SOME ASPECTS REGARDING LOW INTENSITY MICROWAVE ELECTROMAGNETIC FIELD INFLUENCE ON AQUEOUS SOLUTIONS

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Abstract: *This article presents some aspects regarding the influence of the low intensity microwave electromagnetic field on aqueous solutions in which there is electric load as ions. The theoretical concept of the analysis method is exposed joined by the experimental results obtained in the frequency band 1200-1800 MHz on aqueous solutions with pH between 2-13. In the article there are presented only the partial results of the pH modifications in the electromagnetic field of microwaves, the matter being under research.*

Key words: *microwave, radiation, pH, ionization, deionization.*

1. Introduction

Microwave electromagnetic field is used as information carrier in fixed and mobile communications, satellite and terrestrial television systems, wireless computer networks, radio control systems in automation, measurement techniques and systems. The radiant fields are generally of low intensity and they dominate the ambient space.

If in radiated zone there are substances that contain aqueous solutions they are submissive to the specific effects of the microwave, most of these are:

- the heating effect in volume if in the watery solution free ions exist;
- the effect of ionization-deionization of the solution under radiant field influence.

Both mentioned effects determine the *pH* modification of the respective solution.

At the cessation of the radiant field, the aqueous solution fall-back on the anterior state of exposure.

The reversion to the initial state depends on the amplitude of the ionization-deionization process. In case of an exposure to a strong radiation, the new solution state remains unchangeable. This new solution state depends on the intensity of the field and the exposure time duration.

Some quantitative and qualitative aspects of this process are related in this paper.

The experiments were accomplished on aqueous solutions with both types of *pH*: acid and alkaline, in microwave radiant field with the same intensity as the intensity of the radiant field generated by a mobile phone.

2. *pH* Fundamental Concepts

pH, named 'potential of hydrogen', is defined as the co logarithm of the activity of dissolved hydrogen ions (H^+) [2], [4]:

$$pH = \log_{10} C_H{}^+ . \tag{1}$$

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C_H is the (dimensionless) activity of hydrogen ions, defined by:

$$C_H{}^+ = H^+ \cdot f_H , \quad (2)$$

where: H^+ is *hydrogen ions* concentration [mol/liter]; f_H is activity coefficient of hydrogen ion.

Hydrogen ion activity coefficients cannot be measured experimentally, so they are based on theoretical calculations. The *pH* scale is not an absolute scale; it is relative to a set of standard solutions whose *pH* is established by international agreement.

Usually, measured *pH* values will mostly lie in the range 0 to 14 (*pH* scale), with neutral value *pH* = 7. Pure water is said to be neutral. The *pH* for pure water at 25 °C (77 °F) is close to 7. Solutions with a *pH* less than 7 are said to be acidic and solutions with a *pH* greater than 7 are said to be basic or alkaline [5].

pH determination is based on electrometrical method and its mechanism is the measurement of the difference of potential that appears between a metal electrode inserted in a solution that contains its ions, and an unknown *pH* solution as a subject of the measurement process [1], [4].

This difference of potential depends on concentration of the ions from the unknown solution and its temperature.

The separation between the standard solution in which the metal electrode was inserted and the unknown solution is realized trough a hydrogen ion selective membrane.

Hydrogen ions concentration of the unknown *pH* solution ideally follows the *Nernst* equation:

$$E = E_0 + \left[\frac{R \cdot T}{2.303 \cdot F} \right] \ln a , \quad (3)$$

where: E is a measured potential; E_0 is the standard electrode potential (the electrode potential for the standard state in which the activity is one); R is the perfect gas constant (8310 J/grad · mol); T is the temperature in Kelvin; F is the Faraday constant (96.500 C/mol); a is ions concentration of solution [3].

(3) equation is equivalent by (4):

$$E = E_0 + \left[\frac{(60\ mV) \cdot T}{300} \right] \lg a . \quad (4)$$

3. Research Method

From (4) equation results:

1. Variation of measured potential E is linear dependent on solution temperature for constant hydrogen ions concentration.
2. E potential depends on logarithm of hydrogen ions concentration of tested solution.
3. E potential simultaneous depends on multiplication $T \cdot \ln a$.

The exposure of a solution in a microwave electromagnetic field determines two effects:

- the thermal effect (the solution heating);
- the ionization-deionization effect.

According to the (4) equation, the two mentioned effects lead to *pH* potential modification.

It is known that *pH* unit has linear temperature dependence:

$$1_{pH}(T) = \frac{54.2}{273} \cdot T , \quad (5)$$

where: 1_{pH} is *pH* unit equivalent in mV; T is temperature in Kelvin. *pH* = 7 remains invariable and its electrical equivalent in mV is zero (null).

So, *pH* = 6 can be considered the first unity of electrical equivalent *pH* with negative polarity, and *pH* = 8 is the first unity of electrical equivalent *pH* with positive polarity (alkaline).

