BPS 2017

16th International Workshop
for Young Scientists
„BioPhys Spring 2017”

BOOK OF ABSTRACTS

1th- 3rd June, 2017
Lublin, Poland

INSTITUTE OF AGROPHYSICS PAS

PAN
POLSKA AKADEMIA NAUK
ODDZIAŁ W LUBLINIE

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

SLOVAK UNIVERSITY OF AGRICULTURE NITRA

SZENT ISTVÁN UNIVERSITY

BPS 2017

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Conference Organisers:

Institute of Agrophysics, Polish Academy of Sciences

Polish Academy of Sciences Branch in Lublin

Czech University of Life Sciences Prague (CULS)

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PLENARY LECTURES

BUILDING INTEGRATED SOLAR THERMAL APPLICATIONS

Farkas I.

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Keywords: scenario, design aspects, collector types

Abstract

Tere are several attempts in order to improve the solar thermal technologies. Accordingly, a great number of books, publications and confrence proceeding are presented to share all the available infomation in the field ([4], [5], [6]):

Renewables 2015 – Global Status Report
REthinking Energy 2015
Solar Heat Worldwide – 2015

The biannual event series of the International Solar Energy Society (ISES) World Congresses along with the ISES-Europe Conference in the consecutive years cover the most updated topic. The last ones were organized in 2015 in Daegu, Korea and in Palma, Spain in 2016. The development of the solar thermal applications is shown in Fig 1.

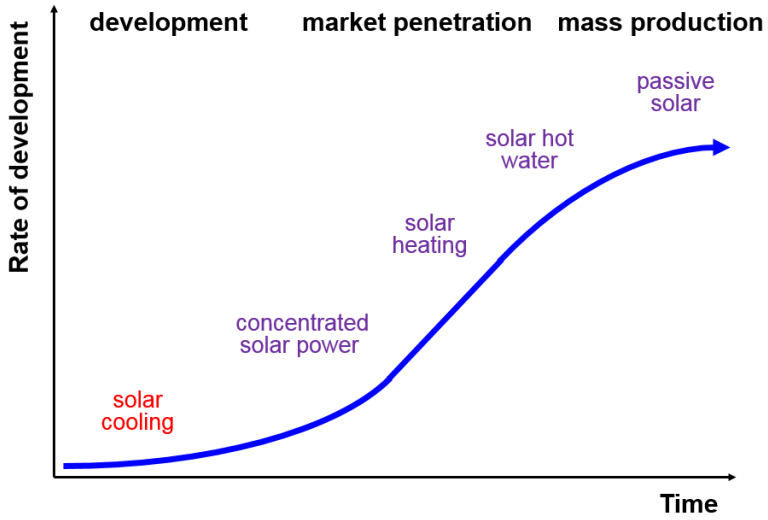

Fig. 1. Development of solar thermal applications in a long term time horizon

The main features of the European situation of solar thermal use are as follows:

- mainly use of solar domestics hot water systems,
- growing share of combined systems for DHW and heating,
- growing number of large scale systems,
- use of swimming pool systems,
- solar district heating systems,
- different applications to produce process heat,
- solar thermal assisted cooling systems.

In the coming period several trials are to be performed to increase significantly the building oriented solar applications, so lowering the energy consumption in buildings and/or find new solutions for providing energy resources from renewable energies.

The solar thermal vision for 2030 in Europe, especially to the building industry, is projected by European Renewable Heating and Cooling Technology Platform (RHC-ETP):

New buildings:

100% solar heated buildings will be the standard,

Existing buildings:

50% solar heated will be the most effectve way to refurbish the building stock.

The new building components will be:

- the entire roof is covered by solar collectors and solar photovoltaic modules,
- the faced is used to harvest solar enegy,
- seasonal heat storage,
- active heating system,
- compact units for solar heating and cooling,
- very well insulated.

The existing building components will be:

- renovation with multi-function modules for roof and facede,
- insulation and solar collector,
- seasonal storage,
- solar assisted cooling,
- aroung 70% heat demand is covered by solar thermal energy,
- remaining heat demand will be covered with other type of renewables.

Thus, this paper is focusing to the development and design aspects of building integrated solar collectors. The literature review confirms that solar collectors appreciated not only by their thermal efficiency and so the entire energetic performace, but also according to their aesthetic considerations. In he recent development a new type of shell-structured solar collector is shown, which is a proper combination of the traditional and new type of construction materials. During the investigation the temperature distribution on the collector surface was validated by an infrared camera recording ([1], [2], [3]).

Conclusions

1. In the coming period several trials are to be performed to increase significantly the building oriented solar applications.
2. In Europe 100% solar heated buildings will be the standard by 2030.

Acknowledgement

This work was supported by the Mechanical Engineering Doctoral School, Szent István University, Gödöllő, Hungary.

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SOME BEE PRODUCTS ELECTRICAL PROPERTIES

Hlaváčová Z. [1], Regrut T. [1], Ardonová V. [1], Brindza J. [2], Brovarskyi V. [3], Velychko S. [3]

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Keywords: honey, perga, electrical properties, frequency

Abstract

Bee's products like honey, pollen, royal jelly, propolis, bee venom have immense medical importance. Honey is useful for healing the wounds, helps to build up haemoglobin, used as laxative blood purifier, preventive against cold, cough, sore throat, eye ailments, burns and gastrointestinal disorder etc. Honey has antibiotic property and is effective in reducing the risk of heart disease, cancer and diabetes. Pollen lowers blood pressure, increases haemoglobin and erythrocyte content, useful in pernicious anaemia, sterility, hypertension, in complaints of the nervous and endocrine system. Royal jelly has antimicrobial, anti-inflammatory, antiaging, vasodilate and hypotensive, antioxidant, antihypercholesterolemic and antitumor property [6]. Bee bread – also called "Perga" – are fermented bees pollen in the comb, which store bees as protein supply. It was found that bees preferentially consume fresh pollen stored for less than 3 days. Newly collected pollen contained few bacteria, values which decreased significantly as pollen were stored more than 96 h [1]. The bee bread is harvested by hand from the honeycomb and thus is not only the most valuable, but also the most expensive bee products [3]. Bee bread is considered the most perfect of all natural foods – used by the Greeks as ambrosia. It includes many vitamins (A, B1, B2, B6, B12, C, D, E, P, PP) and trace elements (potassium, magnesium, calcium, copper, iron, sili-con, sulphur, chlorine, manganese). In the perga there is everything that is required for the normal growth and existence of a live organism. Good results are noted by specialists at treatment of patients with many diseases [2, 6]. Bee bread is of benefit not only for the materials of health food diets, but also for in patients undergoing various diseases such as cancer, cardio-vascular diseases, diabetes, and hypertension [5].

The measurement of electrical properties of food can be used to get information about many other characteristics of this material; in addition, there are some food processes which are based on electrical effects. Electrical properties of honey are utilized at the sugar and water contents determination [3]. Dielectric constant increases with water content and decreased with total soluble solids content.

Perga samples of different plant species were collected by beekeepers from selected regions of Ukraine (Poltava and Dnepropetrovsk) according to a new patented technology developed by the research team of the Department of Apiculture at the National University of Life and Environmental Sciences of Ukraine, with offices in Kiev. All samples were polyfloral Perga. We used floral honey, which consists from fructose (38 %), glucose (31 %), sucrose (1 %), other sugar (9 %), water (about 17 %), ash (0.17 %) and other substances [4]. Low-frequency electrical properties of perga and honey were measured by an instrument GoodWill Instek LCR meter 821 at different frequencies using four-electrode (tetra polar) system. We measured capacitance, resistance, impedance and loss factor. Each property was measured in the frequency range from 0.1 kHz to 200 kHz, at all frequencies three times. The capacitance was at higher frequencies from 1 MHz to 16 MHz measured by the Q-meter TESLA MB 560. The device was connected with the testing coaxial capacitor, which was used as a sample holder.

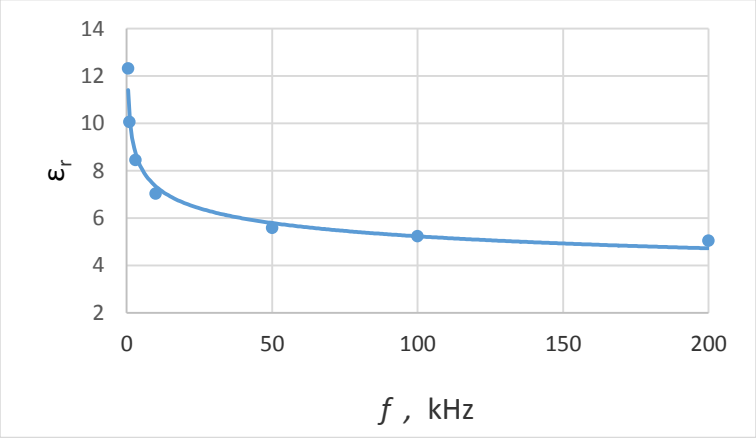

Fig. 1. Frequency dependency of perga relative permitivity

On Fig. 1, a decreasing frequency dependency of perga relative permitivity is shown. We used power function as regression equation and the coefficient of determination has high value 0.9786.

Conclusions

1. We found that resistance, impedance, and resistivity of perga and honey also decrease with frequency according to power function. The change of these electric properties at low frequency is significant, compared to the higher frequencies. Only loos factor increased in this frequency range.
2. It was determined that the conductivity, and relative permittivity of perga and honey increase with the moisture content and also with temperature.
3. According to values of the electrical properties, the perga and honey belong to the semiconductors.

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OPTICAL SCATTERING PROCESSES FROM Q1D AND Q2D SYSTEMS

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Keywords: symmetry theory of condensed matter, line groups, Raman-type scattering processes

Abstract

It is well-known nowadays, that the detailed experimental and theoretical investigation of basic structural and physical properties of different types of carbon nano-tubes plays a role of continuously increasing importance in both fundamental research activities in the condensed matter physics, as well as in the various types of energetic engineering applications [1]. One of the most successful mathematical techniques from this point of view is related to detailed application of the abstract-, and representation theory of quasi-one-dimensional (Q1D) systems, also known under the name of line groups [2], which represents a genuine mathematical background for structural investigation of polymers by diffraction methods for decades [3]. Among the newest methods of investigations of such types of condensed matter systems, research activities connected to possible applications in solar cells became also very significant, e.g. [4], despite of the fact, that even in the most detailed quantum-statistical models of collective elementary excitations relevant for light absorbing organic materials, the selection rules based on the representation theory of line groups have not been applied [5], but which may be of importance at accurate descriptions of the exciton-type collective modes, too.

In the present work we will demonstrate in detail some further possible and very promising applications of this mathematical technique relevant for chain-type molecular systems, which may contribute to understanding and increase of the energy transformation efficiency in solar energetics.

Accordingly, the irreducible representation $D^{(\mu)}(L)$ of a full line group *L* can be obtained from the irreducible representation of symmetry groups (i.e. point groups) of the motifs (which are the monomers in the case of stereoregular polymers) $D^{(\nu)}(P)$ by use of the induction technique elaborated in the theory of group representations and widely applied in solid state physics [6], usually denoted by $D^{(\mu)}(L) = D^{(\nu)}(P)\uparrow L$). On the base of this formalism, the formulae necessary for quantum-mechanical selection rules between an initial („i") and final („f") state in chain-type systems at a given quantum-mechanical transition are („k" denotes the absolute value of a wave vector, „j" is an integer number, and „a" is the length (i.e. generating element) of the possible allowed translations along the main axis of a Q1D system being investigated):

$$k_f - k_i = k + 2\pi j/a.$$

Furthermore, it is a unique feature of the representation theory of line groups, that analogous relations expressing conservation of quasi-angular momenta during propagation of collective excitations along the main axis of the actual chain-type system must also be taken into account, i.e.:

$$m_f - m_i = m + zq,$$

where „m" denotes the value of the momentum, „z" is an integer number, while „q" is the order of a simple cyclic rotation group, also characterizing allowed integer translations along the main axis of the system (a collective term for all of them is also known as helical quantum numbers). These relations directly generalize the usually applied selection rules elaborated within frame of the classical crystallographic formalism based on the abstract and representation theory of the well-known 230 space groups e.g. [6]. The extension of the basic crystallographic formalism to more general theory of incommensurate systems initiated by us [7] is also in agreement with this concept. All these relations must be applied and incorporated into correlation functions necessary for comparison of experimental-, and theoretically derived light scattering intensity curves, e.g. in the case of Raman-scattering processes.

Conclusions

1. The selection rules relevant for discrete infinite Q1D systems must be incorporated into the quantum-statistical formalism of excitons propagating through molecular crystals.
2. Taking into account the well-known structural properties of carbon-nanotubes, and other non strictly - crystallographic type condensed matter systems, which are able to scatter incoming electromagnetic waves coherently, it is necessary to extend the whole above-discussed formalism to quasi-two-dimensional (Q2D) (i.e.: layer-type-) systems, too.

Acknowledgement

This work was supported by the Mechanical Engineering Doctoral School, Szent István University, Gödöllő, Hungary.

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THE WONDERFUL LIQUIDS BY HOPEFULLY INTERESTING EXPERIMENTS

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Keywords: hydrostatics, flow, Bernoulli law, surface tension, experiments

Abstract

In the conferences and workshops most of the presenters introduce their work through Powerpoint or Prezi presentations, with full of theories and equations. However these equations are very important, we thought, that among the presentations we should show the interesting and entertaining side of the Physics, as well, that is the reason, why we started several years before to have experimental presentations of special topics connected to the Biophysics. We would like to continue this tradition this year, as well, with a very important chapter of the Physics, with the Physics of liquids. This topic was chosen as the Physics of liquid is very essential in the Engineering, but for the biologicals systems as well. During the presentation experiments from the Hydrostatics and Hydrodynamics will be shown, with ideal, Newtonian and non-Newtonian liquids as well.

At the beginning, some experiments about the Hydrostatics is planned to present. The first important quantity, we would like to introduce by some experiments, is the pressure. For the human beings, the pressure (mainly the air pressure) has to be in a very narrow range to be able to survive. With the pressure of the liquids, which changes much faster as the air pressure with the height because their higher density, the effect of the increased pressure and the low pressure can be shown. However there are some special equipment for the pressure decrease (e.g. vacuum pumps), similar results can be achieved by other tricky ways with everyday tools as well, as it will be demonstrated (Fig. 1).

Fig.1. Demonstration of the hydrostatic pressure

If the medium starts moving, it can cause pressure change as well, as it is described by the Bernoulli law. This law gives the background for numerous surprising experiments (Fig. 2.), which will be demonstrated mainly with air stream, instead of liquid, as the realization is much simpler. The theory itself can be shown with a cone, but with the help of an old vacuum cleaner and a ping-pong ball, the background phenomena can be introduced in more funny way, and with the help of a toilette paper roll even the working principle of the Flettner ships are planned to be demonstrated, too.

Fig. 2. Demonstration of the Bernoulli law with simple tools

Until this point the viscosity of the medium was considered to be negligible, but for some materials the inner friction determines the flow. We think, that in this case the most interesting materials are the so called Non-Newtonian mediums, where the viscosity of the medium is depending on the speed of the deformation. These kind of materials can be bought as a fun toy in the shops, but we have numerous everyday material with the same property. During our experiments we will demonstrate this behavior with starch, or to be more exact, with starch solution. After preparing the optimal rate of the solution, it can be used to form a ball – if you are fast enough – but it will flow out of your hand if you don't move it. After demonstrating its ability, we would like to show, how a starch solution can dance, or we will prepare a "bullet-proof" layer from starch for an egg, to protect it from breaking while falling down to the ground.

At the end of the presentation some experiments for the surface tension is planned to present. The surface tension has important role in the biological systems, for e.g. in the water uptake of the plants and during the evaporation, too. The basic rules of the surface tension, for example the surface energy minimisation is planned to demonstrate by bubbles and minimal surfaces of special liquids.

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STUDY OF THERMAL BEHAVIOUR OF BIOLOGICAL MATERIALS

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Keywords: biological materials, thermal analysis, differential scanning calorimetry

Abstract:

The contribution deals with study of physical properties (thermophysical, rheological etc.) and the thermal behaviour of biological materials. Brief characterization of biological materials, relevant physical properties and thermal variations in properties are presented. The most common methods of investigation including some examples of experimental results are introduced.

In accordance with the authors (1, 2, 3 and 4) biological – food, as well as non-food materials, in generally can display large compositional variations, in homogeneities, and anisotropic structures. Composition can change due to seasonal variations and environmental conditions, properties can be affected by process conditions and material history. In generally biological material is in the macroscopic as well as in the microscopic scale considerably inhomogeneous, capillary-porous and wet dispersed medium. It is well known that the influence of water – existence of free or bound form, difference in binding energy of each water bond (chemical, physicochemical and physical) and sorption properties of the materials dominates among other factors at properties of these materials. The temperature is an important factor which influences nearly each property of the material.

Considering that the temperature is the value which influences nearly each property of the material, investigation of physical properties also thermal variation in properties is necessary for describing biological – food or non-food materials behaviour during processing or storage.

Thermal behaviour of biological material or physical and chemical processes running in the material due to temperature changes can be investigated by method of thermal analysis (5). They are the analytical techniques that measure physical and chemical properties of the sample as a function of the temperature or time. One of the most common methods of thermal analysis is differential thermal analysis (DTA) or differential scanning calorimetry (DSC), both of them provides information on thermal effects which are characterized by an enthalpy change and by temperature range, such as phase transitions (melting, crystallization etc.).

Investigation methods and used experimental equipments are presented in the paper more in details. Research of thermal behaviour of biological (food) material are provided in the Laboratory of Physical Properties of Raw Materials and Foodstuffs (Research Centre Agro-Bio-Tech), which is oriented to investigation of physical properties of food and raw materials and application of physical methods in the process of quality assessment and food safety guarantee.

Obtained experimental data of thermal behaviour of edible vegetable oils are introduced in the published papers, there is presented the example of experimental data – DSC curve of Sunflower oil – fresh and over-burned in the Fig. 1.

