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DIELECTRIC PARAMETERS OF MEAT INDUSTRY WASTEWATER

[1]KOVÁCSRóbertné, [2] KESZTHELYI-SZABÓGábor,DSc[3] SZENDRŐ Péter, DSc

[1] Technical Department, Faculty of Engineering, University of Szeged

E-mail: veszelov@mk.u-szeged.hu

[2]Department of Process Engineering, Faculty of Engineering, University of Szeged

[3] Institute of Mechanics and Machinery, Faculty of Mechanical Engineering, SzentIstván University,

Abstract

Microwave (MW) irradiation has gained a great deal of attention owing to the molecular level heating. In addition to heating the materials consistently electromagnetic treatment can disrupt cell membrane and change biological structure increasing degradability. In our studies we were carried out pre-treatment of food industrial waste water (WW). However, the commercialization of MW technology for real-time WW treatment requires the understanding of basic mechanism of MW method. Determination of dielectric properties can provide the electrical or magnetic characteristics of the materials, which useful in many research and development fields improving design, processing, quality and control of product. Dielectric materials placed in electromagnetic field can change the nature of the field and changes can occur in the material itself. This changing ability of the materials can be characterised by dielectric parameters. Dielectric parameters of the material were determined by methods elaborated earlier based on the changing electric parameters measured by the unit attached to the pretreating system. Dielectric parameters of meat industry WW follow the trend of parameters of water, however in case of ε" at a critical temperature (52 ^oC) it began to increase. In addition to MW at this temperature cell membranes can rupture and cell sap releases. Because of increasing concentration of ions releasing with cell sap in the free water ionic conductioncome to the fore increasingly affect dielectric loss factor, increasing its value.

Keywords:*wastewater, microwave pretreatment, dielectric parameters*

1. INTRODUCTION

Sludge treatment is often resolved by product producer companies themselves due totightening of the rules on WW disposal and increasing cost of destruction by specialized companies. In this respect, anaerobic digestion of WW is a cost-effective configuration for industrial companies who owe to dispose the wastewater safely and, at the same time, could benefit directly from the energy recovered in the form of biogas. Most soluble organic materials which can be converted into biogas are produced during hydrolysis process, but it is identified as the rate-limiting step [4]. Consequently, the biogas production depends for the most part on the biodegradability and hydrolysis rate [3].

Pre-treatment of sludge to break down its complex structure can be used for enhancing anaerobic digestibility in order to lyse sludge cells further to facilitate hydrolysis. Thermal, chemical, biological and mechanical processes as well as different combinations of them have been studied as possible pre-treatments. Thermal treatments can be highlighted as no additional chemicals needed and they can be controlled easily. Microwave pre-treatment was found to be superior over the thermal treatment with respect to sludge solubilisation and biogas production. [2]

Measuring of dielectric properties of materials has gained increasing importance in many research and development fields, especially in material science, microwave treating system design and operation, absorber development, biological research. There are many methods developed for measuring dielectric properties but each method is limited to specific frequencies, materials, applications. At University of Szeged measuring equipment was developed using reflection method. Voltage Standing Wave Ratio (VSWR), as the ratio of the maximum to the minimum voltage in the standing wave is measured. Results of our measurements were evaluated by three methods.

2. METHODS

Meat industry WW was treated by the microwave system Fig. 1. Microwave pre-treating system contains a water-cooled, variable-power magnetron operating at 2450 MHz. Electromagnetic energy of the magnetron travels through a rectangular waveguide and spread over a resonant slot. Getting through this slot the energy gets in the toroidal resonator. During the operation of toroid resonator energy is given to the treated material. As a result of energy transmission the temperature of the material rises and the dielectric properties change continuously.
The material can flow through the waveguide of dielectrometer attaching to the system in a Teflon tube. Electric signal of the dielectrometer, the inlet and outlet temperature of the material are received by the measurement data collector and recorded on-line by software and displayed in the computer screen.

