MICROWAVES ELECTROMAGNETIC FIELD INFLUENCE ON PH. THEORETICAL AND EXPERIMENTAL RESULTS

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Abstract*: Microwave radiation determines the pH modification of the watery solutions. The paper presents the influence of microwaves on watery solutions with both types of pH* **-** *acid and alkaline, using thermographic analyses.*

Keywords*: pH, deionization, microwave.*

1. INTRODUCTION

The low intensity electromagnetic radiant fields of microwaves are often manifested in areas such as: fixed and mobile communications, satellite and terrestrial television systems, wireless computer networks, control systems in automation, measurement techniques and systems.

All of these radiant fields can be either guided or unguided, but regardless of the manner of propagation between emission and reception they enter into the contact with the substances from radiated zone.

If in radiated zone exists substances that contain watery solutions they are submissive to the specific effects of the microwave, most pithiness of this are:

- The heating effect in volume if in the watery solution exist free ions;

- The effect of deionization of the solution below radiant field influence.

The both mentioned effects determine the pH modification of the respective solution.

At the cessation of the radiant field, the temperature of the solution fall-back on the anterior state of exposure (to ambient medium temperature).

When the solution is submissive to the effect of deionization, in most of cases the return to the initial do not achieves and the modification of ions concentration remaining definitively.

Some quantitative and qualitative aspects of this process are related in this paper. The experiments were accomplished on watery solutions with both types of pH: acid and alkaline.

2. FUNDAMENTAL CONCEPTS

pH**,** named "potential of hydrogen", is defined as the cologarithm of the activity of dissolved hydrogen ions (H^+).

$$pH = \log_{10} C_H{}^{+} \qquad (1)$$

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

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

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 7.0. 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.

pH determination is based on electrometrical method and is commonly measured by means of a combined glass electrode, which measures the potential difference, or electromotive force, E, between an electrode sensitive to the hydrogen ion activity and a reference electrode, such as a calomel electrode or a silver chloride electrode.

The potential difference depends on ions concentration of unknown pH solution and its temperature.

Hydrogen ions concentration of unknown pH solution (the combined glass electrode) ideally follows the *Nernst* equation:

$$E = E_0 + [(R\cdot T)/2{,}303\cdot F]\cdot \ln a, \qquad (3)$$

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) equation is equivalent by (4):

$$E = E_0 + [(60\text{mV})(T/300)]\cdot \lg a \qquad (4)$$

3. RESEARCH METHOD

From (4) equation results:

1. Variation of measured potential E is linear dependent on solution temperature.
2. E potential depends on the logarithm of hydrogen ions concentration of tested solution.
3. E potential depends simultaneous on the multiplication T·lna.

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

- Thermal effect (the solution heating);
- Deionization effect.

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

It is known that pH unit has a linear variation depending on temperature.

$$1\text{pH}(T) = \frac{54{,}2}{273}\cdot T \qquad (5)$$

where: 1pH is the pH unit mV equivalent; T is the temperature in Kelvin.

pH = 7 is invariable and his electric mV equivalent is zero. Hereby, we can consider that pH = 6 is the first unity of electric pH equivalent with negative polarity and pH = 8 is the first unity of pH electric equivalent with positive polarity.

Due to microwave radiation exposure, a pH known solution is warming up; its rise in temperature from T_a to T_b ($T_a < T_b$) determine the rise of pH electric equivalent (absolute value).

- In case of acidic solutions:

$$\begin{aligned}&[7-\text{pH}(T_a)] \rightarrow [7-\text{pH}(T_b)] = \\ &= \frac{[7-\text{pH}(T_a)]}{273}\cdot 54{,}2\cdot T_b\end{aligned} \qquad (6)$$

- In case of alkaline solutions:

$$\begin{aligned}&[\text{pH}(T_a)-7] \rightarrow [\text{pH}(T_b)-7] = \\ &= \frac{[\text{pH}(T_a)-7]}{273}\cdot 54{,}2\cdot T_b\end{aligned} \qquad (7)$$

where: $\text{pH}(T_a)$ is pH numerical indication at temperature T_a; $\text{pH}(T_b)$ is pH numerical indication at temperature T_b.