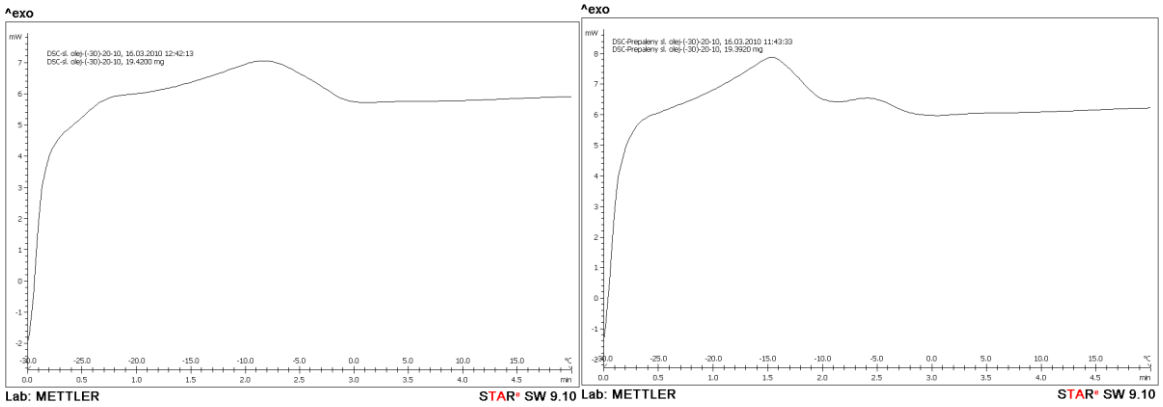

Fig.1 DSC curve of Sunflower oil – fresh and over-burned

Conclusion

It can be concluded that thermal properties of biological materials and thermal variations in properties are important for thermal behaviour describing. The most common methods of investigation including some examples of experimental results are introduced. It is shown that the temperature is one of essential factors that influence processes and properties of the biological materials during thermal treatment. Monitoring of the thermal behaviour of materials provides the important information for the design optimal thermal processing regime.

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NANOSTRUCTURE-RELATED FRUIT MECHANICS AND CELL WALL-BASED NEW BIOPRODUCTS

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Fruit mechanical properties result from multi-scale structure at macro-, meso -an nano- length scale. Linking structure with mechanical and other properties of fruit is still challenging due to a number of methods that must be involved in structure characterisation. Moreover, insufficient data on the structure hampers development of multiscale models of plant tissue.

Some breaking-through methods has been recently introduced to plant science that help to explore new or confirm known nano-structural features. What is more, there is interesting progress in the study of mechanical properties of plant tissue at the same length scale. Experimental research on both structure and mechanics provides data for computational models that would give feedback in testing and predicting the macroscopic quality attributes of fruit.

The main focus if this presentation will be on atomic force microscopy (AFM) that has opened new venues for structure and mechanics study of cell walls and cell wall polysaccharides. Moreover, a link of AFM study with atomistic modelling will be briefly discussed. Second part of this lecture will discuss features of the cell wall polysaccharides that might be used for designing new bioproducts. Two examples of new pectin based food texture additive and nanocellulose from fruit will be presented.

ORAL PRESENTATIONS

THERMAL ANALYSIS OF SINGLE AND DOUBLE-PASS SOLAR AIR COLLECTORS

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Keywords: contact solar collector, solar drying, performance evaluation

Abstract

Energy is available in multifarious forms and plays a significant role in world wide economic growth and industrialization. The growth of world population accompanied with rising material needs intensified the rate of energy usage. On the other hand, environment degradation with use of fossil fuels is a menace to life in the Earth [2].

Solar air collectors, because of their simplicity and low-cost, are a promising heating technology for buildings and industrial processes [3]. Solar air collectors are becoming more and more popular in heating and drying processes due to their cost effectiveness and easy maintenance. Solar air heater (collector) is one of the basic equipment through which solar energy is converted into thermal energy. However, how to increase thermal performance of solar air collectors becomes a major challenge. Many parameters are affecting significantly on thermal performance of the solar collector, such as area of absorber, shape of absorber, speed of air, number of flow passes, number of glasses, material of absorber, etc. The major parameters, which discussed in this paper is the absorber shape, absorber area, double pass air flow and double cover glass. In this paper, the effects of number of air flow passes on the thermal performance of solar collector have been studied experimentally.

This study focused on the performance of air solar collector dryer [1]. For this purpose, two simple solar collectors were constructed. The first, single pass collector and second double pass air collector (Fig. 1)

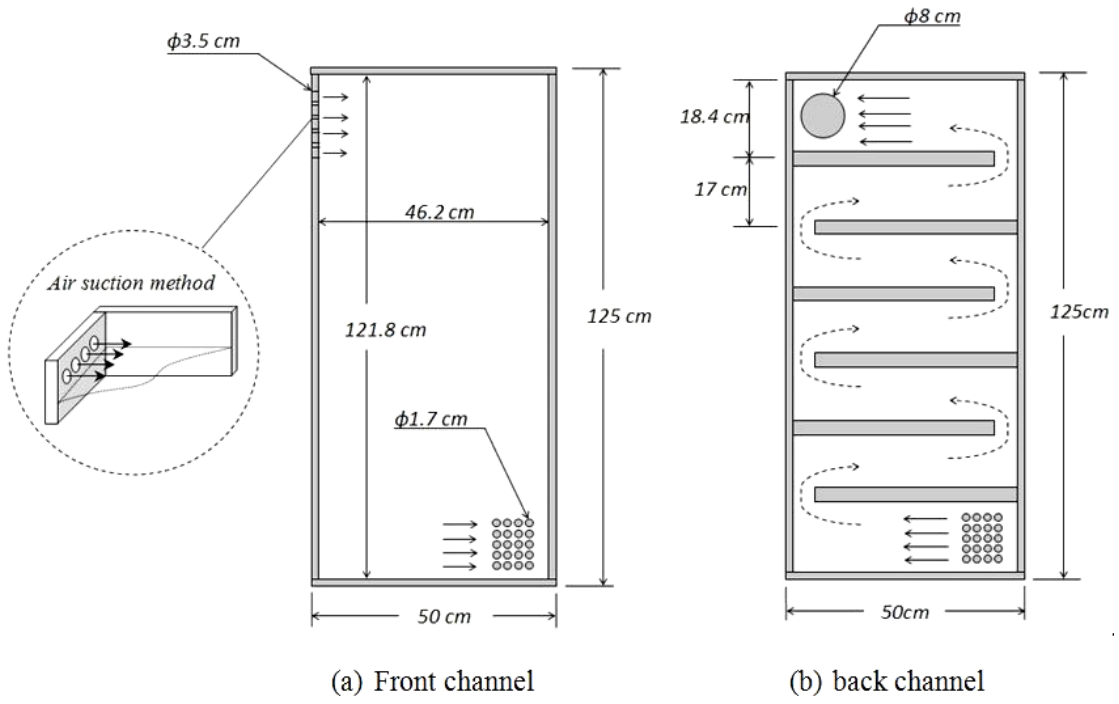

Fig. 1. Double-pass air solar collector

The absorber plates made from copper metal, because the high conductivity of copper. The external box of collector had made from wood. The collector insulated from back by polystyrene insulation layer, to decrease the back direction losses. To give the air to spend more time inside the collector, many baffles integrated with back channel of double pass collector. From the front side, a normal glass cover with 4mm thickness used to decrease front convection losses.

Experimentally, the temperatures in many points have been measured: as the inlet and outlet of collector, many points on the absorber surface and ambient temperature. Also, measured data were collected from the solar radiation, wind speed and air speed inside the collector.

In case the free convection, the greenhouse effect achieved within the collector drives the air current through the drying chamber. The hot air rises and escapes while cooler air at ambient temperature enters through the lower vent in the collector. Therefore, an air current is maintained, as cooler air at a temperature (T_{air}) enters through the lower vents and hot air at a temperature (T_{exit}) leaves.

Many results obtained theoretically and experimentally, such as temperature distribution through absorber, temperature difference between inlet and outlet, useful energy and thermal efficiency. Also, the two types have been tested according to the experimental results.

Conclusions

1. Double pass air flow will increase the efficiency of solar collector significantly in case the thickness of absorber will not be more than limits.
2. The double cover glass has a strong effect on the performance of the collector. In case the transitivity of glass material high, the double glass cover will play as a positive parameter for collector efficiency increasing.

Acknowledgement

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THERMAL PROCESS USED IN BIOREFINERY PROCESS OF THE BIOMASS

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Keywords: biomass, biorefinery, thermo-chemical

Abstract

The present paper are focused to presenting the experimental results of the thermal process used in hydrolysis process of the lingo- cellulosic feedstock in biorefinary process. According to the definition established by the NREL the biorefinery is an integrated system of the process and equipment used to produced fuels, power and chemicals from biomass [1]. The technological process in the production of the add value product from biomass is one thermo-chemical process such thermal hydrolysis, pyrolysis and gasification of the biomass feedstock. In generally this type of technology is realized in a large scale system, called two platform concept that is one thermo-chemical and another is one bio chemically conversion process [2]. Our work is representative for thermo-chemical process.

The experiment start with the collecting of the sample than grinding, milling it and preparing the biomass for the hydro -thermal treatment in one lab scale reactor, but first is important to established the moisture content of the used biomass. That value is take into account in establishing of the solid liquid ratio in this experiment and in the evaluation of the solid yields based on the literature data that value for the solid liquid ratio is around 1 part solid to 6-10 part liquid, expressed in mass units, we used for this experiment 40 gram biomass and 280 g H_2O, and the reactor type is a lab scale 1000 ml volume automatic controlled reactor, where we can monitoring the temperature and the pressure values in time.

We used one mechanical filtering process for the separation of the solid component from the liquid phase. The obtained liquid part has been used for preparing the sample for the HPLC chromatograph analyzed by liquor. We established the obtained total sugars and inhibitors quantities presents in this liquid phase. The resulted solid are used after drying for the characterization of the biomass in establishing of the hemicelluloses, cellulose and lignin content of the used feedstock. That is the first step in biorefinery process, and from the monitoring data of the temperature we has evaluated the severity factor of the hydrolysis process, which is an important technological value and give information from the degree of the hydrolysis. For the studied reactions we established this parameter, the severity factor, [3], [4]. (R_0), has evaluated with the following expression:

$$R_0 = \int_0^t \exp[\frac{T_R - T_B}{14.75}]dt \ ,$$

where: T_R – is the reaction temperature in °C, T_B –is the base temperature, that value is 100 °C, t -is the reaction time in minutes

This index is an expression, which combines the independent variable of the temperature and time into a single independent variable. In case of the experimental method we study the hydrothermal process hydrolysis of the biomass resulted from energy willow in temperature range; 125-230 °C. The experimental results of the HPLC analysis and the evaluated severity index values are presented in the table 1.

Table 1. Experimental results of the HPLC analysis of the resulted liquid phase and the severity index

T(°C)	Glucose [g/l]	Cellulose, [g/l]	Arabinose [g/l]	Acid. Formic [g/l]	Acid. Acetic [g/l]	HMF, [g/l]	Furfural, [g/l]	Log R_0
125	1.20	1.05	1.08	0.79	0.20	0.00	0.00	1.86
170.00	0.96	1.60	1.55	0.00	0.00	0.00	0.00	2.72
200.00	1.50	10.81	3.43	0.40	3.60	0.48	1.60	3.56
210.00	2.26	7.50	4.10	0.14	3.69	0.80	1.30	3.84
230.00	1.90	5.60	1.55	2.01	0.41	0.94	1.61	4.39

Conclusions

1. The good quality hydrolysate with high content of the glucose we obtained at 200-210 °C temperature-which value can be applied for pilot plant process for evaluation the optimal technological schemes for producing from biomass produced on energy plant plantation the second generation of biofuels.
2. The most preferable severity factor for obtaining high yield of the hydrolysis process is around: log R_0=4 that can be achieved at 200 °C, based on the experiment results dates that can be confirmed.

Acknowledgements

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ACOUSTIC WAVE PROPAGATED IN THE AIR AFTER THE RAINDROP IMPACT ON SOIL SURFACE

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Keywords: soil splash, water erosion, sound wave

Abstract

Soil as a top layer of the Earth's crust undergoes continuous degradation induced by a variety of different factors: chemical, biological and physical. One of the physical degradation types is water erosion which covers a broad spectrum of processes: from the splash, through the movement of the soil and water mixture on the soil surface, to the soil loss in streams and rivers. A water drops hitting soil surface during rain can cause the breakdown of soil aggregates, create sediment for transport or cause the crusted surface. An important issue is splash phenomenon (first stage of water erosion process) where the particles of the soil are detached from the surface and transported in different directions. This work focus on a new aspect of splash phenomenon characterization which is related with acoustic wave resulted from drop impact.

The aim of this study was to qualitatively and quantitatively describe the acoustic (sound) wave propagated in the air during the raindrop impact on soil surface.

Three types of soil (*Endogleyic Umbrisol, Fluvic Endogleyic Cambisol, Haplic Chernozem*) with different textures and initial moisture content were used in this study. Soil samples were dried, sieved through a 2mm mesh and placed in aluminium rings (40mm diameter). Next samples were humidified to four moisture levels related with specific pressure head (0.1, 1, 3.16, 16 kPa) to provide different initial water content. The experiment was implemented through registering sound pressure changes caused by 10 consecutive drops falling on the surface of the sample (the signal was recorded after each drop). All measurements for different types of soil were done in 15 repetitions. The measuring system was based on: 1) system for dosing water drops with 4.28mm in diameter and releasing them from capillary on height of 1.5m; 2) recording system consisted of eight microphones of type 40PH (G.R.A.S. Sound & Vibration Company, Denmark) and two NI-9234 (National Instruments) acquisition cards. The microphones were mounted in one plane, at a distance of 1m from the place of drop impact. LabView (National Instruments) dedicated application was used for registering and analysing sound pressure. The mentioned system was installed in the anechoic chamber (AGH University of Science and Technology, Kraków) in order to minimalize the level of sound waves reflected from walls and reduce the noise from the outside.

The signal of the instantaneous value of the sound pressure generated by water droplets striking the soil surface constitutes a non-stationary course of a polyharmonic, fading character (Fig. 1). The choose of the adopted method allowed to measure the sound pressure level values for different soils.

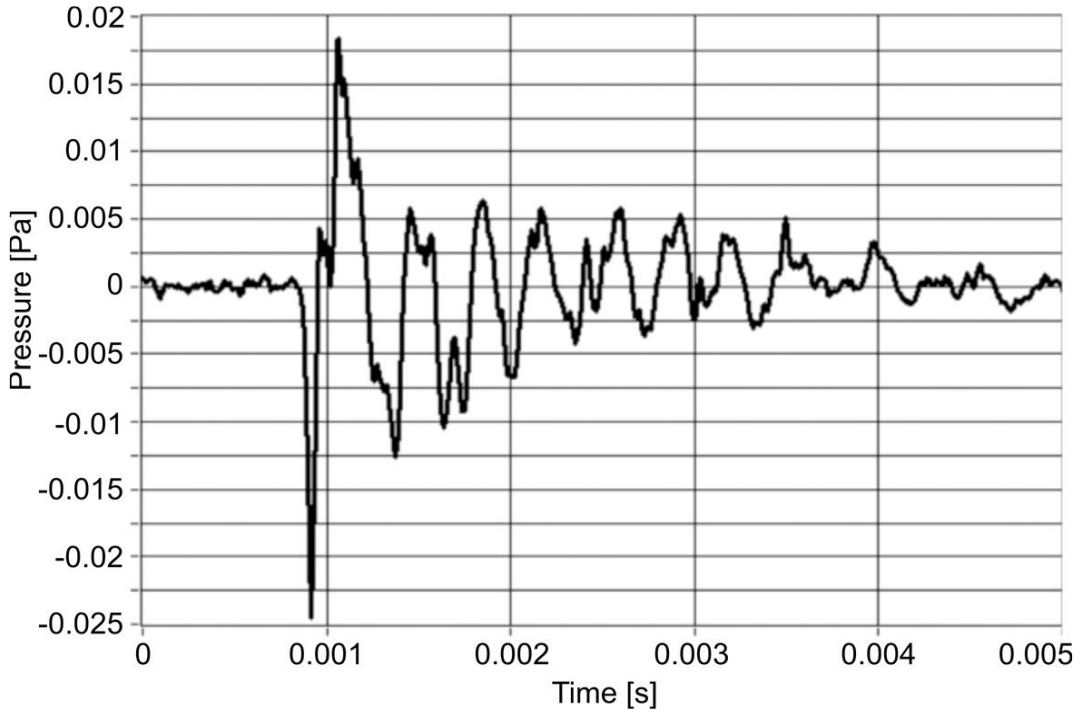

Fig. 1. Example of the signal for 10th drop impact on *Endogleyic Umbrisol* soil surface registered on one of the microphones.

Conclusions

1. The sound pressure level values for three types of soil ranged from 27dB to 42 dB.
2. The highest sound level value equal to 42 dB were observed for sandy soil (*Endogleyic Umbrisol*).
3. The sound pressure level depends mostly on the particle size distribution of the soil and less on the initial moisture content.
4. The sound wave of the instantaneous value of the sound pressure generated by water drops impact on soil surface constitutes a non-stationary course of a polyharmonic and fading sound signal character.

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CARBOHYDRATES METABOLISM BY NEOSARTORYA FUNGI USING BIOLOG SYSTEM

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Keywords: *Neosartorya,* Biolog, FF Plates, catabolic profile

Abstract

The fungi of *Neosartorya* genus are involved in the spoilage of thermally processed fruit products. *Neosartorya* has the capacity to sexual reproduction, resulting in ascospores. Ascospores of *Neosartorya* are able to survive pasteurization process and temperatures above 85°C even for 100 minutes [4]. Ascospores have been reported to be resistant against a lot of environmental stresses such as desiccation, high pressure and heating [4]. They are one of the most stress-resistant eukaryotic cells [3, 4] because ascospores contain large amounts of Trehalose, Trehalose-based Oligosaccharides and Mannitol [4].

Trehalose is a disaccharide regarded as energy reserve and stress protectant. This disaccharide is widely distributed in fungi. In vegetative structures where it is located generally together with sugar alcohols and glycogen. Trehalose can also be found in reproductive structures in high concentrations serves as a storage carbohydrate for survival during the starvation period and spore dormancy [3, 7, 8].