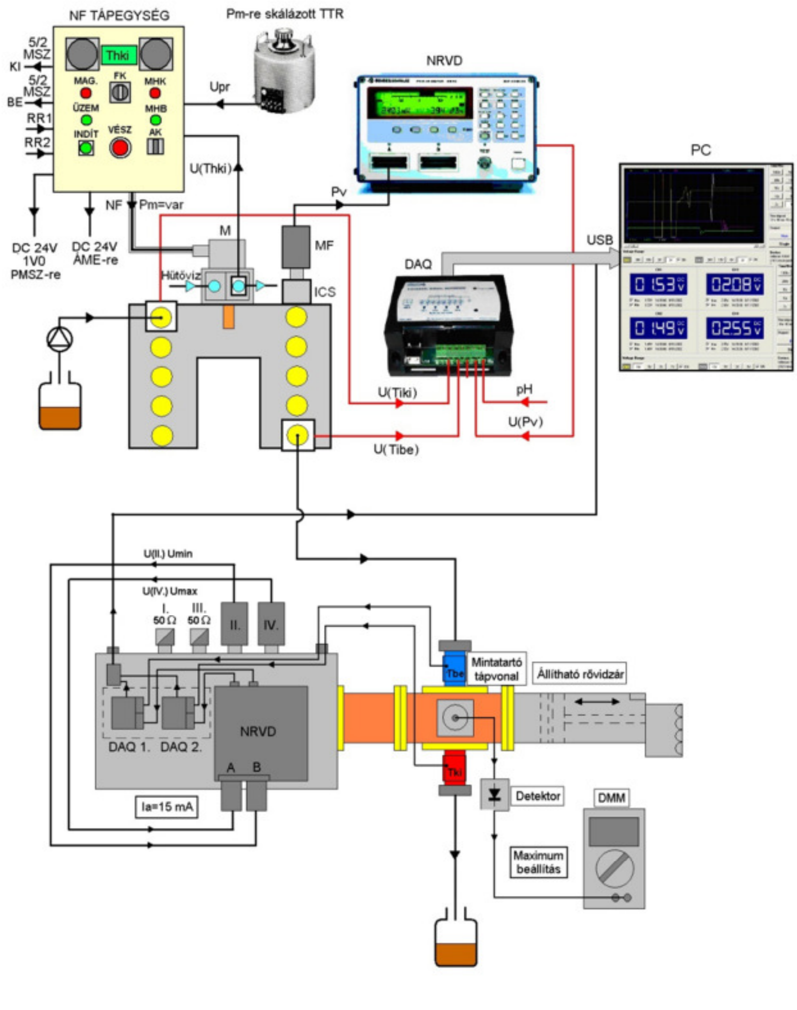


Figure 1 Microwave treating system

Three methods were developed for evaluating the measured electrical parameters. In case of Method1 from electrical parameters Voltage Standing Wave Ratio, phase shift, and voltage reflection coefficient are counted. Dielectric parameters can be determined on their basis.

The ratio of the maximum to minimum voltage is known as Voltage Standing Wave Ratio (VSWR). [1]

$$r = \frac{U_{max}}{U_{min}} \tag{1}$$

If the signals from the diode detectors are quadratic, as is typical, the standing wave ratio will be:

$$r = \sqrt{\frac{U_{max}}{U_{min}}} \tag{2}$$

The relationship between VSWR and reflection coefficient is the following:

$$|\Gamma| = \frac{r-1}{r+1} \tag{3}$$

Phase shift (4)

$$\Gamma_0 e^{-2\gamma l} = |\Gamma| e^{j\varphi}$$

$$-2\gamma l = j\varphi \tag{5}$$

$$\varphi = \frac{-2\gamma l}{j} = (-j)\cdot -2\gamma l = j2\gamma l \tag{6}$$

where γ is the complex propagation constant.
In case of Method2 travelling-wave coefficient is calculated first, then impedance of the short-circuited line and its real and imaginary part can be determined. According to these and the geometry of the waveguide dielectric parameters are determinable.

Travelling-wave coefficient that is calculated when $K_t \geq 0.4$ as

$$K_t = \sqrt{\frac{E_{min}}{E_{max}}} \tag{7}$$

where E_{min} and E_{max} are the minimum and maximum values of electric field amplitude.
Input impedance of the short-circuited line:

$$Z_{in} = \frac{K_t^2 + tg^2\left(\frac{2\pi}{\lambda_g} l\right)}{K_t\left[1 + tg^2\left(\frac{2\pi}{\lambda_g} l\right) + j\left(l - K_t^2\right) tg\left(\frac{2\pi}{\lambda_g} l\right)\right]} \tag{8}$$

where *l* is the distance between the dielectric surface and the first minimum of the standing wave, λ_g is the wavelength in unloaded part of transmission line.

$$\varepsilon' = \left(\frac{\lambda}{2\pi d}\right)^2 (x^2 - y^2) + \left(\frac{\lambda}{\lambda_{qc}}\right)^2 \quad (9)$$

$$\varepsilon'' = \left(\frac{\lambda}{2\pi d}\right)^2 2xy \quad (10)$$

where λ is the free-space wavelength, λ_{qc} is the quasicutoff wavelength, d is the sample thickness $x=Re(Z_{in})$, and $y=Im(Z_{in})$Ţ, and Z_{in} is the input impedance of the short-circuited line.
In case of Method3 Voltage Standing Wave Ratio, phase shift, and voltage reflection coefficient are counted as in Method1, but on their basis complex permittivity can be determined.

