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Magnetoelectric Studies on Curcumin : Analysis of Voltage and Conductivity in Electrochemical Mediums Based Fuzzy Logic

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Abstract *In the curcumin compound there are aromatic compounds that have electronic spins on each side of the benzene. In previous research, the concentration of curcumin and H_2O as coatings on copper coils could provide physical changes to the characteristics of copper coils, namely increasing the strength of the magnetic field and increasing the electric current in the coil. The fuzzification process can be described using membership variables with concentrations of curcumin and H_2O as input, magnetic field strength and current as output. It is known that the greatest concentration of curcumin indicates increased magnetic field strength and electric current. Simulation of the aromatic spin on the curcumin compound as an Op Amp shows that the highest curcumin concentration value results in an increase in the output voltage (V_{out}).*

Keywords *: Curcumin Concentration, Copper Winding, Op Amp,Fuzzy Logic*

1. INTRODUCTION

Modern synthetic biology has been reinvented as an engineering discipline to design new organisms as well as to better understand fundamental biological mechanisms. Here, we review six principles of living systems and how they compare and contrast with engineered systems.[1] One technology that can be represented by biological behavior is electronic instruments. Several electronic circuit designs and devices including oscillators[2], latches, logic gates, logarithmic linear circuits, and load drivers were designed and ported to biological systems and applications[3]. However, operational amplifiers (OpAmps), which are the fundamental and most popular electronic devices in negative feedback and regulation loops[4], have never been transferred to biology. Here we demonstrate the design and construction of a biological operational amplifier (Bio-OpAmp), which achieves precise, robust, and controllable molecular homeostasis through three stages of amplification and global negative feedback. Homeostasis is a ubiquitous phenomenon in biological systems with broad applications in biotechnology and medicine [5]. OpAmp implements a simple circuit building block in which the voltage difference of the two control inputs is amplified with a large gain and reported at the output terminal. This simple circuit becomes very powerful when connected to components in a negative feedback loop. In such a configuration, it enables powerful and precise analog computing such as weighted summation, inverting and non-inverting amplification, as well as integration despite variations in OpAmp parameters[6].

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Fig. 1. Energy path in the aromatic ring of benzene

In Fig.1, the aromatic benzene ring in curcumin compounds in general, cyclic polyenes are only closed shell (each electron paired up) and extra stable for with (4n+2) π electrons (n=0,1,2…). These special molecules have the highest delocalization energies and are said to be aromatic. For benzene this is the energy by which the delocalized electrons in benzene [7]–[9] are more stable than those in three isolated double bonds. In experiments with coating concentrations of curcumin onto copper coils, it was proven that curcumin compounds can increase the strength of the magnetic field and electric current in the coil. This is due to the electron spin in the aromatic ring of the curcumin element which generates electrons on each side of the π.

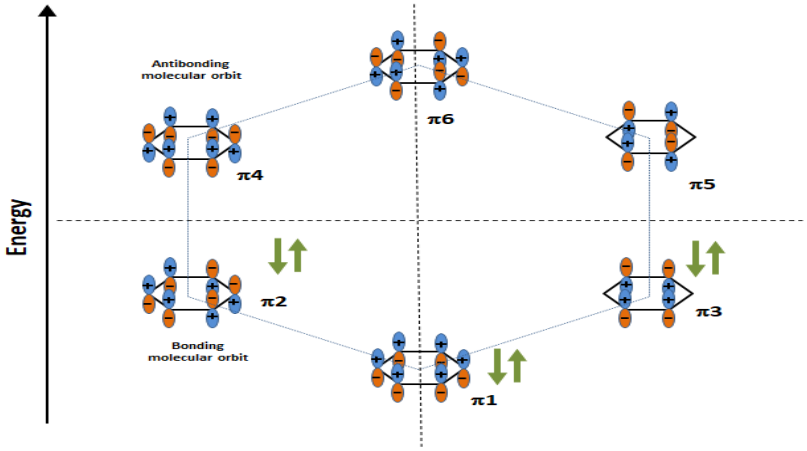


Fig 2. Energy level of the aromatic benzene ring in curcumin for 6π orbital members