Mannitol accumulates in conidia and ascospores without interfering with cell metabolism. Mannitol in fungi is responsible for: carbon storage, maintaining reduction potential, water absorption and protection against heat, oxidative and osmatic stresses [6].

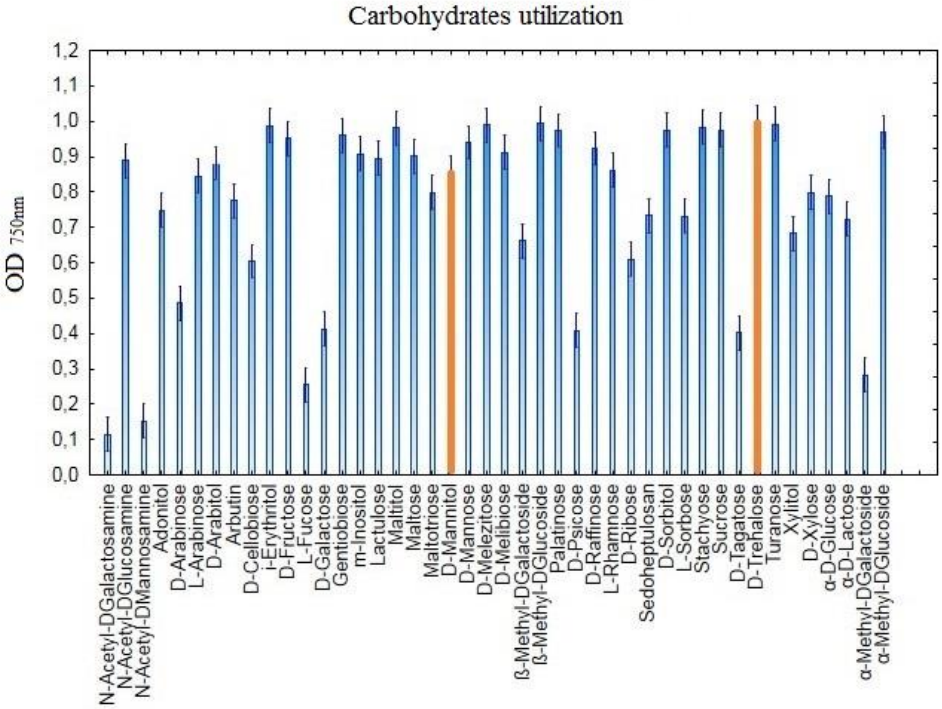

Fig.1 The utilization profiles for particular carbohydrates.

The aim of the study was to evaluate the carbohydrates metabolic pattern of 42 *Neosartorya* strains. Metabolic profile was evaluated using FF microplates (Biolog™). We obtained data on utilization of carbohydrates, among others Trehalose and Mannitol. Optical density (OD) was measured at 750nm wavelength.

All of tested Carbohydrates located on the plates were consumed by the tested strains (Fig.1.). Trehalose was used on the highest degree, although its consumption was not statistically different from the consumption of such substrates as: Turanose, Stachyosa, Sucrose, D-Sorbitol and many others. Mannitol was used in not much lesser extent. The consumption of Mannitol and Trehalose does not stand out against other Carbohydrates.

Acknowledgement

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STRUCTURAL AND MORPHOLOGICAL CHARACTERIZATION OF THE MCF SILICA SURFACE COVERED BY PROTEIN MOLECULES

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Keywords: Protein adsorption, MCF silica material, AFM, TEM analysis

Abstract

Investigation of biomolecules adsorption (proteins, enzymes, pharmaceuticals) from solutions on solid surfaces is of great importance with regard to prominent role in biology, medicine and bio-nanotechnology [1]. Therefore, it is important to understand mechanisms of sorption processes of compounds showing biological activity at different solid surfaces as well as study practical use of the modified biological materials in many areas (BioSS - Surface Biological Science) [2].

The mesoporous silica materials like MCF (mesocellular foam) with desirable and unique properties (highly ordered pore structure, high surface area and pore volume, possibility of functionalization and changing the surface properties) are very attractive group of adsorbents which can be very useful in the processes involving substances with large molecular sizes, including albumins. For large protein molecules the rate of adsorption process is controlled by their diffusion in pore system of a solid, therefore the studies on the effect of pore sizes on the kinetics of these processes are very important..

This paper presents structural and morphological characterization of MCF silica material with differentiated porosity for adsorption of protein molecules. The adsorption processes of LYS protein (*Lysozyme*) from aqueous solutions at pH=7.4 on the series of MCF materials with different porosity are investigated. The MCF adsorbents with various structures were prepared by using the non-ionic tri-block Pluronic copolymers as a template and trimethylbenzene as a pore expanding agent according to a modified procedure described in the papers [3,4].

The equilibrium adsorption isotherms and concentration vs. time profiles were determined from UV–Vis spectra [5,6]. The dependences between pore diameter and kinetic rate were analysed. It was observed that protein adsorption process on mesoporous silica support is slow and limited by diffusion of biomolecules into internal adsorbent porous structure and is strongly dependent on the pore size of MCF material (Fig. 1).

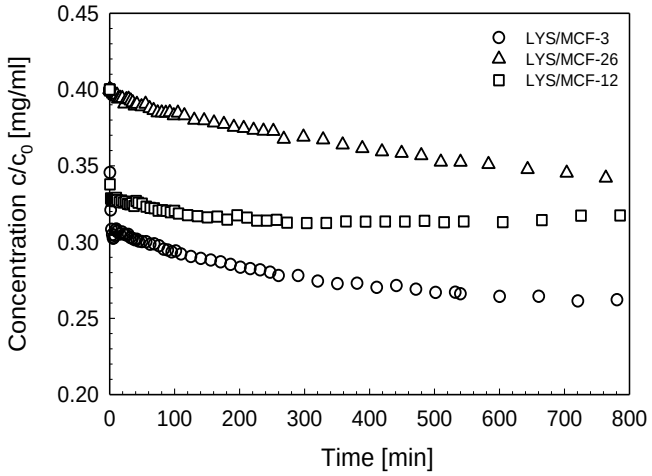

Fig. 1. Comparison of concentration profiles of LYS on the MCF-3/pore size:15 nm, MCF-26/pore size:5 nm and MCF-12/pore size: 30 nm (relative concentration~time).

Structure of the protein/silica composite system was investigated by means of nitrogen adsorption/desorption isotherms. The basic porous structure parameters of the studied silica supports as well as protein/silica composites: the BET specific surface area *(S_{BET})*, the micropore area (S_{mic}), the external surface area *(S_{ext})*, the total pore volume *(V_t)*, the micropore volume *(V_{mic})*, the average pore diameter *(D_{av})*, the average hydraulic pore diameter *(D_{hy})* were determined. Analysis of

porous structure of the MCF material after adsorption of both albumins shows that all porosity parameters *(S_{BET}, S_{ext}, V_t, V_{mic}, D_{av}, D_{hy})* are reduced.

The morphology and micro nanostructure of MCF surface with adsorbed protein layers were monitored by using the atomic force microscope (AFM) and optical profilometer (OP). The results show that the surface roughness and waviness after protein adsorption is lower than for the native silica material.

The TEM analysis before and after the protein adsorption confirm the structure and presence of the adsorbed proteins on the surface of porous material (Fig. 2).

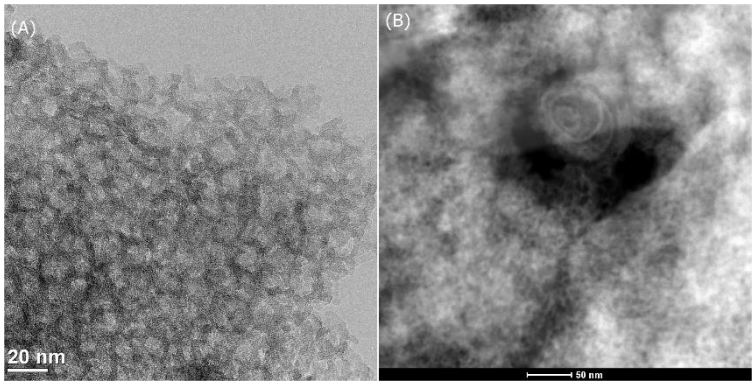

Fig. 2. TEM micrographs of the pure MCF silica surface structure (A) and covered by the LYS molecules (B).

Conclusions

1. The porosity (pore size, pore volume, specific surface area and a grain size) silica material have a great influence on the rate of adsorption process.
2. Adsorption process of protein on microporous silica adsorbents is slow and limited by diffusion of molecules into internal adsorbent porous structure.
3. AFM and OP morphological and microstructural analysis showed that the MCF surfaces with the adsorbed proteins molecules are less porous than the surface of the pure silica material. The surface roughness (S_q) and waviness (S_{dq}) decrease after protein adsorption on the adsorbent surface.
4. TEM/EDX examinations before and after the adsorption confirmed the structure and presence of the adsorbed protein on the surface of porous material.

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INFLUENCE OF WEARING ON THE CHARACTERISTICS OF BIOLUBRICANT

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Keywords: dynamic viscosity, biolubricant, DSC

Abstract

Viscosity is an important fluid property when analyzing liquid behavior and fluid motion near solid boundaries. Temperature dependence of viscosity – viscosity as one of the most important rheological parameters is defined as the resistance of a fluid to flow. Present data have been obtained from measurements performed on laboratory viscometer DV2T fy Brookfield. The experiments have been performed with use of ULA (0) spindle.

Monitoring of pour point by differential scanning calorimetry (DSC) - differential scanning calorimetry or DSC is a thermo-analytical technique which monitors heat effects associated with phase transitions and chemical reactions as a function of temperature, at pre-defined speed of heating (cooling), with assuming that both materials – sample and reference are under the same conditions (Haines, 1995).

The hydraulic fluid is of an ERTTO-type (Environmentally Responsible Tractor Transmission Oil) is biodegradable tractor oil. The oil is made from vegetable natural oil and special additives. The oil is destined for use in the gearbox and hydraulic circuit of agricultural and construction machines. It is used for lubrication of gearboxes, hydraulic circuits, for agricultural and construction machinery. Primary biodegradation per CECL-33-A-93 is 90% within 28 days and test method OECD 301 B is 65%. (Majdan, 2011).

Sample was weared in a special laboratory equipment, which was at the Department of Transport and Handling at Faculty of Engineering, Slovak Agriculture University in Nitra. The laboratory equipment was constructed from the elements of the hydraulic systems of the tractors. Hydraulic pump was loaded with cyclically changing pressure from 0.1 MPa to the nominal pressure of the hydraulic pump 20 MPa during the test.

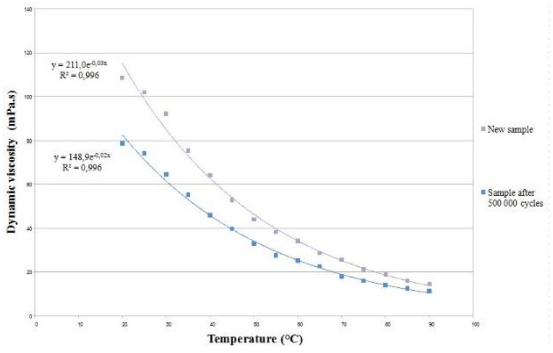

Figure 1: Temperature dependent viscosity of new sample and sample after 500 000 cycles.

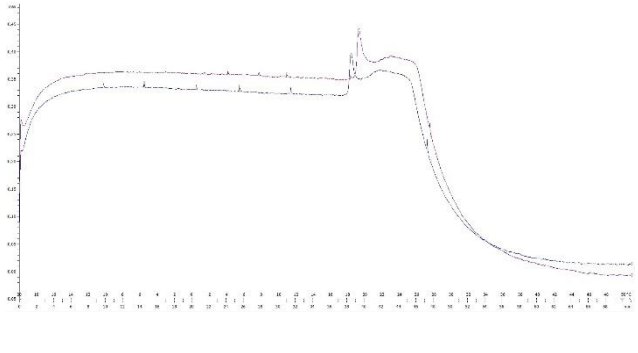

Figure 2: Pour point monitoring by DSC method of ERTTO hydraulic oil – new and sample after 500 000 cycles.

Results

Dynamic viscosity of hydraulic oils is decreasing exponentially with increasing of temperature. Regression equations and determination coefficients are for new sample $y = 211{,}0e^{-0{,}03x}$ $R^2 = 0{,}996$ and sample after 500 000 cycles is $y = 148{,}9e^{-0{,}02x}$ $R^2 = 0{,}996$. The determination coefficients for all the samples are very high, which also confirms strong exponentially decreasing dependence.

For monitoring of pour point of oils by DSC method was used device DSC 1 Mettler Toledo. We treated at the speed of heating (cooling) 1 K/min in the temperature range from 20°C to the temperature of -50°C. The measurement was carried out in an inert, dynamic atmosphere of N_2. As a result we got a DSC thermogram, which was evaluated in STARe software (Fig. 1). We observed exothermal peak at the temperature -19,41°C. This point is defined as a freezing point. Since oil is an amorphous matter, the pour point takes place not only in one point, but in the range of temperatures which shows the graph (onset at -19,02°C and endset -20,33°C). Exothermal peak for ERTTO after 500 000 cycles is -18,47°C and onset at -18,14°C and endset -19,32°C.

As it can be seen from the graph, there is a difference between new sample and used samples. The exponential dependency of viscosity on the temperature for the each sample was obtained in accordance with Arrhenius equation. The experiment shows that the new sample has higher temperature of pour point. Experimentally measured values can serve as an input into technological processes and also as the base for research of the types of biologically degradable oils necessary for development of new technologies.

Acknowledgements

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THE EFFECT OF BIOCHAR ADDITION ON PODZOLIC SOIL – HYGROSCOPIC MOISTURE CONTENT

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Keywords: maximum hygroscopicity, biochar, grassland, fallow

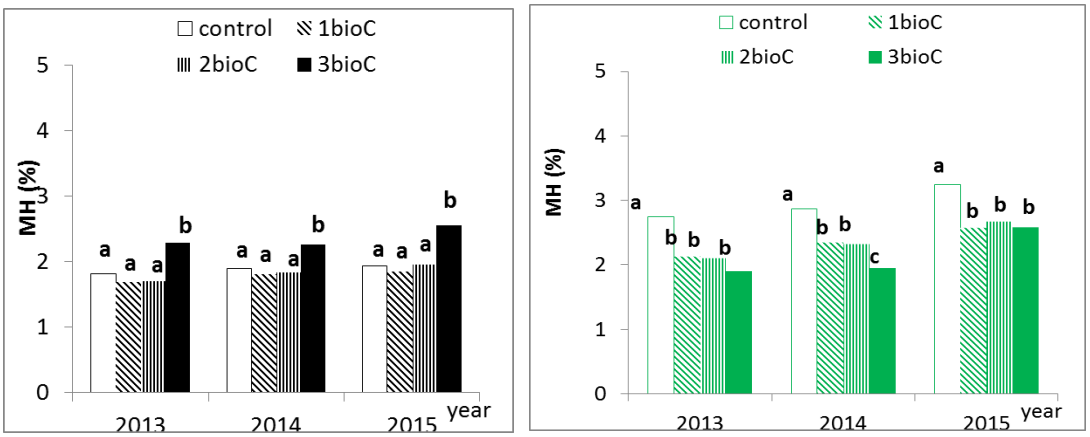
Abstract

Biochar (defined simply as charcoal) is a carbon – rich product obtained from pyrolyzed biomass, during the heating under oxygen limited conditions[2, 3]. Biochar amendments to agricultural soils have been shown to reduce nutrient leaching and to have a positive effects on soil physical, chemical and microbiological properties [1, 5]. According to the literature, properties of biochars are related to the type of source material, production method and conditions [6].

The studies were conducted on a Haplic Luvisol derived from loess with a sand, silt and clay content for the 0 – 20 cm soil layer, of 23, 58 and 19%, respectively. Biochar used in the experiment is a commercial product – Biochar FLUID made by FLUID S.A. company (Poland). Biochar was applied to the soil sub – plots under fallow and grassland in the amount of 0 (control), 1, 2 and 3 kg/m^2 of soil. Soil samples were taken three times per year during 2013 – 2015.

The main goal of this study was to investigate the effect of biochar on hygroscopic water content (maximum hygroscopicity) of grey – brown podzolic soil.

Hygroscopic moisture content of soil is usually determined by an air drying method and has been related with the clay content, the surface area and cation exchange capacity of the soil [4]. The adsorption isotherms belong to basic hydrophysical characteristics describing the relationship between the relative humidity or relative water vapour pressure and the equilibrium water content in soil. Water sorption isotherms are equivalent to the water retention curves that display the soil water content as a function of the logarithm of water potential. Maximum hygroscopicity was estimated from sorption isotherms at the relative water vapour pressure p p_0^{-1} = 0.965 and expressed as the amount of the sorbed water vapour (g g^{-1}) multiplied per 100.



1. The maximum hygroscopicity (MH) for all soil samples taken every 4 months during the period 2013 – 2015 varied from 1.5 to 3.3%. Soil samples from grassland exhibited higher values of MH (about 2 ~ 3.3%) than soil samples from fallow (about 1.5 ~ 2.5%).

2. The effect of biochar addition to soil on MH was ambiguous. In the case of grassland, the addition of biochar caused a decrease of MH value with increase of biochar dose.
3. For the fallow the significant increase of MH with the maximum dose of biochar (3 kg/m^2) took place.

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TEMPERATURE CHANGES OF PHOTOVOLTAIC CELLS PARAMETERS

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Keywords: Photovoltaic cell, temperature dependence, Fermi energy

Abstract

A photovoltaic (PV) cell converts solar energy directly to electrical energy by means of a PN junction. It is well known that the efficiency of PV cells decreases with an increase of temperature [1]. In the reference [2], Wysocki shows, that the effect of temperature on efficiency depends on the carrier transport mechanism (diffusion and ohmic current) between 0÷400°C. In the reference [3], the temperature dependence of shunt and series resistance of PV cell was measured between 22÷47°C. The physical principles of temperature dependence and mathematical derivation can be found in reference [4]. Temperature dependence of PV solar cell between -20°C to 50°C is the subject of this presented paper.