The equations (6) and (7) show the dependence between pH potential and temperature not considering the deionization effect. The mentioned equations are valid only for theoretical quantitative verification, because the measurement results denote different values.

The difference between results of theoretical calculus (equations (6) and (7)) and practical measurements emphasizes the simultaneity of the phenomenon manifested in microwave electromagnetic field.

The calculus of thermo effect influence and deionization effect influence about solutions fulfills separately (due to the superposition of the phenomenon) by equations (4), (6), (7).

4. EXPERIMENTAL RESULTS

The experiments have been accomplished using a thermographic camera and a pH-meter. The effects of microwaves (900MHz) were investigated for 10 mg distilled water, pH = 2 solution and pH = 13 solution in two cases - on dielectric support and in absorbent medium.

In the next we present only a part of experimental results - the representative once.

Figures 1 to 6 show thermographic results in the beginning of the experiments (0 sec exposure - Fig. a) and after 60 sec exposure to radiation (Fig. b).

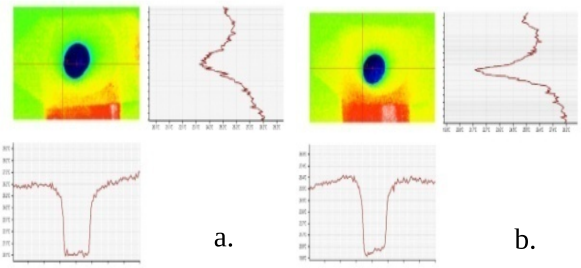

Fig. 1 Thermographic result - distilled water

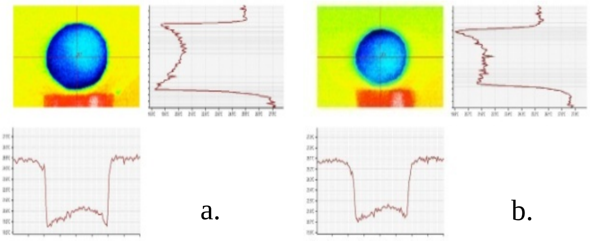

Fig. 2 Thermographic result - distilled water in absorbent medium

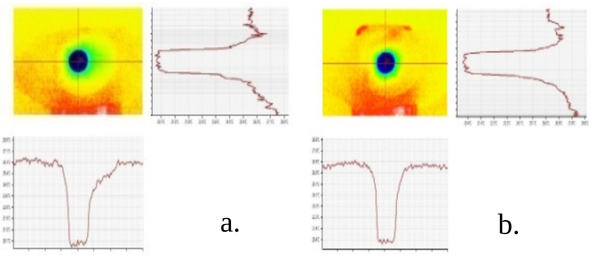

Fig. 3 Thermographic result - pH = 2 solution

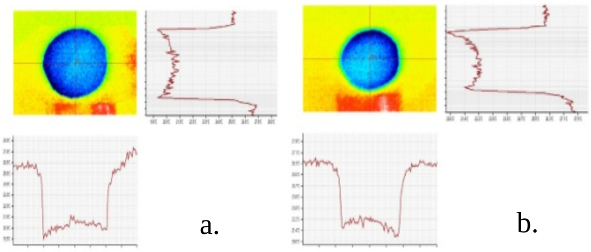

Fig. 4 Thermographic result - pH = 2 solution in absorbent medium

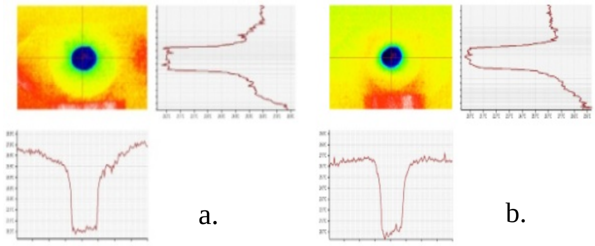

Fig. 5 Thermographic result - pH = 13 solution

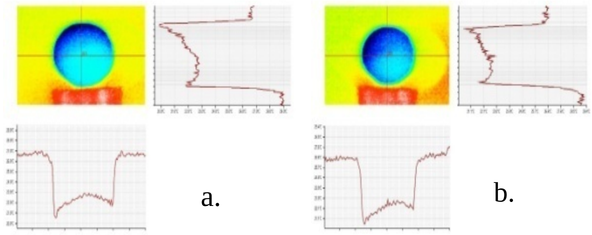

Fig. 6 Thermographic result - pH = 13 solution in absorbent medium

The thermal evolutions of solutions are presented in figures 7 to 12.