Each p orbital overlaps equally with both adjacent orbitals creating a cyclic overlap involving all six p orbitals[10]–[12]. This allows the p orbitals to be delocalized in elongated molecular orbitals around the ring allowing more overlap than obtained from the linear 1,3,5-hexatriene equivalent. For this to happen, of course, the ring must be planar– otherwise the p orbitals cannot overlap properly and benzene is known as a flat molecule. The electrostatic

potential map of benzene, shown below, shows that the pi electrons are evenly distributed around the ring and each carbon is equal. The plus and minus signs shown in the diagram do not represent electrostatic charges, but refer to the phase signs in the equations that describe these orbitals (in the diagram, the phases are also color coded). When phases correspond, the orbitals overlap to produce a general region of similar phases, with the orbital that has the greatest overlap (e.g. π1) having the lowest energy. The remaining carbon valence electrons then occupy these molecular orbitals in pairs, resulting in a set of completely filled bonding molecular orbitals (6 electrons) [7], [11].In Figure 1.2, the curcumin molecule is constantly spinning, producing energy that flows through the bonds in a stable manner. This can be illustrated that the energy is assumed to be an inverting and non-inverting op Amp adder. Op Amps ideally have infinite input impedance and gain and output impedance equal to zero. In fact, op amps have quite large input impedance and gain and small output impedance[13] .

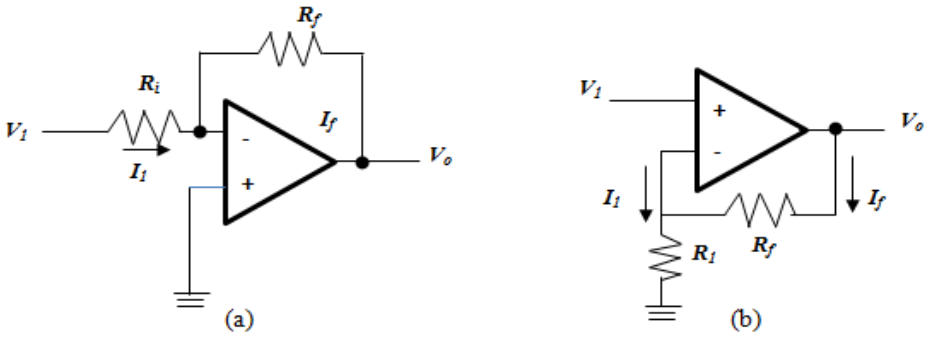


Fig. 3. (a) Inverting Op Amp, (b) Non Inverting Op Amp

In the op amp in Figure 3(a), this type of amplifier has a special characteristic, namely that the output signal has a phase difference of 180°. An ideal amplifier has the condition that the input voltage = 0 and the input impedance is infinite. The strengthening formula is [9], [14], [15]:

$$I_1 + I_f = I_{(-)} \quad (1)$$

Where the $i_{(-)} = 0$, then :

$$I_f = -I_1 \quad (2)$$

$$I_f = \frac{V_{out}}{R_f} \quad (3)$$

$$I_{in} = \frac{V_{in}}{R_i} \quad (4)$$

Equation (3) and (4) substituted into:

$$\frac{V_{out}}{R_f} = \frac{V_{in}}{R_{in}} \quad (5)$$

$$V_{out} = -\frac{R_f}{R_{in}} V_{in} \quad (6)$$

The (-) sign indicates that there is a reversal at the output or that it has a phase difference of 180° with the input. In Figure 3b, the output signal of this non-inverting amplifier is in phase with the input signal. As in the inverting amplifier, the ideal gain is if the input voltage = 0 volts and the input impedance is infinite, so that the circuit can be stated.