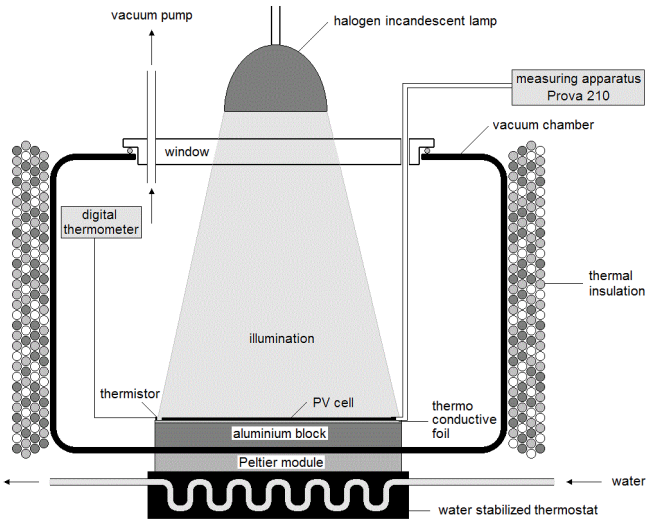

Fig. 2 Measurement setting

The experimental arrangement is shown on the Fig. *2*. The reference PV cell was based on crystalline silicon, square in shape with area 50x50 mm^2. In order to receive consistent data and eliminate external factors, a vacuum chamber was used to keep the experiment space around the reference PV cell isolated. Light source was calibrated to ensure its stability and the distance from the light source to the reference cells was carefully chosen. The cell was constantly irradiated with irradiation I_r = 35000 lx. Temperature of the cell was stabilized by Peltier module and measured by a calibrated thermistor. Reference cell was fixed on an aluminum block using a thermoconductive foil. Solar module analyzer Prova 210 was used to measure *I-V* characteristics of the reference cell at defined temperatures.

The performance of reference cell agrees quite well with physical theory of semiconductors. The coefficients from measuring data (open-circuit voltage V_{oc}, short-circuit current I_{sc}, maximum power P_m and fill factor *FF*) are shown in the Tab. 1 below.

Tab. 1 Important coefficients of the reference PV cell

Coefficient	Value
$\frac{dV_{oc}}{dT}$	-0.0021 V.°C^{-1}
$\frac{dI_{sc}}{dT}$	0.0005 A.°C^{-1}
$\frac{dP_m}{dT}$	-0.0004 W.°C^{-1}
$\frac{d\,FF}{dT}$	-0.0013 °C^{-1}

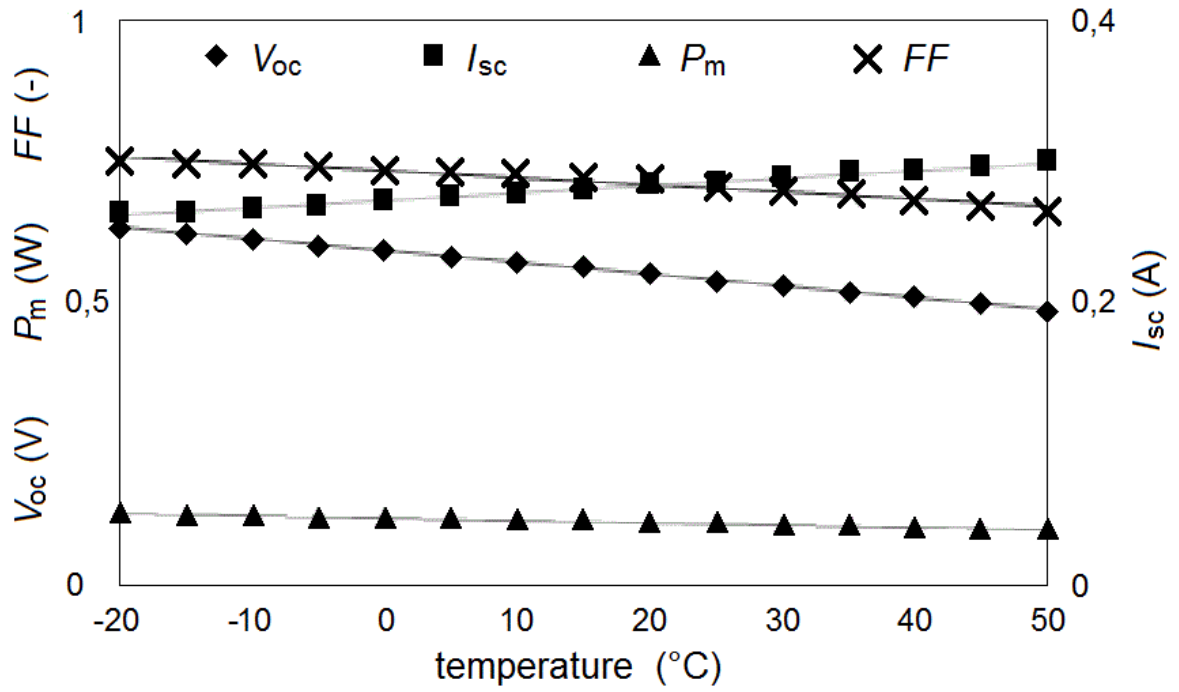

Fig. 3 Temperature series of important characteristics of the reference PV cell (open-circuit voltage V_{oc}, short-circuit current I_{sc}, maximum power P_m and fill factor *FF*)

This phenomenon could be theoretically explained by using the band theory of solid state physics [5]. When the temperature increases, the Fermi energy level is shifted toward the center of the forbidden gap, which reduce the open-circuit voltage of the cell [6]. As a consequence, the bandgap becomes narrower, which increase the short-circuit current. The electron-hole pairs generation rate is increased, which leads to slightly raise of the ohmic current. In general, the maximum power generated by the cell is decreased as well as the filled factor and efficiency of energy conversion (see Fig. 3). The rate of open-circuit voltage decrease is much higher than short-circuit current increment. If the temperature approaches to 500 K, the conversion efficiency will approach to zero.

Results from the measurement confirmed the theory and encourage to continue the investigations on other materials. The temperature coefficients of different types of materials will be find, these provided important information to photovoltaic solar system dimension and design.

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SHORT TERM IN-FIELD MEASUREMENTS OF O2 CONSUMPTION AS A SUBSTITUTE FOR BOD5

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Keywords: biochemical oxygen demand, BOD_5, WWTP

Biochemical or biological oxygen demand (BOD) usually expressed in milligrams O_2 per litre (4) is widely used as a proxy for concentration of biodegradable organic compounds in water. For the first time BOD_5 ("5" stands for five day period to estimate the parameter) was selected in 1908 as an indicator of the organic pollution of rivers by the U.K. Royal Commission on River Pollution (1). As for now the BOD parameter has many modifications aimed at acceleration and simplification of procedure. But the essence of the method — consumption of dissolved oxygen by microorganisms isolated in a given volume during a given time — remains unchanged.

As the main drawback of the BOD_5 Riedel and coauthors pointed out that span of time needed to obtain result is quite long (5). Due to the worldwide use of BOD methods, alternatives have been developed that range from static bioassays to online biosensors (1). To mention some: methods based on bioluminiscent bacterial biosensors which takes about 72 min (6), microbial fuel cell technology which gives the answer in approximately 5 hours (2) and biosensors with entrapped bacteria with an analysis duration not longer than 90 min and in some cases even 70 sec (3). But all the methods that shortening assessment time are indirect and not widely applied.

It can be concluded that BOD_5 parameter is used for more than 100 years and it usefulness is widely accepted. On the other hand it is time-consuming or dependent on quite complex and expensive equipment. To cope with mentioned obstacles we measured the oxygen concentration each minute by the HACH HQ40d Portable Multi-Parameter Meter in the darkened submerged *in situ* 250 ml vessels with tested water at the span of one hour of exposition. This procedure solves next problems. First, the overall time of experiment is quite short so in most cases there is no need in dilution which if applied introduces additional artifacts. Second, microorganisms continues to function under environmental temperatures, so intensity of their respiration remains unchanged. We applied this technique on the fragment of river Uzh (Ukraine) continuously affected by sewage discharging from the Uzhgorod municipal wastewater treatment plant (WWTP) and on the some points of WWTP itself. We obtained quite wide spectrum of the rates of the molecular oxygen consumption. Acquired data are in good concordance with other characteristics of investigated stations which allow us consider proposed method as perspective.

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MATHEMATICAL MODEL AND CFD ANALYSIS OF DOUBLE PASS FLAT PLATE SOLAR AIR COLLECTOR UTILIZED FOR ACTIVE SPACE HEATING

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Keywords: double pass, solar air collector, thermal efficiency

Abstract

Solar energy is an important alternative source of energy and plays a critical role as an infinite renewable energy. However, this significance cannot be overemphasised because of the current climate change conditions, at the same time solar energy has a low density and intermittency [1]. All these circumstances call for an effective means for solar energy collection.

Proper designing of solar air collectors is a crucial factor that controls solar performance. Air type collectors have two inherent drawbacks, low thermal capacity of air and low absorber-to-air heat transfer coefficient. The double pass solar air collector is suitably designed to outspread heat transfer area and improve the heat transfer coefficient [2].

The collector is utilized for active space heating. It was manufactured with a cost of 400 EUR in the laboratory of Institute for Environmental Engineering Systems, Faculty of Mechanical Engineering at Szent István University. The measurements of the experimental results were taken on March 2017.

The construction of the collector buddy was mainly from wood since it work as an insulation and light in weight with back side of 20 mm polystyrene layer thickness. The absorber is made from grade C 110 copper sheet having dimensions of (1210 mm x 460 mm) and 1.2 mm thickness painted in black matt. The air inlet to the collector pass through the upper absorber surface with 6.38 cm depth then directed to the lower absorber surface via holes to pass through a 35 mm x 160 mm rectangular cross section path with 3.5 cm depth in seven parallel baffles to the outlet.

A mathematical model under forced convection mode and the solution procedures to predicting the thermal performance was presented and compared with the measured results after validating the accuracy of the theoretical model by developing a MATLAB code with error at the range between 0.31% and 0.92% as showen in Fig. 1. The iteration was repeated until the consecutive of the outlet temperature value differed by less than 0.0001 ^{o}C [3].

The influence of the inlet mass flow rate of the collector on the thermal performance was examined under several environmental conditions. Considering the energy gained and the fan power consumed under real conditions, the optimum mass flow rates were discussed and simulated with different inlet temperature, ambient temperatures and solar radiations by the help of thermo-hydraulic efficiency.

The result shows that the optimum mass flow rate for this collector is 0.02 kg/s at I = 1000-700 W/m^2, and 0.015 k/s at lower radiation with collector efficiency of 67%. The effeciency increase in this double pass structure with 11.3% to 24.07%.

The computational fluid dynamics (CFD) tool has been used to simulate the solar collector for better understanding the heat transfer capability and distribution. 3D model has modelled by ANSYS Workbench using ANSYS FLUENT software. The CFD simulation has a good agreement in the result which even declare the temperature and the velocity distribution. Although there are small discrepancies due to the assumptions which deliberately influence the result, but the results are useful

for analysing and designing new solar air collectors especially for more complex solar collectors design and applications.

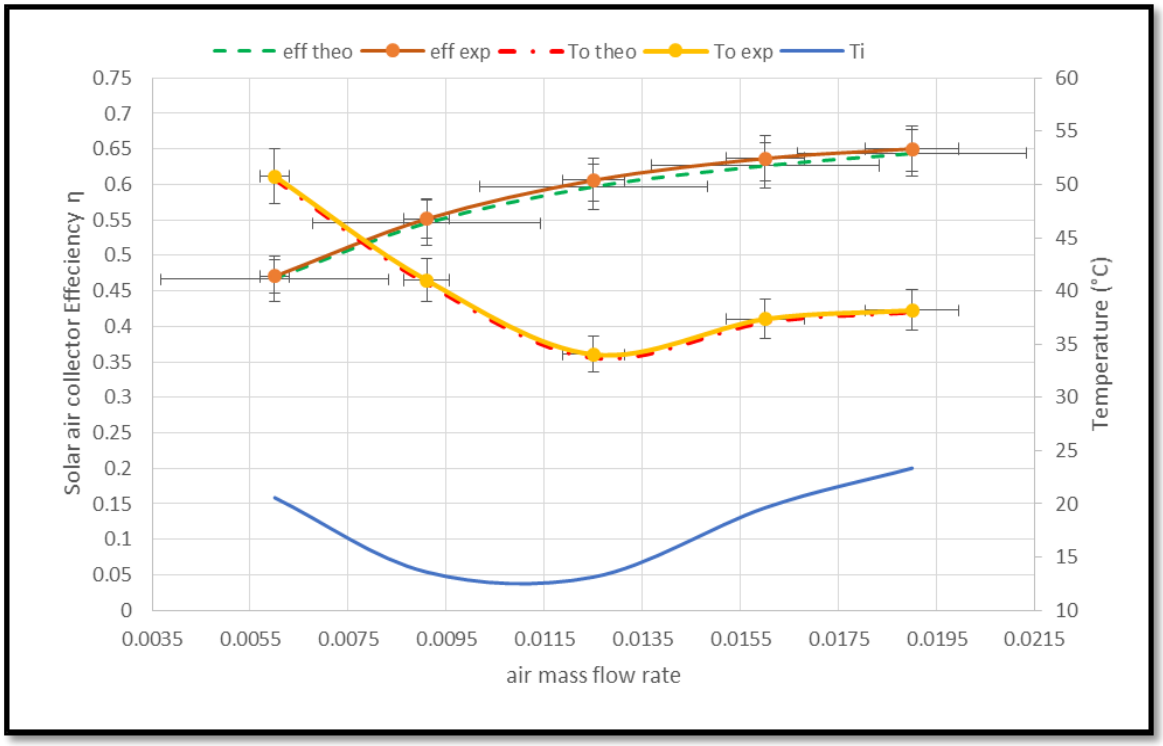

Fig. 1 Comparison of experimental and theoretical results

Conclusions

1. The accuracy of the theoretical model was checked and validated with measured data from the experimental results. The structure of this collector obtain high efficiency comparing with other collector for the same purpose.
2. The maximum thermo-hydrolic efficiency of the collector obtained is 62% at 1000 W/m^2 solar radiation and the minimum is 55% at 450 W/m^2 whereas the efficiency of the collector is 67% at the optimum mass flow rate 0.02 kg/s.
3. It is economical process technology, self construction and the improvement or enhancement is possible always.

Acknowledgement

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MODELLING OF SATURATED HYDRAULIC CONDUCTIVITY COEFFICIENT - VALIDATION FOR SOIL CORES

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Keywords: hydraulic conductivity, modelling, X-ray CT

Abstract

Saturated hydraulic conductivity coefficient can be easily measured with different laboratory methods. Whereas three-dimensional modelling has been widely used for fluid flow analysis in porous media [1], experimental validation of these models is not commonly undertaken. The aim of the study is to validate FVM (finite volume method) modelling for soil cores.

The soil cores (of 42 mm length and 46 mm diameter) have been scanned in X-ray microtomograph GE/Phoenix Nanotom 180 (the basic scan parameters: voxel size - 23 µm, X-ray source voltage – 100 KV, X-ray source cathode current – 150 µA). The acquired data was processed in order to obtain mesh for FVM. The FVM calculations were carried out in OpenFOAM – the open source programming environment.

The used solver models water flow through the medium, which can be divided into two parts. Pore space, through which water flow is simulated using Navier-Stokes equations, and soil matrix, where Brinkman-Darcy equation is additionally incorporated in Navier-Stokes equations [2]. Such approach enables flow simulations for samples of soil, which pore network does not percolate.

In order to validate experimentally modelling method the saturated hydraulic conductivity coefficient was calculated . CT scanned soil cores were then used for experimental measurement of saturated hydraulic conductivity coefficient. The measurement was made with the constant head method using Eijkelkamp permeameter.

Comparison of values obtained experimentally and with FVM calculation shows that this approach could be used for soil cores.

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INTERACTION OF ZINC IONS WITH DILUTED ALKALI SOLUBLE PECTIN FRACTION

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Keywords: pectin, interaction, gel formation

Abstract

Pectin is a group of polysaccharides which is mainly composed of linear chains of D-galacturonic acid units (homogalacturonan), segments of D-galacturonic acid and L-rhamnose units (rhamnogalacturonan I) and backbone composed of D-galacturonic acid residues (7-9) with attached four side chains containing sugar units such as rhamnose, arabinose, galactose and fucose (rhamnogalacturonan II) [1]. These polysaccharides extracted from different sources vary in structure and properties. The important property of pectin is gel formation which depend on a lot of factors such as pectin structure (degree of methylation and molecular weight), pectin concentration, the presence and concentration of sugar and crosslinking agents, pH and temperature. Due to degree of methylation low methoxy and high methoxy pectin can be distinguished. In the gelation process of low methoxy pectin (DM<50 %) the presence of crosslinking agents such as calcium ions and pH=2-6 are required. The gel formation of high methoxy pectin (DM>50 %) occurs at sugar concentration above 55 % and pH below 3.5 [2]. Gelation mechanism of low methoxy pectin is explained by "egg-box" model [3] which assumes formation of ionic bonds between non-esterified galacturonic acid units and calcium ions. Other divalent metal ions can also interact with pectin but this mechanism has not been known yet.

The aim of presented research was to characterize the interaction between zinc ions and pectin. Zinc is a microelement which plays an important role in human body. Binding of zinc ions to pectin could be used for example in drug delivery systems. The investigated pectin was extracted from apple using water, CDTA and sodium carbonate with addition of sodium borohydride. The last obtained fraction called diluted alkali soluble pectin fraction (DASP) was used for further studies. The concentration of D-galacturonic acid in this fraction was determined (Continuous Flow Analyzer, Skalar, The Netherlands). The 0.01 % solutions of the DASP fraction with zinc chloride were prepared to obtain the salt to galacturonic acid molar ratios in range from 0 to 30. The atomic force microscopy (Multimode 8 with Nanoscope V controller, Bruker, Billerica, MA, USA) was applied to analyze the structural properties of samples. The measurements of pH (Oakton pH Spear, Osprey Scientific Inc., Canada), electrolytic conductivity, electrophoretic mobility and aggregation index (Zetasizer Nano ZS, Malvern Ltd., UK) were executed (3 repetitions, T=20°C). Based on the analysis of both the acidic and electrokinetic properties of the Zn-treated pectin the molar ratio range was determined in which a significant neutralization of negative electrical charge simultaneously with the H+ release to bulk solution occur. The change of the aggregation index sign from positive to negative, which is connected with the disappearance of differences in optical properties between dispersed and dispersing phases, led to indicate the gel point.

