	=	Urticae herbe
M_1	=	Uh +Am
M_2	=	B + Am + Cf + Uh

Comparison between the electric, respective magnetic energies by which the drugs belonging to the classes $\left(1^{**}\right)$ respective $\left(1^{*}\right)$ operate.

Consider a drug: $D \in \left(1^{**}\right)$. Then:

$$\left(E_D\right)_E = \frac{1}{2} C_p V^2 = \frac{1}{2} C_P R^2 I^2 \quad \text{respective:} \quad \left(E_D\right)_B = \frac{1}{2} L_p I^2 \tag{19}$$

Thus:

$$\left(E_D\right)_E = R^2 \left(E_D\right)_B \cdot \frac{C_p}{L_p}(\omega) \tag{19'}$$

equation valid for $\omega = \omega_1$ too, i.e.,

$$\left(E_D\right)_E, \max = R^2 \left(E_D\right)_B, \max \frac{C_p}{L_p}(\omega_1) \tag{20}$$

For a drug $D \in \left(1^{*}\right)$ the equations are:

$$\left(E_D\right)_E = \frac{1}{2} C_s V^2 = \frac{1}{2} C_s R^2 I^2 \quad \text{respective} \quad \left(E_D\right)_B = \frac{1}{2} L_s I^2 \tag{21}$$

Thus :

$$\left(E_D\right)_E = R^2 \left(E_D\right)_B \cdot \frac{C_s}{L_s}(\omega) \tag{21'}$$

equation valid for $\omega = \omega_1$ too, i.e.,

$$\left(E_D\right)_E, \max = R^2 \left(E_D\right)_B, \max \frac{C_s}{L_s}(\omega_1) \tag{22}$$

The indexes **p, s** indicate that the Warburg pseudo-capacity is replaced by a pseudo-inductance, respective pseudo-capacity arranged in parallel, respective in series.

Further, using the expressions obtained for $C_p(\omega)$, $L_p(\omega)$ respective $C_s(\omega)$, $L_s(\omega)$, where $C_p(\omega) = C_W^{**}(\omega)$, $L_p(\omega) = L^{**}(\omega)$, respective $C_s(\omega) = C_W^{*}(\omega)$, $L_s(\omega) = L^{*}(\omega)$, one gets:

$$\frac{C_p}{L_p}(\omega) = \omega \left\{ \frac{C_W(\omega)}{\alpha_D^{**}(\omega)} \right\}^2 \cdot \left[1 - \alpha_D^{**}(\omega)\right] \tag{23}$$

respective:

$$\frac{C_s}{L_s}(\omega) = \omega C_W^2(\omega) \left[\alpha_D^{*}(\omega)\right]^2 \cdot \frac{1}{1 - \alpha_D^{*}(\omega)} \tag{23'}$$

equations which for the resonance radial frequency ω_1 (when $\alpha_D^*(\omega_1)=\alpha_D^{**}(\omega_1)=0$) become:

$$\frac{C_p}{L_p}(\omega_1)\cong\omega_1\left\{\frac{C_W(\omega_1)}{\alpha_D^{**}(\omega_1)}\right\}^2 \qquad \text{respective}$$

$$\frac{C_s}{L_s}(\omega_1)=\omega_1\,C_W^2(\omega_1)\left[\alpha_D^*(\omega_1)\right]^2 \tag{24}$$

and replacing in eq.(20), respective eq.(22) results:

$$(E_D)_E,\max = R^2(E_D)_B,\max\ \omega_1\left[\frac{C_W(\omega_1)}{\alpha_D^{**}(\omega_1)}\right]^2;\qquad D\in\left(1^{**}\right) \tag{25}$$

respective:

$$(E_D)_E,\max = R^2(E_D)_B,\max\ \omega_1\left[\ C_W(\omega_1)\,\alpha_D^*(\omega_1)\right]^2;\qquad D\in\left(1^{*}\right) \tag{25'}$$

Because $\alpha_D^*(\omega_1)=\alpha_D^{**}(\omega_1)$ tend to zero, eqs. (25), (25') lead to the conclusions:

$$(E_D)_E,\max \rangle\rangle\ \omega_1 R^2\,(E_D)_B,\max \qquad \text{for}\quad D\in\left(1^{**}\right) \tag{26}$$

$$(E_D)_E,\max \langle\langle\ \omega_1 R^2\,(E_D)_B,\max \qquad \text{for}\quad D\in\left(1^{*}\right) \tag{26'}$$

The inequalities (26), (26') show the superiority of the drugs belonging to the class $\left(1^{**}\right)$ because these drugs act both by magnetic and electric energies while those belonging to the class $\left(1^{*}\right)$ act very few by electric energy. At resonance (i.e., for $\omega=\omega_1$) these energies take the maximum values $(E_D)_B,\max$, respective $(E_D)_E,\max$, the energy $(E_D)_E,\max$ being very small as compared with $(E_D)_B,\max$ (see eq.(26')) for drug $D\in\left(1^{*}\right)$, respective very great as compared to $(E_D)_B,\max$ (see eq.(26)) for drug $D\in\left(1^{**}\right)$.