$$V_{(-)} = V_{(+)} = V_{in} \quad (7)$$

$$I_f = \frac{V_{out} - V_{in}}{R_f} \quad (8)$$

$$I_{in} = -\frac{V_{in}}{R_{in}} \quad (9)$$

Equations 8, 9 are substituted:

$$\frac{V_{out} - V_{in}}{R_f} = \frac{V_{in}}{R_{in}} \quad (10)$$

$$V_{out} = \left(\frac{R_f}{R_{in}} + 1\right) V_{in} \quad (11)$$

2. METHOD

The research method is to carry out (a) experiments on preparing curcumin and H2O compounds at percentage concentrations of 100%:0%, 90%:10%, 80%:20%, 70%:30%, 60%:40%, 50%:50 %, 40%:60%, 30%:70% and 20%:80%, 10%:90% with a volume of 100 ml each. Then measure the output voltage value of each concentration. Next, prepare the circuit as in Figure 3 below. (b) Simulate the circuit with Multisim 14.0 as in Figure 3, (c) Fuzzification the concentration of curcumin on the influence of strong magnetic fields and electric currents in the copper winding.

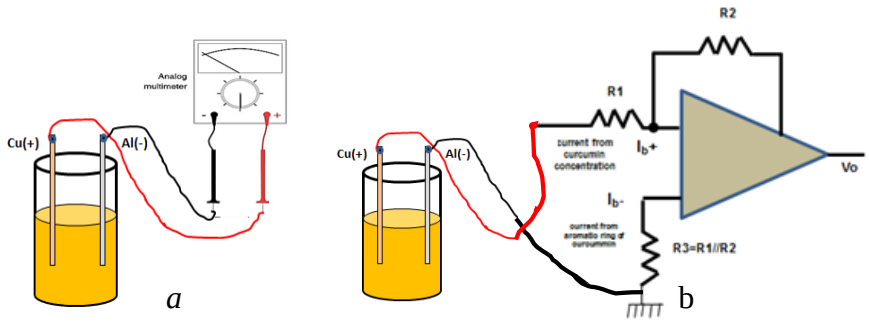


Fig. 4. Method of measuring voltage of curcumin concentration[16], [17]**, a. Voltage measurement of curcumin concentration with a voltmeter; b. Testing voltage adders with Op Amps**

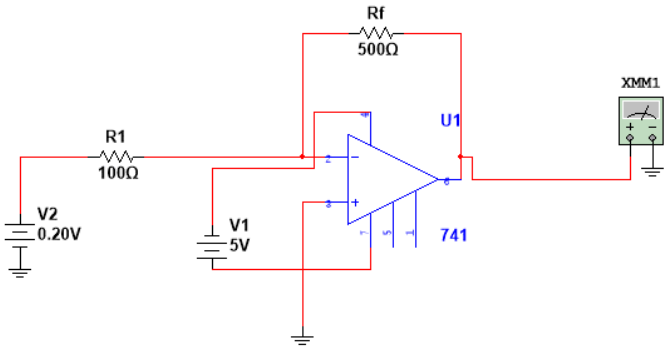


Figure 5. Modeling of Curcumin and an Inverting OpAmp Adder [18]

Fuzification Method

Describe the effect of Curcumin:H_2O concentration on the influence of magnetic field strength and current values in the copper coil, simple fuzzy logic can be used, which can describe curcumin and H_2O as input and magnetic field strength and current as output. Fuzzy variables in input and output use categories: NB (Negative Big), NS (Negative Small), Z (Zero), PS (Positive Small) and PB (Positive Big).[19],[20]