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Acknowledgments

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FORECASTING OF METEOROLOGICAL TIME SERIES USING COMBINED TBATS AND SVM METHODS

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Keywords: meteorological time series, forecasting, TBATS, SVM, support vector machine

Abstract

Agricultural meteorology is the branch of meteorology that uses weather and climate data to qualitatively and quantitatively improve the crop and livestock production and soil management (Baranowski et al., 2015). Every farm operation and the process of plant growth and development as well as the yield of a crop are strongly affected by weather conditions (Pirttioja et al., 2015). A diverse, multidisciplinary array of data as well as complex statistical models (including a combination several methods are frequently used in time series forecasting (Murat et al. 2016).

Modelling and forecasting of agro-meteorological time series improve the quality of the data needed for planning and conducting crop fields management and can be used for prediction of the climatic change impact on crop production (Smith et al., 2007). In literature there are several approaches to model time series. The most promising forecasting models are ARIMA models (Box and Jenkins, 1970), state-space models (Harvey, 1989) and innovations State Space Models (Hyndman et al., 2008).

The study was conducted in four locations from northern, central and southern Europe to present different climatic conditions. Jokioinen in Finland was chosen for northern Europe and Lleida in Spain for southern Europe. For central Europe two sites were chosen: Dikopshof located in the west part of Germany and Nossen in the south part of Germany. Jokioinen city has a subarctic climate that has severe winters, with cool and short summers and strong seasonality. Lleida has a semi-arid climate with Mediterranean. Dikopshof represents maritime temperate climate. There are significant precipitation throughout the year in Dikopshof and Nossen. Data was collected the 11322 days data from January 1st 1980 to December 31st 2010.

The aim of forecasting the agro-meteorological time series time series is to generate future predictions of studied quantities on the base of past observations of a time series. The evaluation of the inherent structure of the series is then possible.

In this study we combined two methods, i.e. TBATS and SVM (Support Vector Machine). TBATS is an acronym for the key features of the model, where T stands for trigonometric representation of seasonal components. SVM symbols mean Method Support Vector Machine. SVM methodology uses training datasets for model building. The trained model may be applied for further evaluations, especially to check its performance with the so-called testing dataset.

The study analyzed the possibility of robust prediction of maximum and minimum temperature. Two models of different origin were used, the first one TBATS and the second SVM.

This results showed the SVM modeling approach can be used for estimations of maximum and minimum temperature changes in time with the accuracy comparable to the physically based model.

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THE POTENTIAL OF SOIL ELECTRICAL CONDUCTIVITY DATA ACQUISITION BY UAV MOUNTED WITH RGB CAMERA

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Keywords: soil electrical conductivity, remote sensing

Abstract

Soil is the main resource for crop production in agriculture. Intensive use of this resource is required for high yields in any crop production, therefore it is essential to establish the optimal dose of fertilizers or chemical protection, optimal rate of soil cultivation and ploughing, irrigation, sawing and other field operations [1]. Optimalization is the key to successful farming practice in modern days, but it requires great amount of information about physical properties of the field itself [2]. Soil electrical conductivity (EC) can help to significantly reduce amount of soil sampling spots based on characterization of field spatial variability and thus reduce farming costs and time and work required to gather sufficient amount of data.

Soil EC has become one of the most frequently used measurements to characterize field variability for application to precision agriculture and it is among the most useful and easily obtained spatial properties of soil that influences crop productivity [3]. But measurement of soil EC requires substantial amount of time and money in form of expensive measuring aparatus. The aim of this study was to explore the possibility of using unmanned aerial vehicle (UAV) mounted with traditional RGB still camera to speed up the process of soil EC measurement. Soil EC in a horizont 0-1 m was emasured by conductivity probe EM38-MK2 towed behind a quadbike on the 14.25 ha research plot while UAV (Asctec Falcon 8) was acquiring images from the height of 300 m. Fig 1 (left) shows field classified based on shades of grey into 6 classes. In this case lower index was assigned to darker color on the field. Fig 1 (right) shows soil EC measurement acquired for the same plot. Spatial resolution of both of the maps was then set to 5 m and statisticaly analysed.

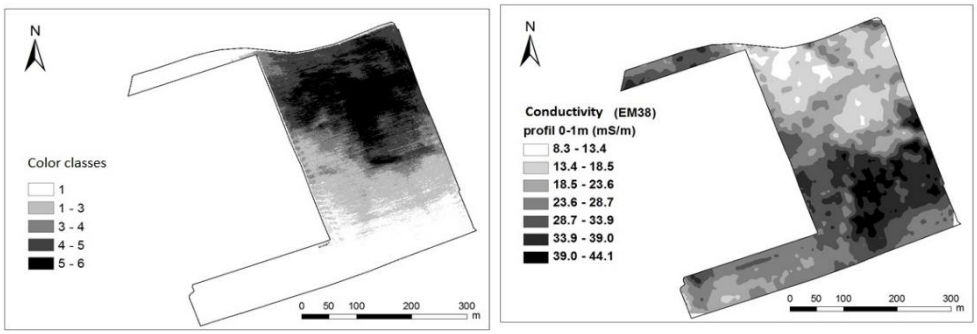

Fig 1: Color classification of the plot (left) and soil EC measurement by EM 38 (right)

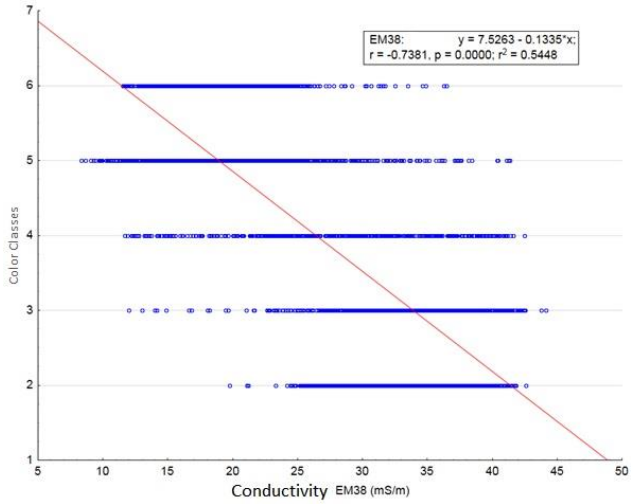

Fig 2: Correlation of color classes (UAV) and EC measurement (EM 38)

Correlation between color classes and soil EC was established with the correlation coeficient (r= -0.74) and determination coeficient (R^2 = 0.54) . Those results suggests that the darker is the color of the soil, the higher is soil EC. Remote sensing in the visible spectrum proved as viable aid in speeding up the process of soil EC data acquisition as less time can be spent on large homogenous parts of the field and soil sampling grid can be further optimized in shorter period of time.

Conclusions

1. Remote sensing is viable tool for lowering time requirements of soil physical data acquisition.
2. Despite providing temporaly intensive data, remote sensing can not fully replace soil EC measurements.

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DEM MODELLING OF PRESSURE DISTRIBUTION IN A 3D PILE OF SPHERICAL PARTICLES

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Keywords: granular pile; pressure dip, force chains, distinct element method (DEM)

Abstract

Granular materials behave like solids or liquids depending on amount of kinetic enegy of particles. Under gravity particles fall and and settle on a flat surface creating a pile. Distribution of intergranular forces inside the deposit of particles is far from homogeneous. Experiments indicate that in some conditions of a pile preparation pressure under a conical pile of particles reveal counterintuitive behaviour. In the location at at centre of pile base, having the greatest material height, where maximum of pressure may be expected, the pressure dip can be observed (Brockbank et al. (1997). Explanation of that unexpected behaviour of granular solids is searched in distribution of forces in particle-particle contacts which is far from normal and similar to exponential one.

The distinct element method was applied to study force distribution inside the 3D pile of spherical particles and to determine distribution of stress components inside the pile. Effect of sliding and rolling friction on the angle of repose of the pile and on the pressure dip under the pile was investigated. For the study the sliding friction of particle-particle $\mu_{p\text{-}p}$ in the range from 0 to 1.5 and the rolling friction m_r in the range from 0 to 0.1 were applied. Particles were poured on the horizontal plain (particle-wall friction $\mu_{p\text{-}w}$ of 0.35) from the the filling device with the orifice diameter equal to 10 particles diameters slowly lifted to maintain the distance between the uppermost particle of the deposit and the orifice of 4–8 particle diameters.

A numerical analysis of the transmission of contact forces in a granular pile comprising 50,000 frictional, coarse spherical particles was performed. The goal was to attempt understanding the microscopic origins of macroscopic behaviours, such as the pressure dip at the centre of the base of a conical pile. The particles were 8.2 mm in diameter with a standard deviation of 0.1 mm to avoid ordering effects. The stress tensor σ_{ij} in the system of particles averaged over all the contacts in the volume V was determined as the dyadic product between the contact force f_j^c vector at contact c and the branch vector l_i^c connecting two contacting particles (Christoffersen et al., 1981):

$$\sigma_{ij} = \frac{1}{V}\sum_{c=1}^{N_c} l_i^c f_j^c \quad (i, j = x, y, z). \tag{1}$$

Stress components σ_z, σ_n, and σ_t in cylindrical coordinates were determined applying (r, ϕ, z) components of contact force and branch vector in formula (1). The shape of the representative volume element (RVE) of particle contacts used for the stress calculations was assumed to be a cylinder or ring of height Δh = 0.05 m (approximately 6 average particle diameters) and radius increment Δr = 0.03 m. The total number of contacts in the RVE was dependent on the radius of the ring and increased from 580 to 8 000 with an increase of the inner ring radius.

The study confirmed earlier finding (Brockbank et al., 1997) that gentle filling from narrow source localized slightly above the pile apex and high sliding and rolling friction favour the generation of a pressure dip. The highest repose angle (Fig. 2) and the highest pressure dip were associated with a low coordination number (Fig. 1). Fig. 3 illustrates a dip in radial distribution of the bottom presure $\sigma_{z\text{-}Base}$ and in the stress components σ_z and σ_r inside the pile. Particle-particle contact orientations (Fig.

4) established during the pile formation determines the preferred direction of transmission of forces from higher layers of the pile to outher locations. This effect leads to formation a dome-shaped structure of maximum of the mean pressure inside the pile bearing a portion of the load from higher layers of the bedding.

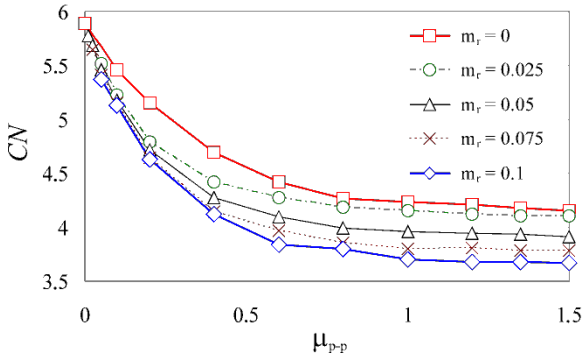

Fig. 1. Coordination number *CN* as influenced by the coefficients of particle-particle friction $\mu_{p\text{-}p}$ and the rolling friction m_r (Horabik et al., 2017).

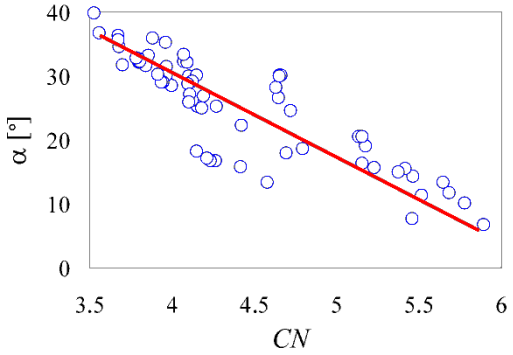

Fig. 2. Repose angle α of the pile as influenced by the coordination number *CN*.

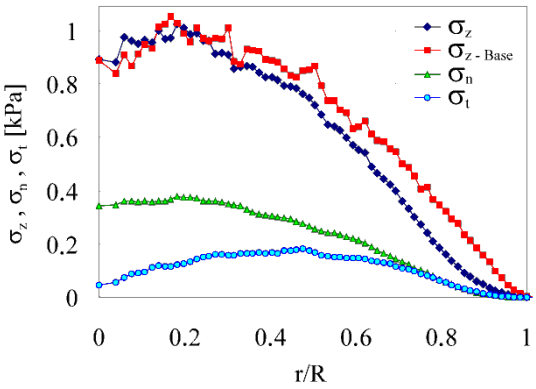

Fig. 3. Bottom presure $\sigma_{z\text{-}Base}$ and stress components σ_z, σ_n, and σ_t inside the bottom (1/3 of the pile height) layer of pile for $\mu_{p\text{-}p}$ = 1, m_r = 0.1.

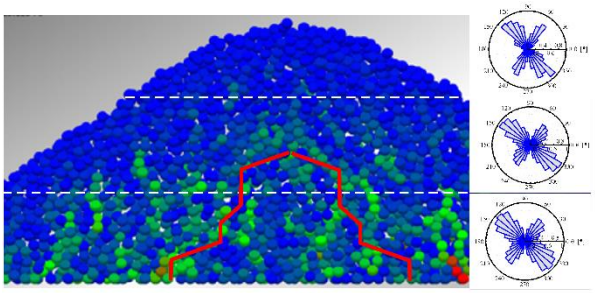

Fig. 4. Dome-shaped structures of maxima of mean pressure at the cross-section of the pile and distribution of contact orientations for μ_{p-p} = 0.4 and m_r = 0.1.

Conclusion

The characteristic dip in the base pressure distribution as well as in the stress components inside the pile of spherical particles of relatively high vales of coefficients of sliding and rolling friction appears when the particles are poured via a dense, slow stream of moderate thickness. A dome-shaped structure arises inside the pile transmitting a portion of the load from higher layers of the bedding to outher locations.

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REDOX POTENTIAL DURING THE LABORATORY SBR STABLE WORK STAGE

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Keywords: redox potential, pH, activated sludge, sequencing batch reactor

Abstract

The active sludge is an artificial system consisting of: prokaryotic (including heterotrophic bacteria) and eukaryotic organisms (protozoa, fungi, yeast and invertebrates: rotifers and nematodes) [4]. Sequencing Batch Reactor (SBR) systems work on the principle of activated sludge allowing for highly efficient wastewater treatment. The SBR reactor's operating time is defined as a cycle, which consists of sequentially successive phases [1,5].

In recent years, real-time control processes using oxidation-reduction potential (redox), pH or dissolved oxygen (DO) as parameters to control the oxic and anoxic cycles of SBR systems, have received much attention [2], but there is not much information about using the redox or pH to define the stable work stage.

The main goal of this study was to investigate the redox potential and the pH during the working stage in the SBR reactor.

A full SBR operation cycle (12 h) was characterized by the following phases: filling the chamber (10 min); mixing (180 min); aeration (420 min); settling (90 min); decantation (10 min) and idle (10 min). The laboratory equipment consisted of three independent SBR chambers, in this study, SBRs were used with a total volume of 2 dm^3.

During the experiment, the temperature iside bioreactor was kept at 20 ± 0.1 °C, while dissolved oxygen was kept at a level of 2±0.1 mg O_2 dm^3. Over the study, the redox and pH parameters were analyzed on-line (HQ 440D; Hach).

The redox and pH results for the summer season, at stable work of SBR, has analyzed. During the mixing phase the decrease in the redox potential is observed. However, during the aeration phase, the value of the redox potential rises. These results are consistent with those reported by the Kishida (2003) and Li (2007) team [2,3]. The pH value kept at about pH ~ 8. However, no significant changes have occurred between the mixing and aerating phase during experiment.

Conclusions

1. The laboratory SBR reactor enables efficient sewage treatment by activated sludge.
2. The redox potential and pH can be used as the indicators of the stable work of SBR.

Acknowledgements

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BENEFITS AND CHALLENGES OF PALM OIL IN A FUTURE BIOECONOMY

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Keywords: Vegetable oil market, food consumption, biofuel production, sustainable development

Abstract

This paper presents a brief literature information on the favourable and unfavourable factors of palm oil sustainability in a green economic and industrial vision. Palm oil, soybean oil, rapeseed oil and sunflower seed oil are the most common oil types used for food consumption and industrial uses. The global vegetable oil production in 2015/2016 amounted to over 179 million metric tonnes which is expected to increase through the next years. On the other hand, the consumption forecast for 2016/2017 of the above-mentioned vegetable oils in that order is 64.02, 53.15, 27.65 and 15.55 million metric tonnes respectively. For palm oil particularly it is estimated that about 90% is used for food whiles the remaining 10% is for industrial applications including biofuel production [1]. The crude palm oil provides almost 30% of the total vegetable oil market and plays a very significant role in poverty alleviation, food and energy independence and rural development in several tropical developing countries [2-5]. The oil palm as a multi-purpose crop produces two unique kinds of oil from its fruit or mesocarp and the kernel. A fruit bunch yields about 20% palm oil and 2% palm kernel oil. The economic life of oil palm is about 25 years [6-8]. Malaysia and Indonesia have been the focal point of oil palm cultivation contributing to over 80% of palm oil production. Other leading producing countries are Thailand, Colombia and Nigeria. India, China and Europe are the largest importing countries [9-11].

In a bio-based economy, renewable resources are used for industrial applications and energy generation without compromising food and feed provision. With recent campaigns against the rapid expansion of oil palm cultivation in the tropics, the reliability of palm oil in a bio-based economy is in the balance. Based on the literature, the overall activities associated with crude palm oil production include land or soil preparation and planting, fertilzer and pesticide application, weed control, fresh fruit bunch harvesting and transportation, oil extraction, wastewater treatment, palm oil mill effluent treatment and empty fruit bunch disposal. These activities lead to potential environmental impacts namely global warming, acidification, eutrophication, photochemical ozone, human toxicity and freshwater ecotoxicity [12]. Generally, the cultivation of oil palm thus contributes to land-use change, peatland loss, carbon stock loss and deforestation with major impact on biodiversity [13-14]. This change in land use has become a critical concern of consumers of the palm oil especially in Europe and the USA. However, it is important to reiterate that the change in land use is also initiated by other drivers such as timber harvesting, mining and uncontrolled bush fires [8]. Studies have shown that carbon stock change has contributed significantly to annual global anthropogenic carbon dioxide emissions between 8 and 20%. Methane and nitrous oxide emissions are other greenhouse gases from wastewater at the milling stage and nitrogen fertilizer use in the cultivation phase which put forward serious environmental problems [12,15].