By exposure of a known *pH* solution to a microwave radiant field, its temperature increases from initial value T_a to final value T_b that depends on radiation intensity and exposure time duration.

The temperature increase from T_a to T_b has as a consequence the rise of the electrical equivalent absolute value of the solution *pH*, following the relations:

- in case of acidic solutions:

$$[7 - pH(T_b)] = \frac{[7 - pH(T_a)]}{273} \cdot 54.2 \cdot T_b ; \quad (6)$$

- in case of alkaline solutions:

$$[pH(T_b) - 7] = \frac{[pH(T_a) - 7]}{273} \cdot 54.2 \cdot T_b , \quad (7)$$

where: $pH(T_a)$ is *pH* numerical indication at temperature T_a; $pH(T_b)$ is *pH* numerical indication at temperature T_b.

The equations (6) and (7) show the dependence between *pH* potential and temperature considering the ionization-deionization effect unchanged during time exposure. The mentioned equations are valid only for theoretical quantitative verification, because the measurement results denote different values.

The equations (6) and (7) can be reduced to a singular linear relation:

$$|pH(T_b) - 7| = \frac{|pH(T_a) - 7|}{273} \cdot 54.2 \cdot T_b . \quad (8)$$

Take into consideration the absence of the ionization-deionization phenomenon $pH(T_b) \equiv pH(T_a)$. The differences are obtained only for the electrical equivalent of the *pH* units.

In condition of not manifested ionization-deionization phenomenon the equation (8) became an equivalence relation between the *pH* units and the electrical potential equivalent (9), being a linearity solution between $pH(r)$ and the electrical equivalent:

$$|pH(T) - 7| = \frac{|pH(r) - 7|}{273} \cdot 54.2 \cdot T . \quad (9)$$

The emphasis of the ionization-deionization phenomenon in solutions with known *pH* is realized trough unlinearity of *pH* unity dependence on temperature.

If the measured equivalent electrical potential is different from the calculated electrical potential according to the relations (6), (7) or (9), (it is presented in the diagrams below for the reference temperature 0 °C) the concentration of hydrogen ions is modified by the radiant field through the ionization-deionization phenomenon.

4. The Results

In the next chapter there are presented some experimental data for aqueous solutions with known *pH*, for a central frequency equal to 1800 MHz and the bandwidth ±100MHz.

Figures 1 to 6 show thermographic results in the beginning of the experiments (0 sec. exposure - left images) and after 60 sec. of exposure to microwave radiation (right images). Figures 7 to 12 present the thermal evolutions of the solutions.

Figures 13 and 14 present *pH* diagrams according to equations (6), (7) and (9).

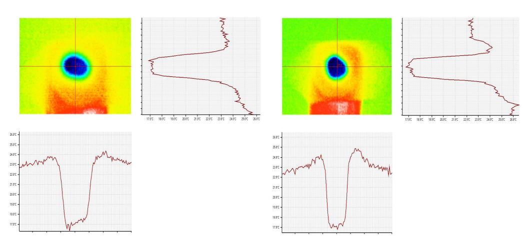

Fig. 1. *Thermographic result - distilled water* (*pH = 6.5*)