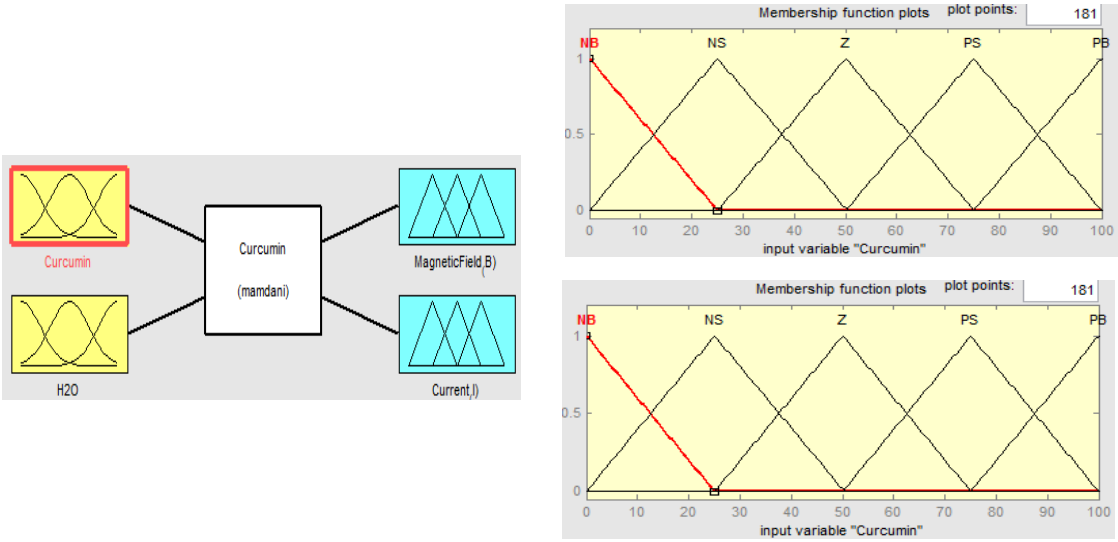


Figure 6. (a). FIS Editor Membership, (b) Fuzzy Variable

3. RESULTS AND DISCUSSION

From the method based on Figure 5, the voltage measurement results obtained at the concentration of Curcumin: H_2O: (100%:0) shows a voltage value of 0.85 volts, 80%:20% shows a value of 0.65 volts, 60%:40% shows a voltage value 0.45 volts, at a concentration of 40%:60% shows a voltage value of 0.30 volts and at a concentration of 20%:80 shows a voltage value of 0.20 volts. Calculations based on Figure 5 can be analyzed using equation (2):

$$V_o = -\left[\frac{500}{100} x\ 0.65\right] = 3.25 \text{ volt}$$

$V_o = -\left[\frac{500}{100} x\ 0.45\right]$ = 2.25 volt

$V_o = -\left[\frac{500}{100} x\ 0.30\right]$ = 1.50 volt

$V_o = -\left[\frac{500}{100} x\ 0.20\right]$ = 993,706 mV

From the voltage measurements (V_{out}) in the multisim simulation in Figure 5, the following table can be seen:

Table 1. V_{out} measurement results using Multisim simulation

Cur	*H_2O*	*V_{in} (volt)*	*V_{out} (volt)*
100%	0	0.72	3,60
90%	10%	0.70	3,50
80%	20%	0.65	3,25
70%	30%	0.55	2,75
60%	40%	0.45	2,24
50%	50%	0.35	1,75
40%	60%	0.30	1,49
30%	70%	0.22	1,10
20%	80%	0.20	0,99
10%	90%	0.09	0,45
0%	100%	0	0

From the calculation results of equation (2) and the results of multisim measurements, it shows that the highest concentration of curcumin:H_2O (100%: 0%) has a V_{in} value of 0.72 volts and a V_{out} OpAmp voltage of 3.60 Volts.

From the voltage measurements (V_{out}) in the multisim simulation in Figure 7, the following table can be seen:

Table 2. V_{out} measurement results using Multisim simulation

Cur	*H_2O*	*V_{in} (volt)*	*V_{out} (volt)*
100%	0	0.72	2,679
90%	10%	0.70	2,677
80%	20%	0.65	2,675
70%	30%	0.55	2,674
60%	40%	0.45	2,672
50%	50%	0.35	2,671
40%	60%	0.30	2,670
30%	70%	0.22	2,660
20%	80%	0.20	2.654

10%	90%	0.09	2,500
0%	100%	0	2,000

Fuzzy Process Results

The rules used in fuzzy can be seen in the following table 3 [23]:

Table 3: Fuzzy Rules for Concentration of Curcumin:H_2O in copper and Magnetic Field -Current Output

Curc-H_2O / B-I	NB	NS	Z	PS	PB
NB	NB	NB	NB	PS	PB
NS	NS	NS	NS	PS	PB
Z	Z	Z	Z	PS	PB
PS	Z	Z	Z	PS	PS
PB	Z	Z	Z	PS	PS

B = magnetic field, I = Current

From the applied fuzzy rules, it shows that the highest concentration of Curcumin:H_2O results in the value of the magnetic field strength and electric current increasing by the same percentage. For more details, see the following rule:

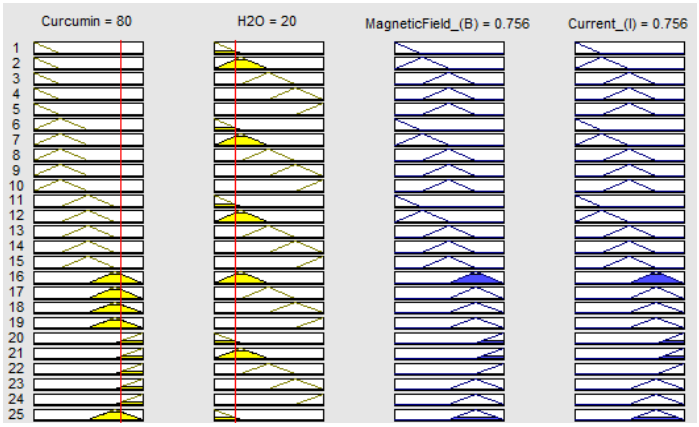


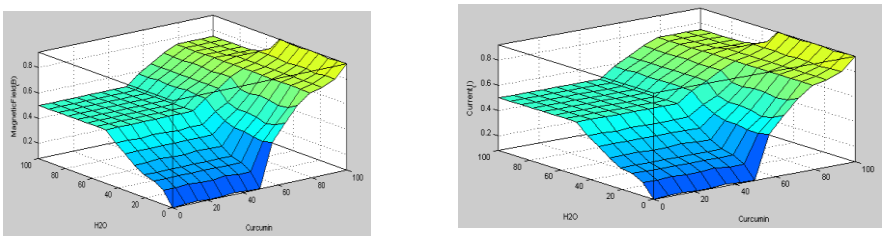
Figure 7. Fuzzification Rules Curcumin Concentration:H_2O

From Figure 8, it can be stated that the largest percentage of curcumin compared to H_2O produces the largest values of magnetic field strength and electric current. From the fuzzy rules, the value of curcumin concentration: H_2O produces a linear magnetic field strength and current which has a linear percentage increase, as in table 4.

Table 4: Curcumin:H_2O Concentration and Magnetic Field and Current values

Concentration		Magnetic Field (B)	Current(I)
Curcumin (%)	H_2O (%)		
10	90	0,500	0,500
20	80	0,500	0,500
30	70	0,500	0,500
40	60	0,500	0,500
50	50	0,510	0,510
60	40	0,511	0,507
70	30	0.624	0,620
80	20	0.756	0,756
90	10	0.797	0,797
100	0	0.920	0,922

Figure 8 shows the surface of the fuzzy logic process of the fuzification process of Curcumin:H_2O concentration on magnetic field strength (B) and electric current (I).



(a) **(b)**

Figure 8. Surface Fuzification Concentration of Curcumin:H_2O, (a) Magnetic Field Strength effect, (b) Electric Current Effect

From the explanation regarding the implementation of the curcumin:H_2O concentration add with Op Amp, it can be proven by the results of voltage measurements at liquid curcumin concentrations and simulations using Multisim prove that the largest curcumin concentration produces the largest V_{out}. In the fuzification process, by determining several membership variables it was found that the highest concentration of curcumin produced the highest values of magnetic field strength and electric current in the copper winding.

The implementation of the use of curcumin concentration on copper, which is simulate with OpAmp as biomaterial elements, this is still a preliminary study that needs to be discussed further to examine more deeply the benefits of curcumin concentration in increasing the efficiency of magnetic field strength in copper coils in electronic applications.

4. CONCLUSION

The aromatic ring in curcumin has rotating electrons on each side, and the electron donation in the copper winding. The electron donation from the two aromatic rings is added with Op Amp which can strengthen the output voltage in the copper winding. The largest percentage concentration of curcumin produces increased current values and also the strength of the magnetic field around the live copper coil.

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