The unpredictability of the global market trade has been also indicated to have an effect on the sustainability of palm oil for use in a bio-based economy. Notwithstanding these challenges, palm oil is seen as the potential source of biodiesel in future compared to other vegetable oils. Therefore, the global call for fully enforcing existing environmental regulations on oil palm expansion and intensification; namely the sustainable certification standard, RSPO (Roundtable on Sustainable Palm Oil) and the European Union and the United States sustainability criteria on feedstock imports for biofuel production as well as best management practices including waste management would provide a more sustainable production in terms of economic, social and environment [16-17].

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THE RELIABILITY OF FIBARO HC LITE FROM VIEWPOINT OF DEPLOYMENT AS INTRUSION AND HOLD-UP SYSTEMS

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Keywords: Fibaro HC Lite, I&HAS, Z-Wave, integration, intelligent building

Abstract

For a long time we can see many forms of integration the Intrusion and hold-up systems (I&HAS) with others systems in building. In practice we can see the I&HAS integrating the technology systems (HVAC, ACC, CCTV etc.) [1] or some complex systems called "the intelligent households", „the intelligent buildings" [2] or even "the intelligent cities" [3] integrating the I&HAS. These technologies have a potential of complex technology solution of building in the agriculture sector, e.g. garages, warehouses, administration buildings etc.

Generally, the integration of I&HAS is not easy from viewpoint of technological feasibility nor adherence of norms [4; 5]. Often we can see the complex systems without the relevant certification. But it may be indicative of worse functional safety which is at the security systems very important. One of these similar systems (they may have the next commercially names e.g. "smart home system") is the Fibaro (Fig.1) system which is the subject of evaluation in this paper. It offers useful comfort and saving functions but also the security functions. However all components of Fibaro system do not have the certificated security level related with I&HAS. Therefore it was appropriate to examine the real reliability of these security functions.

Fig. 1. **The realization model**: 1 – Z-Wave detectors; 2 – Fibaro HC Lite (switchboard); 3 – case; 4 – Fibaro relay FGS-211; 5 – backup power; 6 – GSM output; 7 – Z-Wave access keypad; 8 - Z-Wave alarm

For purposes of this the reliability verification was used the method according to the Functional Examination, which is included in the norm BS EN 50131-3:2009 [6]. It is consisted of the monitoring of cyclic transmission of information about detections (packets) on switchboard input. In this case a switchboard was the control unit Fibaro HC Lite and a component transmitting information about detection was Fibaro Universal Binary Sensor.

The main measurement of the reliability was conducted with direct visibility both antennas on five distances: 1, 5, 10, 15 and 20 m. Every distance was verified in eight measurement cycles therefrom four cycles in a row were conducted with previous restart of control unit and thereafter four cycles in a row were conducted without previous restart. One thousand packets were gradually sent within each measurement cycle. The time period between two sent packets was 0.5 s. After the end of the each measurement cycle the extract from the event log was copied to the table. All results were converted to percentages and represent the reliability.

In measurement when the control unit was restarted before each measurement cycle the average value of reliability was 99%. This result is questionable with regard to the application as I&HAS. Nevertheless, in measurement where the control unit was restarted only before the first measurement cycle the value of reliability was 57%. The independence of the distance was obvious there. The statistical processing based on searching of the Pearsons correlation coefficient ($\alpha = 0.05$; $r = -0.9484$) showed degreasing dependence of reliability on number of packets registered by control unit before the measurement cycle (Fig.2).

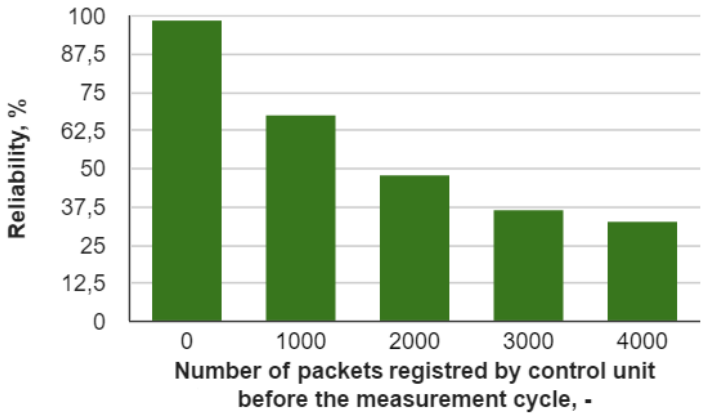

Fig. 2. **The dependence of packet registering reliability on number of packets registered by control unit before the measurement cycle**

These results clearly indicate that the problem with reliability was not in the wireless transmission but in capability of the control unit to process many amount of packets. Since the control unit can work with 230 devices that can transmit quite often, the same situation may arise like in these measurements. Thus the risk of security threats occurs where the system is deployed. The found rate of unreliability of this system is for I&HAS unexepted.

Conclusions

The main purpose of this paper was the demonstration of the unreliability of Fibaro system used as I&HAS. This unreliability demonstrably bound to unreliability of control unit Fibaro HC Lite to register the larger number of detection messages transmitted from detectors. It was declared that this reliability was dependent on the number of packets registered by control unit before the measurement cycle.

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UNMANNED AERIAL VEHICLES IN AGRICULTURE AND SECURITY

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Keywords: UAV, Methodology, Telemetry, Results

Abstract

The Laboratory of Computing Applications of the Technical Faculty of the Czech University of Life Sciences in Prague solved contractual research commissioned by Kelcom International s.r.o in 2017. Research was the surveillance and evaluation of the flight days of an unmanned vehicle specially adapted for perimeter surveillance and surveillance, in this particular case the possibility of using an unmanned vehicle as an instrument of perimetric protection of the airport was tested. From this point of view, the tests and their subsequent evaluation were modified. The whole project was implemented in the spring and summer of 2016. The methodology of this measurement was published last year at the 15th International Workshop for Young Scientists Conference - BioPhys Spring 2016. [1],[2],[3]

After agreeing with the developer of the research, it was decided realize a series of flight days at the Jaroměř. The individual flight days were divided into several logical groups that focused on the individual critical locations of the project. Based on the analysis of the expected requirements, the state of the art and the safety of operation, the individual groups were defined as follows [3],[4]:

1. transmission system for remote control of UAV
2. transmission system for telemetry (transmission of flight parameters and image)
3. life and reliability of the batteries
4. flight features of own mobile unit
5. automated or partially automated flight options
6. system testing in critical and border situations

The temperature during the flight days has been ranged from 14 ° C to 32 ° C. This temperature had a decisive impact on the capacity and lifetime of the batteries. The actual flight parameters monitored in the tests were not affected. Wind speed ranged from absolute wind (unmeasurable speed) to a wind speed of 16.5 m / s (discussed further below).

Fig. 2: UAV Robodrone KingFisher

The main tested mobile unit (UAV) was a dron from Robodrone Industries s.r.o. KingFisher (Fig. 1). [3],[4]

The Kelcom Drone Dual Bridge own transmission system was used to transmit telemetry data and image transmission. This system allows for broadcasting at two frequencies (2.4 GHz, 5.6 GHz) with active back-up broadcasting at a distance of up to 1500 m. In addition to transmitting common telemetry data, this system can also be used to transfer several VGA cameras up to 4K. [3],[4]

UAV Kingfisher from Robodrone Industries s.r.o. Is a quality droning with very good stability that is suitable for industrial use in aerospace, air quality control, but also for quality video capture and photographing. A quality and closed drones dragon is also suitable for flying under more difficult

weather conditions and we have verified that despite the relatively strong impact wind behaves steadily. [3],[4]

The own control system (transmitter - receiver) is more suitable for commercial commercial flights. If it is not possible to fly over more than 1000 meters even though the signal strength is 100%, this system degrades significantly and virtually does not allow the use of the entire UAV system for the intended use in perimeter security. This is mainly because the way of automatic and semi-automatic flight programming is very unpleasant to users and many functions are not working for very unknown reasons. Due to the time when the tests were performed, the apparent effect of shading (interference transfer) on plants at low groundflight (Fig. 2) was also evident. [3],[4]

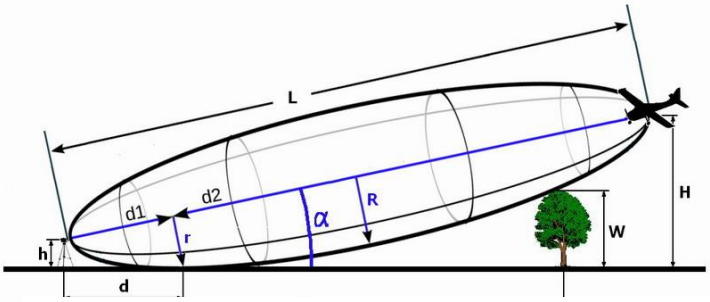

Fig. 2: Fresnel zone

Overall, the Kingfisher UAV system does not meet the requirements for use in the perimeter protection of larger areas, nor for use in agricultural large areas (crop protection). Reasons have been mentioned above, however, as a major cause, was identified very closed control system, without the possibility of simple user programming. [3],[4]

However, it is still possible to use it for safety applications for distances up to about 1000 m, especially in the pilot flights.

From the above tests, it is clear that Kingfisher's own dron is essentially sufficient for perimetric use, but surprisingly problematic is the electronic control unit of the device. For this reason, Kelcom International s.r.o. Hradec Králové established a co-operation with the Military Technical Institute of Aviation and Air Defense, whose unmanned BRUS with its own production unit and user-friendly handling will soon be marketed as a perimeter system of the future for large objects. [3],[4]

Acknowledgement

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PREDICTIVE MODELS OF BIOGAS PRODUCTION FROM AGRICULTURAL WASTE

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Keywords: anaerobic digestion, biogas production, mathematical models, co-digestion

Abstract

Recently, there is a growing pressure on a rapid construction of agricultural biogas plants, particularly in the Czech-Polish border region. This strategy should contribute to harmonize the common agricultural policy of the European Union. The Faculty of Science at the University of Hradec Králové and the Faculty of Natural Sciences and Technology at the University of Opole cooperate on this issue within a cross-border inter-university cooperation. In our work, we are dealing with anaerobic processes of biogas production: we analyze experimental data by using statistical methods as well as we perform mathematical modelling of biogas production processes. Our research can contribute to refine the technical specifications for designing agricultural biogas plants.

We focus on three basic fields: 1) using mathematical models to make experimental determination of the maximum achievable biogas production more precise and to shorten experimental time for co-fermentation of agriculture waste with a predominance of cattle slurry, which is the basic substrate for agriculture biogas stations, 2) using the Matlab software to calculate and visualize the dependency of biogas production on the substrate composition and on fermenter retention time during co-fermentations, 3) utilization of Chen-Hashimoto model for predicting the yield of biogas from agricultural substrates in a continuous fermentation process.

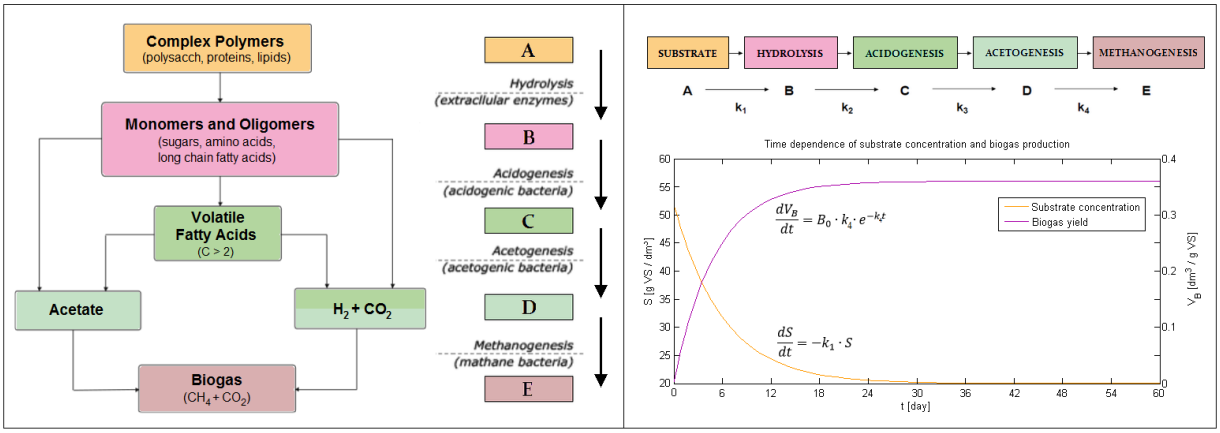

Fig. 1. A graphical representation of processes occurring during biogas production.
V_B - yield of biogas [dm^3/g VS], B_0 - maximum yield of biogas [dm^3/g VS], S - concentration of hydrolyzed substrate [g VS/dm^3], k_1 - hydrolysis rate constant [day^{-1}], k_4 - kinetic parameter [day^{-1}], t – time [day].

Conclusions

Fig. 1 shows a scheme of a four-stage biogas production process according [1], which we modified. For calculating cumulative biogas production, the upper formula in the graph in Fig. 1 is often used, although it poorly corresponds to measured values. That is why we rather used a logistic function [2] and a Gompertz equation [2], [3] which characterize the process of biogas production better and allow to determine the maximum biogas yield more precisely [2]. The logistic function as well as the

Gompertz equation also take into account a fermenter lag time in the beginning of the fermentation process and they allow to estimate duration of the lag period in which the production of biogas is considerably low. We verified that the logistic curve and the Gompertz curve fit better also to our data measured during a fermentation of agriculture waste with a predominance of cattle slurry.

During methanization of agriculture substrates mixtures [4], local extremes in measured values of produced biogas can appear, which is a long time discussed and usually rejected problem. By modelling biogas yield from a co-fermentation of cattle slurry and wheat straw, we confirmed that this effect is not a measurement inaccuracy caused by inhomogeneity of samples. The causes of this technologically important phenomenon have to be further explored and clarified. A sample graphical output of modelling the dependence of biogas yield on the substrate composition and the retention time is shown in Fig. 2.

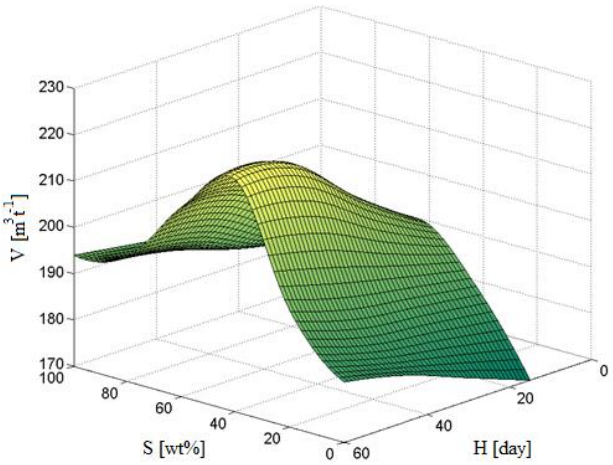

Fig. 2. Dependence of methane yield (V) on the proportion of cattle slurry in the substrate (S) and fermenter retention time (H) within a co-fermentation of cattle slurry and wheat straw.

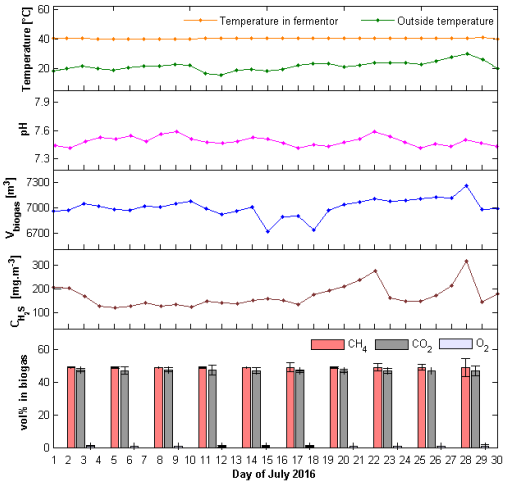

Fig. 3. An example of data obtained by a continual measurement in a biogas plant while processing agricultural waste with predominance of cattle slurry.

By processing experimental data from an agricultural biogas plant (fig. 3), we verified that for determining the biogas yield from continual fermentation of agriculture substrates with a predominance of cattle slurry it is possible to use Chen-Hashimoto model [5].

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USE OF THE DYNAMIC PRESSURE SENSOR FOR RECORDING OF THE MECHANICAL IMPULSE OCCURRING IN THE SOIL AFTER THE WATER DROP IMPACT

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Keywords: splash erosion, dynamic pressure sensor, drop impact, pressure value

Abstract

The impact of water drop on the soil surface causes a phenomenon known as a splash erosion. The soil particles are detached from the surface and thrown in random directions. In addition, the surface of the soil is sealed and deformed at the contact point with the drop.

The majority of the investigations are focused on the above-surface splash aspects such as the mass of detached soil material, the initial velocity and angle of ejected particles or a crown formation. For such investigations the high-speed cameras are the commonly used devices. Investigation of the processes under the soil surface requires different methods and equipment. One of the devices for the under-surface investigations can be a dynamic pressure sensors.

The aim of the study was to measure the pressure value caused by the mechanical impulses propagated through a soil sample resulted by the impact of subsequent drops on the surface, using the dynamic pressure sensor.

Measurement system consisted of the 106B50 dynamic pressure sensor (PCB Piezotronics), a card allowing for recording with the frequency of 2 MS/s (National Instruments) and software (LabView). The range of the study included the impact of series of drops falling from a height of 1.5 m on air-dry soil samples prepared in aluminum rings (hight - 1 cm; diameter - 4 cm). The sensor was placed under the samples.

Data recorded by the sensor contained of waveforms of the pressure induced on its surface by the mechanical impulse propagated through a soil sample. Maximum pressure values were determined by analysing these waveforms, which allowed to compare the pressure values caused by the impact of subsequent water drops.