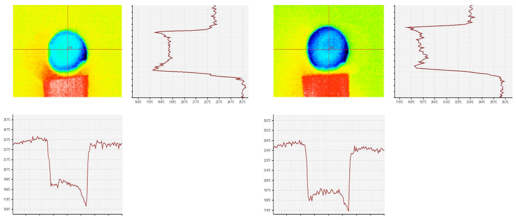

Fig. 2. *Thermographic result - distilled water (pH = 6.5) in absorbent medium*

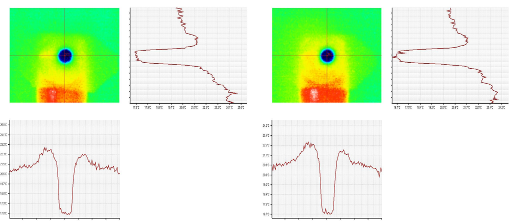

Fig. 3. *Thermographic result - pH = 4 solution*

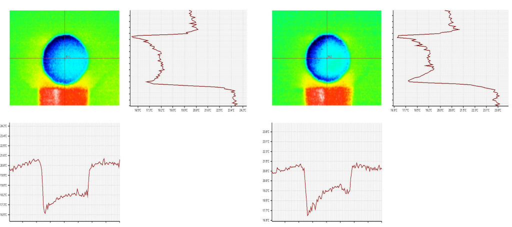

Fig. 4. *Thermographic result - pH = 4 solution in absorbent medium*

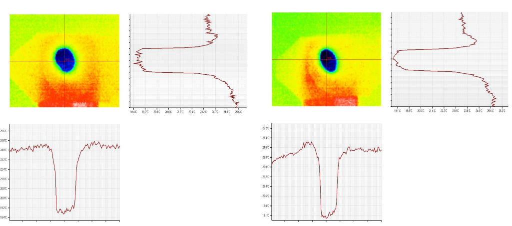

Fig. 5. *Thermographic result - pH = 13 solution*

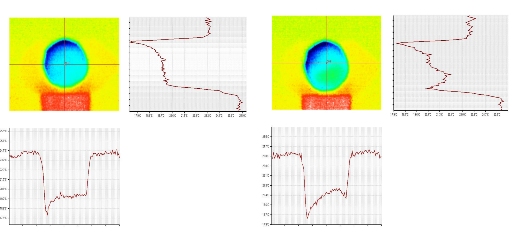

Fig. 6. *Thermographic result - pH = 13 solution in absorbent medium*

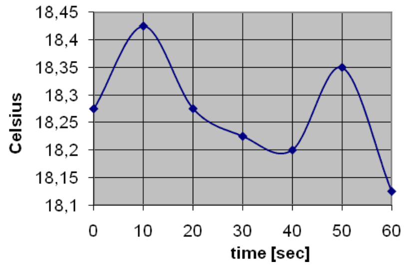

Fig. 7. *Temperature evolution - distilled water (pH = 6.5)*

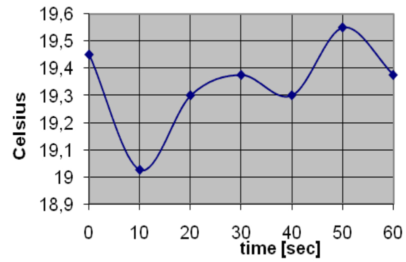

Fig. 8. *Temperature evolution - distilled water (pH = 6.5) in absorbent medium*

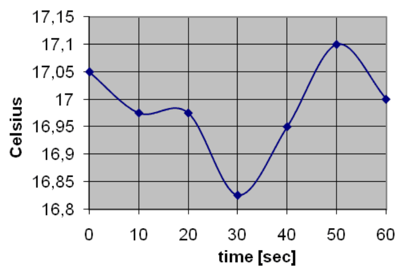

Fig. 9. *Temperature evolution - pH = 4 solution*

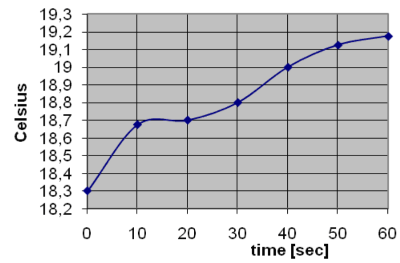

Fig. 10. *Temperature evolution - pH = 4 solution in absorbent medium*

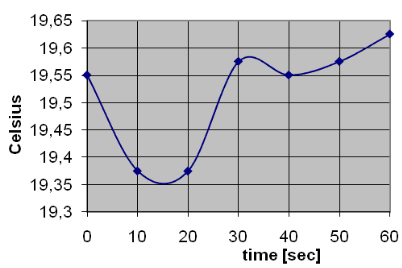

Fig. 11. *Temperature evolution - pH = 13 solution*

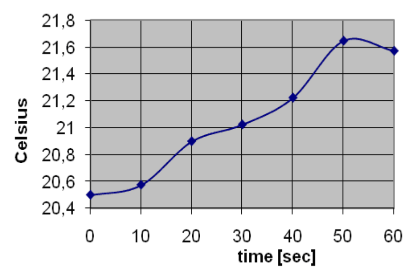

Fig. 12. *Temperature evolution - pH = 13 solution in absorbent medium*

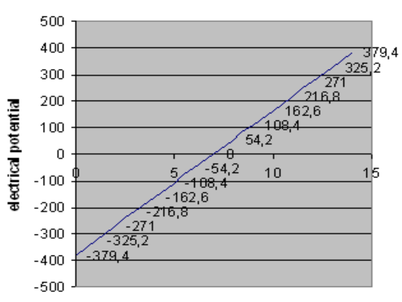

Fig. 13. *pH diagram according to equations (6) and (7)*

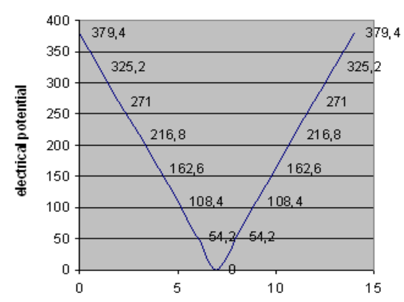

Fig. 14. *pH diagram according to equation (9)*

5. Conclusions

Electromagnetic field of microwaves (~1800MHz) affects *pH* of the aqueous solutions as was theoretically demonstrated. Through the thermographic analyses it was observed that the effects of the exposure to microwaves are manifested in a different way for the two solutions: acid and alkaline.

The *pH* modification is dependent on time duration of microwave exposure and chemical compositions of the solution.

The experimental results emphasize the complexity of the phenomenon.

References

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