We observed that in case of distilled water on dielectric support, microwave radiation determines deionization - the thermal effect is cancelled (Fig. 7). The temperature evolution of the distilled water in absorbent medium (Fig. 8) denotes that the striking effect is the thermal once, followed by the deionization process. The same consideration is true for the pH = 2 solution exposure to microwave radiation.

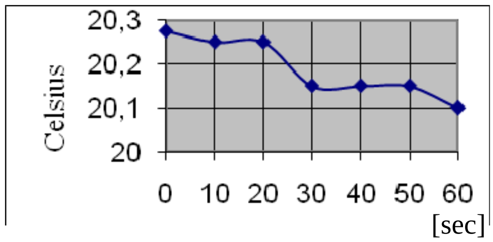

Fig. 7 Temperature evolution - distilled water

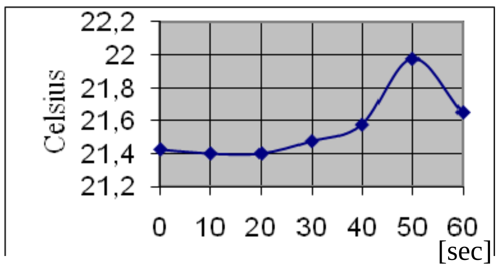

Fig. 8 Temperature evolution - distilled water in absorbent medium

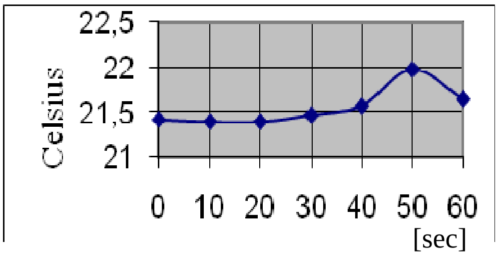

Fig. 9 Temperature evolution - pH = 2 solution

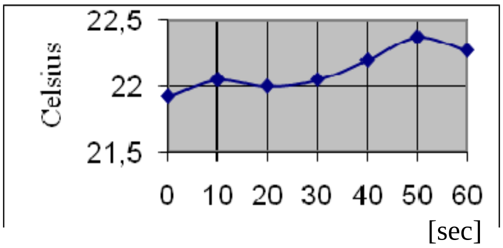

Fig. 10 Temperature evolution - pH = 2 solution in absorbent medium

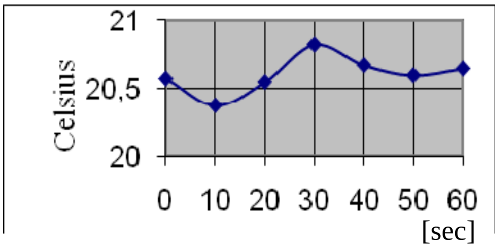

Fig. 11 Temperature evolution - pH = 13 solution

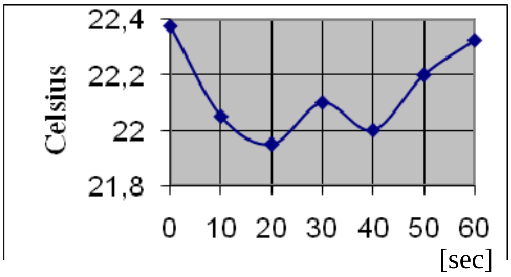

Fig. 12 Temperature evolution - pH = 13 solution in absorbent medium

In case of solution with pH = 13 the effects of microwave irradiation are succeeded: deionization and thermal. The peak at around 30 sec of exposure can be a result of the errors associated with the determination.

5. CONCLUSIONS

Microwave radiation affects pH of watery solutions as was theoretically demonstrated. Through the thermo graphic analyses we observed that the effects of microwave exposure are manifested in a different way for the two solutions: acid and alkaline.

The experimental results emphasize the complexity of phenomenon manifested due to microwave irradiation.

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