Conclusions

1. Use of the dynamic pressure sensor 106B50 allowed observation of pressure changes after water drops impacts.
2. The smallest value of the average maximum pressure recorded by the sensor occurred for the strike of the first drop.

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PROJECTIVE REPRESENTATIONS FOR SOLAR CELLS

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Keywords: projective representations, line groups, quasi-one dimensional materials, external uniform magnetic field, symmetry of electron states, quantum wells, quantum dots

Abstract

Quasi-one dimensional (Q1D) materials (conjugated polymers, carbon nanotubes) have been widely studied nowadays for solar cell applications. [see for example 1,2,3] We wish to study these materials from the aspect of their special symmetry described by so-called line groups [4]. Our goal is to point out the necessity of the research of the so-called projective representations of line groups. It seems to us – observing the literature – that symmetry methods have not been fully exploited yet. Symmetry methods are needed for example for generating the so-called (optical) selection rules which prescribe the admitting transitions between electron states of semiconductors (intraband and/or interband).

The role of projective representations becomes fundamental when materials are in external uniform magnetic field. For the future applications Dzyaloshinskii's and Kats's article [5] – is which authors revealed the external magnetic field stimulated superconductivity of Q1D systems (conductors) – might be decisive.

The symmetry group of the system (Hamiltonian) is based on the projective representations of translation groups of crystals and is called the magnetic translation group (MTG). MTG was introduced by Brown [6] and Zak [7] and in the other terminology by Opechowski and Tam [8] and studied by many researchers (for example for graphene is given by Wal [9]). But in this theory no point symmetry operations are considered and referring to the words of Tronc and Smirnov's article [10] perhaps arises from the complexity of the theory the fact that the formalism of magnetic translations has never been used to solve concrete problems, except in Dzyubenko and co-workers' article [11], which can be relevant for solar cell applications.

Tronc and Smirnov improved the MTG theory for the full symmetry group of the crystal [10] and applied it for various types of semiconductors by giving its symmetry structures, namely: for bulk crystals and for related nanostructures, superlattices, quantum wells and quantum dots. Their consideration based on the symmetry-based classification of the potential energy of the crystals: layer group for QWs, line groups (sometimes rod groups) for rods and tubes and point groups for QDs and molecules respectively. The authors discussed few concrete semiconductor examples applying to them magnetic field relevant mainly to application of optoelectronic devices (for example: GaN/AlN quantum dots, GaAs/InAs quantum dots, $(GaN)_m(AlN)_n$ superlattice, bulk GaN, but for instance bulk GaAs would be important to the solar cells applications. For futher study see Ref. [10] and references therein).

In the field of solar cells application the above mentioned nanostructures are also used for increasing the maximum attainable thermodynamic conversion efficiency calculated by Shockley and Queissar [12,13,14].

Tronc and Smirnov mentioned but did not consider rods or tubes whose space symmetry is described by line groups (for example carbon nanotubes) [10].

Conclusions

1. The projective representations-based symmetry research of semiconductor materials is a powerful tool for understanding their physical properties especially in the presence of external magnetic field
2. The projective representations are needed to study the line group theory for Q1D materials relevant to solar cell applications (carbon nanotubes, conjugated polymers).

Acknowledgement

This work was supported by the Mechanical Engineering Doctoral School, Szent István University, Gödöllő, Hungary.

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BIOSORPTION OF HEAVY METALS ON NATURAL POLYMERS

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Natural polymers such as cellulose or polysaccharides building exoskeleton of arthropods are easily available materials and they characterized by low cost of receiving from the environment. They can be used as effective heavy metal sorbents.

The aim of the study was to determine the sorption capacity of the insect chitin (*Hermetia illucens*) for heavy metals: nickel, cadmium, zinc and lead and characteristic of chitin structure. Measurements were made using ICP (Inductively Coupled Plasma) to determine the amount of bonded metal ions on the polysaccharide. In addition, FT-IR (Fourier transform infrared spectroscopy), SEM (Scanning electron microscopy), XRD (X-ray diffraction), DTG measurements were performed.

The chitin had an α crystalline form, typical of insect chitin and the crystalline index value was 24.9%. Metal removal efficiencies of the chitin were 8.94, 27.77, 19.34, 34.23 $\mu g\ h^{-1}\ mg^{-1}$ for Ni^{2+}, Cd^{2+}, Zn^{2+} and Pb^{2+}, respectively.

Positive results have been obtained, which are the basis for the future use of the tested polysaccharides for biosorption for the removal and recovery of heavy metals from environmental samples. Modification of the specific surface area of the sorbent by functional groups may increase its surface area and affinity for metals. In the future, it can give even better results in the sorption process of this type impurities.

Moreover, for the first time physicochemical properties of chitin extracted from black soldier flies were determined.

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PHYSICAL PROPERTIES OF CORN STARCH-BASED BIODEGRADABLE FOAM PACKAGING MATERIAL BY EXTRUSION PROCESS

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Keywords: extrusion, corn starch, biodegradable, packaging, foam, natural polymer

Abstract

Plastic materials are one of the most used materials in the world and the ones that do not disappear from nature for the longest time. The increase in the use of plastic with each passing day brings with it a high degree of environmental waste (pollution). The rising environmental awareness, especially in developed societies, has led to significant steps in reducing the amount of plastic produced and used. The polymers are divided into two parts, natural (cellulose, starch) and synthetic (polypropylene, polyethylene, polystyrene). Recently, it has been aimed to disseminate the use of biodegradable polymers produced from renewable sources instead of synthetic based polymers.

The aim of this study was to produce foam packaging materials from corn starch using extrusion process. Four factor factorial design was performed to produce foam materials. The factors were the amount of PVA (polyvinyl alcohol) or PDE (plastronfoam) (0-3%), combination of PVA-PDA and screw speed (70-130 rpm). Corn starch with foaming agent was conditioned to 20% (wb) moisture and left stand in a closed plastic container at room temperature for 24 h. The samples were extruded using a modified single-screw extruder TS-45 (Polish design) with a screw diameter of 45 mm and a length to diameter ratio (L/D) of 12/1. The ring die with 3 mm was used. The temperature profile during extrusion was 80°C-110°C-100°C. Expansion ratio and bulk density were determined to analyze the effect of foaming agents and screw speed on physical properties of materials.

Expansion ratio and bulk density are very important parameters in the production of foamed products. The degree of puffing of products is evaluated by measuring expansion and bulk density. Expansion ratio measures expansion in one direction, while bulk density considers expansion in all directions. Expansion ratio of corn starch only varied between 5.6-6.4 at 70-130 rpm screw speed. Incresing the screw speed from 70 to 130 rpm increased the expansion of corn starch. Expansion ratio of materials increased when the foaming agent was added and extruded at 70 rpm. Foaming agent either PDE or PVA had significant influence on bulk density at low screw speed. Bulk density of corn starch only was between 122 and 193 kg/m^3 while bulk density of corn starch with foaming agents was in the range of 28 -119 kg/m^3 at 70-130 rpm screw speed. The lowest bulk density was found for corn starch with 3% PDE at 70 rpm. Results showed that the possibility of obtaining foamed packaging materials.

RHEOLOGICAL PROPERTIES OF GERANIUM ESSENTIAL OIL

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Many essential oils are nowadays commonly used not only in aromatherapy, but also in food or cosmetic industry as well as in medicine. As a potential ingredient in new cosmetic, it is necessary to study the microbiological, physical and rheological properties of the essential oil. Such studies are a base for the obtaining a great quality product. The purpose of this research was to determine the rheological parameters of three different pelargonium essential oils species in the temperature range of 10°C-60°C.

The study showed that all of the behaved as Newtonian fluids which means that there is a simple linear relation between shear stress and shear rate.

$$\tau = \eta\gamma \qquad (1)$$

where: τ = shear stress, η = dynamic viscosity, γ = shear rate.

Also, the viscosity of studied essential oils increased with an increase in temperature. Once the viscosity values at different temperatures were established, flow Activation Energy for each essential oil, using the Arrhenius equation were calculated:

$$\eta = A \cdot \exp(-\frac{Ea}{R \cdot T}) \qquad (2)$$

where: A = dynamic viscosity, E_a = activation energy, R = universal gas constant, T = absolute temperature.

The viscosity flow activation energy shows the energy that is essential to overcome intermolecular forces, which restrain the fluid layers movement.

The activation energy values of studied essential oils (regardless of the initial material properties) were comparable to each other, which can indicate the similar chemical composition of these oils. That is why it is assumed that they should also have a similar biocidal properties, and that is the major presumption of the conducted research. As another aspect of this study, dynamic viscosities of cosmetic emulsions with added pelargonium oils were measured. The outcome was a base for defining studied essential oils impact on these products aging. While aging, the cosmetic structural changes cause viscosity and another viscosity parameters variations.

As a complement of conducted research, microbiological cosmetic emulsion changes will be evaluated.

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DIRECT LOOP-MEDIATED ISOTHERMAL AMPLIFICATION (DIRECTLAMP) FOR DETECTION OF TALAROMYCES FLAVUS

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Keywords: LAMP, Loop-mediated isothermal amplification, heat-resistant fungi, *Talaromyces flavus*, DirectLAMP

Abstract

Talaromyces flavus is heat-resistant fungus able to survive heat-treatment during process of pasteurization and is responsible for spoilage of heat-processed food [1, 2]. *T. flavus* displays ability to produce numerous mycotoxins, and therefore presents serious threat to food safety [3]. Loop-mediated isothermal amplification (LAMP) allows rapid and sensitive detection of *T. flavus* in samples which is a way to minimize impact of this fungus on food spoilage [4].

LAMP is a method of DNA isothermal amplification. Technique is based on use of six primers complimentary to eight gene regions. Double stranded DNA at the temperature about 60-65°C is in the condition of dynamic equilibrium, which allows the annealing of complimentary primers without the need of DNA heat denaturation. LAMP utilizes the properties of strand displacement activity of *Gsp*SSD DNA polymerase and performs amplification. LAMP reactions give positive results in about 30 minutes. LAMP is reported to be faster and more sensitive reaction than PCR [5, 6]. However, disadvantage of LAMP is step of DNA isolation prior the reaction. High temperature and ability to withstand presence of inhibitors in reaction allowed us to hypothesise that it is possible to perform LAMP without the DNA isolation but directly from fungal ascospores – DirectLAMP.

The aim of this study was the development of specific, sensitive and rapid DirectLAMP method for detection of *Talaromyces flavus*. Specificity of designed primers was tested by performing reaction with 5 *Talaromyces flavus* reference isolates and 14 isolates of other fungi species. In this step the DNA were extracted by column-based procedure [7]. Three pairs of LAMP primers – Tf_F3, Tf_B3, Tf_FIP, Tf_BIP, Tf_LoopF and Tf_LoopB were used in this reaction [4]. The reactions were performed with Isothermal MasterMix (OptiGene). The assesment of DirectLAMP sensitivity was performed by preparation of *Talaromyces flavus* ascospores suspension. The cells were counted in Thom counting chamber and 6 10-fold serial dilutions of 130000-1,3 ascospores per 1µl were prepared. After that 1µl of ascospores suspension was added to the reaction mixture. The results of reaction were visualized with electrophoresis on agarose gel (2%, 7V/cm). LAMP reaction kinetics was visualized by measurement of fluorescence every 60 second of reaction in real-time PCR thermocycler (Applied Biosystems 7500 Fast).

Designed and optimized DirectLAMP reaction was successful in whole range of studied *Talaromyces flavus* ascospores concentrations as presented at Fig. 1. The positive results of reaction were observed in less than 60 minutes.

Proposed DirectLAMP technique is very sensitive, rapid and cost effective method for detection of *Talaromyces flavus* without the need of DNA isolation.

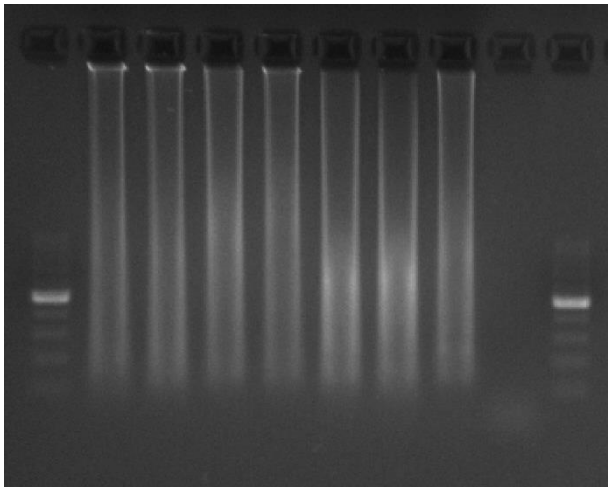

Fig. 1 Detection sensitivity of DirectLAMP reactions. Results obtained with (from left to right): Positive control, 130000; 13000, 1300, 130, 13, 1,3 ascospores of *Talaromyces flavus* and NTC

Acknowledgement

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DSC MONITORING OF PURE OLIVE OIL AND MIXED WITH SUNFLOWER OIL

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Keywords: differential scanning calorimetry, olive oil, sunflower oil

Abstract

In the present work, the pour point of different olive oils was analysed by DSC and compared with the results obtained by mixing olive oil with sunflower oil. Olive oil is globally known for its reputation of great nutritional value and health benefits. This work was done for the purpose of determining of the originality of olive oils. The knowledge of thermal behaviour of the olive oils is quiet useful to determine adulteration of olive oil.

The application of termoanalytical methods for the characterization of oils has increasing interest. Therefore, using one of those methods, such as DSC for the characterization of oils has distinguished role in food industry [4]. Process of freezing may be investigating by method of differential scanning calorimetry (DSC); it is a thermoanalytical technique which monitors heat effects associated with phase transitions and chemical reactions as a function of temperature, at pre-defined speed of cooling, with assuming that both, reference and material, are under the same conditions [5].

DSC cooling curves are affected by chemical composition of olive oil [2]. Some thermal effects (crystallization peak onset and endset and temperature range) were influenced not only by major but, probably, also by minor components. Chiavaro et al. [1, 3] deals with similar issues by adding hazelnut and sunflower oils as adulterants.

First, we measured different samples of olive oils which were purchased or were homemade. Our investigation showed that they have different pour points. Then, mixtures of olive oil with different percentage of sunflower oil were made, in order to determine the cause of shifted peaks in previous experiments.

For monitoring of pour point of olive oil (phase transition of oil components) by DSC method was used device DSC 1 (METTLER-TOLEDO). Samples with weight (9-12) mg, were hermetically sealed in 40 μL aluminium crucibles and thermally treated at a speed of heating 2 K/min in the temperature range from 20 °C to the temperature of -100 °C. The measurement was carried out in an inert, dynamic atmosphere of N_2. As a result we got a DSC thermogram, which was evaluated in STAR^e software.

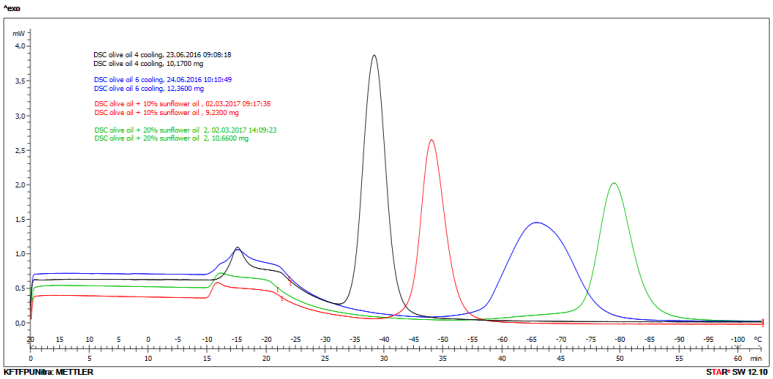

Figure 1 DSC curves taken on pure olive oils and mixtures with sunflower oil

DSC curves of different samples of olive oils and mixtures of olive oil with different percentage of sunflower oil are on the Figure 1. Each peak corresponds to a heat effect associated with a specific

process, such as crystallization of the components, as it is visible in the figure. In the process of freezing of the all olive oil samples, we observed exothermal peak.

Temperature of pour point of pure olive oil which was purchased was -38.26 °C (black). Olive oil as homemade product (blue) has pour point of -65.84°C and it is in between two mixtures pour points. Mixture with 10% (red) has -47.99°C and 20% (green) mixture has the lowest temperature of freezing -78.97°C. It was noticed that the more sunflower oil was added, the enthalpy (ΔH) of the reaction was lower. A shift of the both, onset and offset temperature (T_{on} and T_{off}) is observed in the case of blue curve sample.

Conclusions

1. Results confirm that used method is suitable for investigation of olive oils physical properties and thermal behaviour. Application of DSC method is promising tool for detection of olive oil adulteration with sunflower oil.
2. It was conclude that the pour point of the mixtures is shifted in proportion to the percentage of added sunflower oil. Therefore, we can tell that pour point depends on the composition of olive oil.

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UTILIZATION OF MOLASSES IN MICROALGAL BIOMASS PRODUCTION

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Keywords: molasses, microalgal biomass, *P. kessleri*

Abstract

Heterotrophic and mixotrophic cultivation of algae allow obtaining a higher biomass concentration with higher cellular oil content. Several microalgae species are able to convert and utilize organic substrates present in the culture medium directly into lipids. High-value microalgal oil and biomass obtained in this way are suitable as a feedstock for biofuel production. However, organic carbon sources like glucose or acetate are usually costly and organic substrates are responsible for most of the medium costs. The use of industrial by-products or wastewater could be used as low-cost supplement to reduce microalgal production costs [1,2].

Beet molasses is a by-product in sugar industry consisting of approximately 50% total sugars, predominantly sucrose, and containing significant amounts of reducing sugars - glucose and fructose and other carbohydrates. The non-sugar content includes many metal ions, such as calcium, magnesium, potassium, sodium, iron, and cooper. Total nitrogen content in molasses should be not less than 1.6%. This cheap carbon stock could certainly replace glucose and support cell growth.

The objective of the present study was to investigate the influence of addition of molasses to the culture medium on *Parachlorella kessleri* growth and biomass productivity. Additionally, the work is intended to determine the potential of agro industrial by-product as an alternative culture medium component.