Finally, it has been shown that the antioxidant drugs belong to a sub-class $J_{A.O.}^{**}$ of the class $\left(1^{**}\right)$ while the pro-oxidant drugs belong to a sub-class $J_{P.O.}^{*}$ of the class $\left(1^{*}\right)$. It follows that the inequalities (26), (26') hold true for these drugs, i.e.,

$$(E_D)_E,\max \rangle\rangle\ \omega_1 R^2\,(E_D)_B,\max\ ;\qquad D\in J_{A.O.}^{**}\subset\left(1^{**}\right) \tag{27}$$

$$(E_D)_E,\max \langle\langle\ \omega_1 R^2\,(E_D)_B,\max\ ;\qquad D\in J_{P.O.}^{*}\subset\left(1^{*}\right) \tag{27'}$$

CONCLUSIONS

Equations(27), (27') *lead to the following very important conclusions concerning the anti-oxidant and pro-oxidant drugs.*

- An antioxidant drug acts both by magnetic and electric energies; $(E_D)_B$, $(E_D)_E$

- At resonance (i.e., at the radial frequency $\omega_1 = 2\pi\nu_1$, where $\nu_1 = 0{,}2s^{-1}$ represents the smallest frequency used by the electronic instrument in getting the Nyquist plots, and thus $\omega_1 = 1{,}256s^{-1}$. These energies take the maximum values: $(E_D)_B, \max$, $(E_D)_E, \max$.

- The pro-oxidant drugs act very few by electric energy, because $(E_D)_E, \max$ is very small as compared with $(E_D)_B, \max$.

- The antioxidant drugs act both by electric and magnetic energies, *the contribution of electric energy being very important*, because $(E_D)_E, \max$ is very great as compared with $(E_D)_B, \max$.

The last two conclusions explain the superiority of the anti-oxidant drugs.

Another advantage of an antioxidant drug, comes from the fact that when an electric field disappears (i.e., the intensity of the electric field goes to zero), a magnetic field appears, and similarly when the magnetic field disappears, an electric field appears.

In this way, an oscillation of the two energies appears: electric energy→magnetic energy→ electric energy→. During this oscillation, the antioxidant drugs act permanently, while the pro-oxidant drugs, only when the energy is magnetic.

To explain how an antioxidant(A.O.) drug acts, let's start by remembering the reactions of the RRD-dielectrode. They are:

$\frac{1}{4}O_2 + H^+ + e \rightarrow \frac{1}{4}H_2O$ cathodic reaction

$[Fe(CN)_6]^{2-} \rightarrow [Fe(CN)_6]^{3-} + e$ anodic reaction

The electrons resulted by the oxidation of $[Fe(CN)_6]^{4-}$ are consumed by the reduction of $\frac{1}{4}O_2 + H^+$ to $\frac{1}{2}H_2O$. Therefore $\frac{1}{4}O_2 + H^+$ acts as an oxidizer of $[Fe(CN)_6]^{4-}$. It thus results that an A.O.-drug reduces the oxidation effect of $\frac{1}{4}O_2 + H^+$ by consuming a part of the electrons resulted by the oxidation of $[Fe(CN)_6]^{4-}$ to $[Fe(CN)_6]^{3-}$.

Thus, the important effect of an A.O-drug is the reduction of the intensity of the important oxidation reaction.

As for the P.O-drug, *the important effect is the increase of the intensity of the important oxidation reaction.*

Finally, it is very important to underline that, presently are known many oxidation reactions, occurring in biological systems, about which one supposes that are at the origin of many illnesses, and for this reason, the development of experimental methods for estimating the therapeutic efficiencies of the A.O.drugs, represents the most important aim of the future researchers in the domain of biological and pharmaceutical sciences.

From this point of view, one may conclude that the two EIS methods presented at Journees d'Electrochimie 2009 [1] and RICCCE 2009 [23] have the necessary conditions for playing a very important role for a scientific classifications of drugs produced by the chemical industry, or taken from the God Pharmacy(i.e., by an adequate transforming of the medicinal plants).

Unfortunately, such an action necessitates 4-5 years and a team of researchers in which must enter electrochemists, biochemists, physicists and specialists in medicinal plants. Although such an action implies so many difficulties, it must be done, because the results that will be obtained, will justify the efforts, and what it is much more important will decide the directions in which the future developments of the medicinal sciences in Romania must be done.

This also explains the importance of the criteria:

$$[\omega_{Th,p}]_0 = \omega_1\sqrt{1-\alpha_D^{**}(\omega_1)}; \quad [\omega_{Th,s}]_0 = \omega/\sqrt{1-\alpha_D^{*}(\omega_1)}$$

$$0 \le \alpha_D^{**}(\omega_1) \le 1;\ 0 \le \alpha_D^{*}(\omega_1) \le 1$$

for the classification of drugs belonging to the classes (1^{**}) respective (1^{*}) and of the criteria:

$$J^{**} = \frac{[\omega_{Th,p}]_0^2}{[\omega_{Th,p}]_0^2 - \omega_1^2}; \quad J^{*} = \frac{\omega_1}{[\omega_{Th,s}]_0} \qquad -\infty \le J^{**} \le 0; \qquad 0 < J^{*} < 1$$

for the classification of A.O-drugs, respective P.O-drugs.

These four criteria will be necessary for the future development of drug-sciences not only in Romania, but also in the world.

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