3. RESULTS

As we expected dielectric parameters of meat industry WW follow the trend of parameters of water, however in case of ε" at a critical temperature (52 °C) it began to increase. In addition to MW at this temperature cell membranes can rupture and cell sap releases. Because of increasing concentration of ions releasing with cell sap in the free water ionic conduction come to the fore increasingly affect dielectric loss factor, increasing its value.

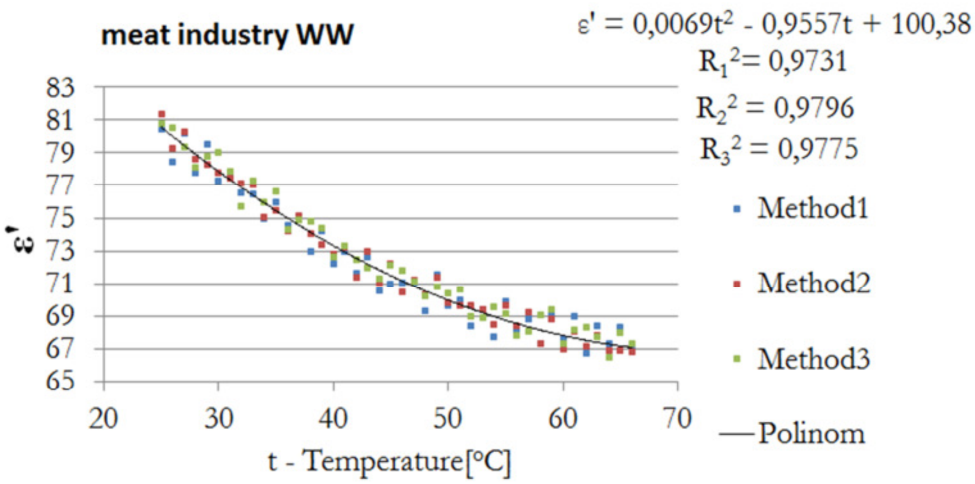
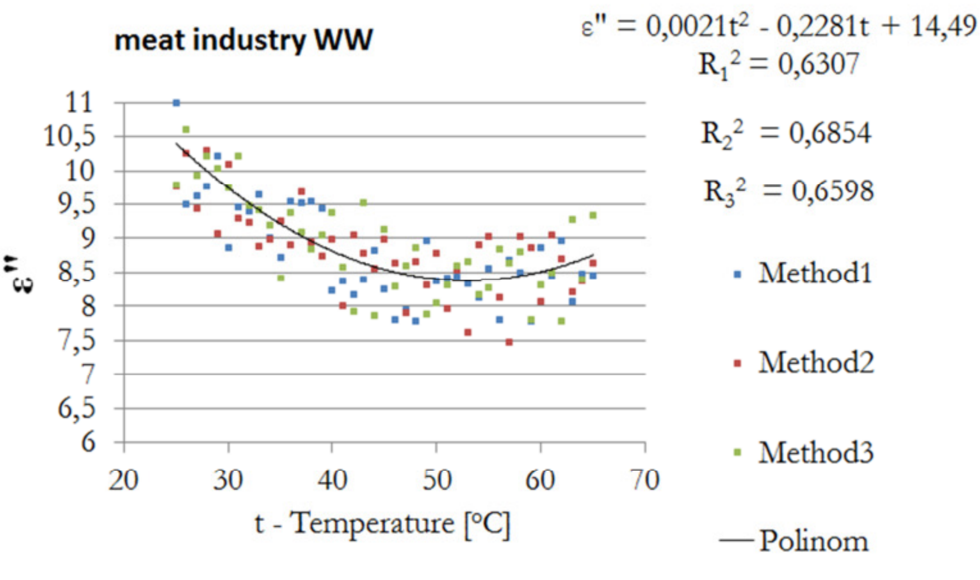


Figure 2 Dielectric constant of meat industry WW



CONCLUSIONS

Results representing the three evaluating methods fit better the approximate polynomic in case of ε' than in case of ε''. Changing the range of measurement results can be improved.

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