The *Parachlorella kessleri* was obtained from the SAG Culture Collection of Algae in Götteningen. An axenic culture of *Parachlorella kessleri* was used for inoculation in 250-ml flasks. Kessler medium was used for culturing the *Parachlorella kessleri*. To prepare the photoheterotrophic and mixotrophic medium, 10g/L molasses was added to the Kessler medium. The autotrophic, photoheterotrophic, and mixotrophic culture of *Parachlorella kessleri* was incubated at 25°C during 10 days under illumination (16h light/8h dark cycle, 100 µmol photons m^{-2} s^{-1}) in flasks with shaking at 100 rpm. The growth of *Parachlorella kessleri* was monitored daily by measuring the optical density (OD650). Estimation of growth parameters (specific growth rate, biomass doubling time, biomass productivity) was achieved using formulas based on measuring the optical density. On the basis of spectrophotometric measurements of the optical density, the growth curves was determined.

Conclusions

The use of molasses as a component of culture medium stimulated the production of *Parachlorella kessleri* biomass. The experiment shows the potential of molasses as an organic compound for photoheterotrophic and mixotrophic cultivation of *Parachlorella kessleri*.

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ASSESSMENT OF SOIL MOISTURE FROM SATELLITE MEASUREMENTS IN REGIONAL SCALE

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Keywords: soil moisture, SMOS (Soil Moisture and Ocean Salinity), satellite measurements, regional scale, European Space Agency (ESA), brightness temperature

Abstract

Soil moisture is one of the fundamental factors affecting the water and energy fluxes on Earth. It plays an important role in water resources management. The significance of water management for crop production, ecosystems and social needs, carrying about good water condition on lands is of vital importance. Currently, monitoring of soil moisture is an key issue, because weather anomalies connected with the abundance or shortages of water are observed more frequently than in the past. Recognition and understanding of time series and spatial distributions of soil moisture are essential to predict and counteract negative phenomena such as floods and droughts.

The aim of the study was to assess soil moisture in the surface layer of soil in Poland using data from SMOS (Soil Moisture and Ocean Salinity) satellite mission, conducted by European Space Agency (ESA). The SMOS satellite is equipped with a radiometer that measures the microwave emission of soil within a frequency of 1.4 GHz (L-band) in order to capture images of surface brightness temperatureThe images are collected every three days and may serve as a database to derive global maps of soil moisture. The accuracy of the SMOS surface soil moisture is 4%, with 35-50 km spatial resolution. For this study, time series of soil moisture in years 2010-2016 were examined. To obtain spatial resolution corresponding to SMOS (approx. 45 km), central Discrete Global Grid cell of each pixel (with agrometeorological station in the middle) were 7-days averaged.

For analysis several regions (e.g. Wielkopolska, Polesie) of Poland were selected, including eastern part of the country, where agrometeorological stations of Institute of Agrophysics, Polish Academy of Sciences are located. For each area, basic statistical parameters such as mean, median, standard deviation, skewness and kurtosis were determined. It was fund that after consecutive, relatively dry years and extremely hot 2015 summer, surface soil moisture decreased significantly. The smallest decrease in soil moisture was observed in previously dry area of Wielkopolska in Poland – only down to ca. 60% of initial value. Polesie, despite the 55% decrease in surface soil moisture, is currently the wettest region thanks to the presence of lakes, swamps and other undrained, conserved areas. In 2015, in the case of Wielkopolska soil moisture values in 2015 were smaller than in 2011, but with similar waveforms over time. In Polesie constant decrease in soil moisture was observed in summer 2015. Lack of rainfall and high temperature in 2015 caused a decrease in moisture content on all the analysed regions. In 2015, in the central part of Poland, the soil moisture was in the range from about 0 to 0.3 m^3m^{-3}. High values, up to 0.5 m^3m^{-3}, were observed in the regions of the north-eastern borders of Poland. In June, July and August, in most of the north-eastern and western regions of the country surface soil moisture was less than 5% (0-0.05 m^3m^{-3}). This indicates the occurrence of drought in the examined area during this period. In 2011, at the beginning of July, heavy rains have reduced the threat of drought in Poland. The statistical representativeness of SMOS data since 2013 is much larger than in previous years. In 2015, compared to the previous period definitely increased range of agricultural drought throughout the country. There is a justified expectation that SMOS data for Poland shall improve water resources assessment and weather forecasting and that way provide more contribution to the regional climate modeling. The most direct application of these data should be in agriculture

and hydrology in the management of water resources. Generally SMOS pixel is large and the population of ground data small, so we got moderate, but considerable results of validation.

Deficit or excess of water in the soil strongly influences the spatial and temporal dynamics of plant cover. For this reason, information on soil moisture is important for various agricultural applications, e.g. identification of regions susceptible to drought or flooding. The results obtained in this study can be used to manage water resources, assess drought and predict floods.

Acknowledgement

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STUDY OF ADSORPCTION KINETICS FOR ORGANIC POLLUTANTS ON ACTIVE CARBON BY USING SPECTROPHOTOMETRY UV-VIS

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Keywords: adsorption kinetics, active carbon, organic compounds, spectrophotometry UV-Vis

Abstract

Adsorption methods are widely used in water and waste water treatment technologies [1-2]. Application of active carbon as an adsorbent allows for effective removal of variety of contaminants, especially organic ones. A special group of toxic substances are aromatic organic compounds such as phenol and its derivatives, pesticides, dyes, pharmaceuticals, surfactants, food preservatives and others. Due to the relatively good solubility of the compounds in question, they can easily migrate into the environment [3-5]. Hence, they require particular attention when optimizing the water and wastewater treatment processes.

The efficiency of adsorption is affected by many factors related to the properties of the adsorbent (specific and external surface area, type and volume of pore, surface charge) and adsorbate (molecular size of the adsorbate, differences in solubility), process conditions (pH), temperature, mixing rate and the presence of other substances [6-7].

The aim of this work was to study of influence of selected process conditions on adsorption kinetics for 4-nitrophenol on active carbon. UV-Vis spectrophotometry applying a flow cell was used for measurements of adsorption rates. The experimental data obtained were analyzed by multiple equations and models of adsorption kinetics.

Conclusions

1. UV-Vis spectrophotometry allows for obtaining high quality kinetic data.
2. Adsorption kinetics is high depend on mass of adsorbent, concentration of adsorbate, agitation speed, pH and prsesnce of other substances

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WATER RELATIONS IN AL-SENSITIVE AND AL-TOLERANT WHEAT UNDER COMBINED DROUGHT STRESS AND ALUMINIUM TOXICITY

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Keywords: aluminium toxicity, drought stress, water relations

Abstract

Aluminium (Al) toxicity and drought stress are two major constraints for crop production in the world. Approximately 30% of the world's total land area consists of acid soils, and it has been evaluated that over 50% of the world's potential arable lands have a pH below 5.0 (Zheng 2010). In low pH soils, it is not hydrogen ion toxicity that affects plant growth but rather aluminium (Al) which is the most dangerous for plant cells. Aluminium toxicity is particularly severe at soil pH values of ≤5.0 (Foy 1978). On many acid soils, variability in rainfall distribution and longer dry spells during the main growing period of crops are becoming increasingly important yield-limiting factor with the change in global climate (Tang et al. 2001). Both water deficit and aluminium toxicity can affect plant growth and development. Recent studies have indicated that the response of plants to combinations of two or more stress conditions is unique and cannot be directly extrapolated from the response of plants to each of the different stresses applied individually (Grigorova et al. 2011; Yang et al. 2012). The effect of combined drought and aluminium stress on root growth has hardly been addressed in the past. However, it should be highlighted that interactive effect of Aluminium toxicity and drought stress differ strongly in experimental approaches.

Therefore the aim of our study was to evaluate the effect of the combined drought stress and aluminium toxicity on water relations, nutrient uptake and root system architecture of near isogenic wheat lines (NIL) (ES8 – aluminium sensitive, ET8 – aluminium tolerant).

MATERIALS AND METHODS

The two wheat genotypes (Triticum aestivum L.) genotypes, Aluminium-tolerant ET8 and Aluminium-sensitive ES8, were near-isogenic (over 95%) lines differing in Aluminium tolerance at the Alt1 locus (Dalhaize et al., 1993). A loamy sand textured soil from an agricultural field situated in south-eastern part of Lublin region was used as a soil material. The native pH of the soil was 4.2, half of collected soil was limed to reach pH 6.5. Aluminium exchangeable concentration was 104 and 10.8 mg kg-1 of soil in acid and limed soil respectively.

Plants were grown in 10 cm in diameter and 40 cm in height soil columns filled with moderately compacted (1.4 Mg m-3) soil in controlled environment. Conditions during plant growth were as follow: temperature of the night and day 18 (10h)/24°C (14h), light intensity 300µmolm-2s-1 PAR, relative air humidity 60%. The unique system for maintaining and controlling of soil moisture based on TDR probes (at 5, 15, 25 and 35 cm) and precise flow meter (E-test, Poland) was used (Wilczek 2013). Soil moisture was maintained on optimum level equal to 13% (v/v) in control treatment (OP.) during whole 64 days long growth period. The drought was induced by controlled water deficit from 55th day after sowing (DAS) to the end of the experiment in drought treatments (DS.). Four different treatments were assayed for both cultivars:

- High soil aluminium concentration, optimum water availability (pH 4.2 OP);
- High soil aluminium concentration, and drought stresses (pH 4.2 DS);
- Low soil aluminium concentration, optimum water availability (pH 6.5 OP);
- Low soil aluminium concentration, and drought stresses (pH 6.5 DS).

MEASUREMENTS

Measurements included: leaf relative water content (RWC), soil water potential, aluminium and nutrient concentration in roots and shoots (ICP OS), transpiration level (GFS 3000, Walz), soil penetration resistance.

RESULTS

As a consequence of differences in aluminium tolerance of studied NILs of wheat there are characteristic differences in their response to drought as it is indicated by root system distribution and water uptake capacity.

Both plants were affected by the same period of withholding watering, their different response to aluminium toxicity resulted in alterations in response to drought stress. ET8 line are characterized by higher water use, and thereby has been subjected to more severe drought stress at the end of the experiment. The opposite effect was noted for ES8. Both ES8 and ET8 lines were affected by drought and aluminium toxicity at low pH in similar way. As expected, the highest water use was noted for both lines grown at limed soil with optimum soil availability (pH 6.5 OP). On the other hand, the lowest water use was noted for both lines in most stressed treatment e.g. pH 4.2 DS. However, we assume that the reason for lowest water use in the pH 4.2 DS treatment may be different for ES8 and ET8 line. Analyses of plant root systems revealed that drought induced preferential root growth except in ES8 under combined high aluminium concentration and drought stress (ES8 pH 4.2 DS). The lack of increased root growth of ES8 under combined drought and aluminium stress can be explained by possibly higher aluminium concentration in soil solution (Siecińska et al. 2016). Except the expected decline of soil moisture in drought stress treatments in comparison to the optimum water availability treatments, we can observe declining water use caused by high aluminium concentration (pH 4.2) in comparison to low aluminium concentration treatment (pH 6.5).

Conclusions

Unlike the hydroponic experiments with PEG induced water deficit, combined drought and aluminium toxicity in the soil results in enhanced the inhibition of root elongation, water and aluminium uptake beyond the effects of the individual stresses in an additive manner. It has to be kept in mind, that in soil drought stress enhance Al toxicity, in hydroponic culture, we can observe opposite effect - alleviation of Al toxicity by drought. However, our results showed, that this soil effect is only observed in aluminium-sensitive wheat line.

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DISCRIMINATION OF FUNGAL INFECTED STRAWBERRY FRUITS USING HYPERSPECTRAL REFLECTANCE IMAGING

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Keywords: strawberries, hyperspectral imaging, gray mold

Abstract

Strawberries (*Fragaria ananassa,* Duchesne) are one of the most popular berry fruits in the world. The heaviest economic losses in fruits production are the result of fungi infections, which can occur both on immature fruits pre-harvest, or on mature fruits at harvest or in the postharvest storage (Guidarelli et al., 2011). The most common pathogens of strawberries are *Botrytis cinerea* and *Colletotrichum acutatum.*

Recent studies illustrate the wide applicability of hyperspectral imaging system on detection of fungal infections in fruits, seeds and plants. In previous research it was used for detection fungal contamination of date fruits (Teena et al., 2014), infections caused by *Penicillium digitatum* in citrus fruits (Gómez-Sanchis et al., 2008) and for the early detection of diseases caused by fungal species belonging to the genus *Alternaria* (Baranowski et al., 2015).

The objective of this study was to determine the efficiency of visible and near infrared hyperspectral imaging technique to early detection of fungal infection caused by *Botrytis cinerea* and *Colletotrichum acutatum* in strawberry fruits. The experimental samples were 'Senga Sengana' strawberries, hand harvested in the local farm located in Lubelskie region. Two pathogenic fungi, namely *Botrytis cinerea* and *Colletotrichum acutatum* were used for inoculation. Strawberry fruits were immersed in spore suspension of appropriate fungal pathogens (or sterile distilled water as a control). After inoculation fruits were stored in a dark chamber at 20ºC with 85% relative humidity.

A VNIR camera with an ImSpector V10E imaging spectrograph (400-1000 nm) and a SWIR camera with a N25E 2/3" imaging spectrometer (1000-2500 nm) (SPECIM, Finland) were used to acquire the hyperspectral images.

In this study, hyperspectral data were acquired at a wide wavelength range (450-2500 nm). For reducing data dimensionality and selecting the most significant wavelengths that contributed the most to the classification, Principal Component Analysis (PCA) was carried out on a dataset of strawberry samples. Prior the analysis Savitzky-Golay pretreatments were used to reduce environmental and texture effects on the samples and to smooth spectral noise.

The results from PCA are presented in Figure 1. The first two PC explained more than 95% of the total variation for. The three groups including *B.cinerea*, *C.acutatum* and control can be clearly distinguished on the 2nd day after inoculation.

The results obtained using hyperspectral imaging system was used to develop classification models for identification of fungal infection in strawberry fruits. The discrimination accuracy among *B.cinerea*, *C.acutatum* and control group were 97%, 97% and 99%, respectively. The average accuracy of classification was 97%, among the control and two fungi. The results were in line with the PCA results.

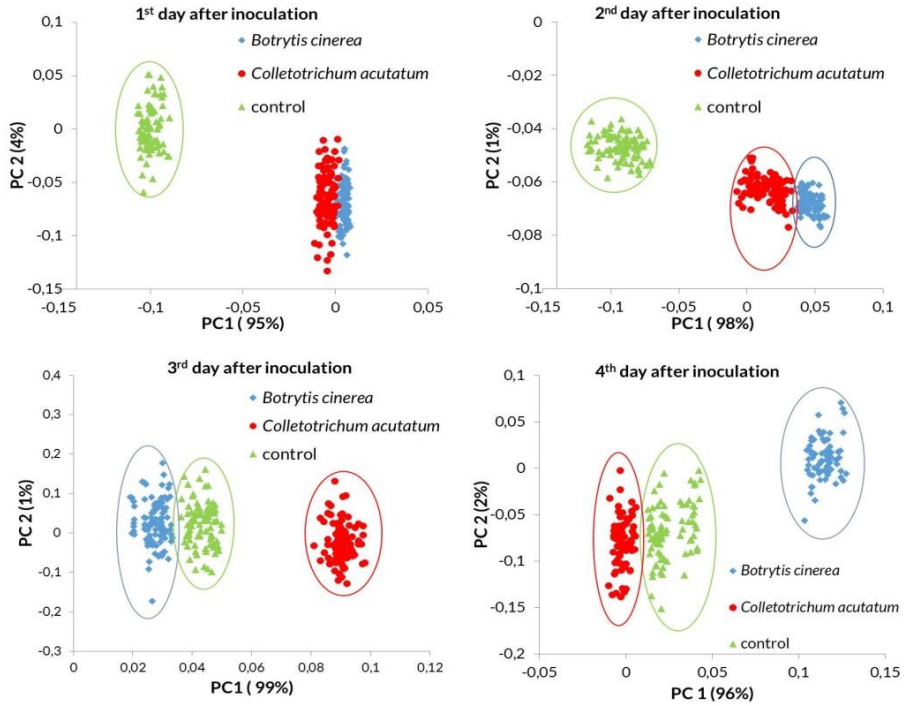

Figure 4. Score plot of the first two principal components (PC) for spectral data included samples infected by two fungi and control obtained for different day after inoculation

This study aimed to develop a method for the early detection of *B.cinerea* and *C. acutatum* infected strawberry fruits using hyperspectral imaging. The results indicate that hyperspectral imaging analysis can discriminate strawberry fruits infected with fungi from healthy ones, even before any visible symptoms of infection. Applying this method in sorting line may limit the presence of toxins in food products by early detection of fungal infection.

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DIELECTRIC RELAXATION MECHANISMS IN SILT LOAM SOIL DETERMINED FROM 0.05 – 3 GHZ MEASUREMENTS

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Keywords: dielectric spectroscopy, dielectric relaxation, soil moisture

Abstract

Measurement of soil dielectric properties is used in practice for non-destructive soil moisture determination . However, the dielectric properties of soil depend not only on water content but also on other soil properties such as texture, structure and mineralogy. In particular, in soil that contain large amounts of clay, a fraction of water is strongly bounded to solid phase particles surfaces which gives rise to several interface dielectric relaxation mechanisms, such as bound-water relaxation, Maxwell-Wagner effect, counterion relaxation effects. Generally, these relaxation processes occur below 1 GHz frequencies [1], i.e. in the operating frequency range of many soil moisture measurement devices. Therefore, the determination of dielectric relaxation mechanisms present in soils is important for improving the moisture measurement accuracy.

In the present study, silt loam soil (sand: 8.7%, silt: 74.0%, clay: 17.4%) was air-dried and sieved using a 2 mm sieve. Soil samples were moistened by adding a predefined amount of distilled water up to saturation (water contents on a dry mass basis: 10%, 15%, 20%, 25%, 30%, 35%). In this study, complex dielectric permittivity of soil samples was measured in the 0.05-3 GHz frequency range using a 1-5/8" coaxial transmission line cell connected to a vector network analyzer. The details of the experimental setup, the applied calibration procedure and the permittivity determination algorithm were presented in [2]. All measurements were taken at controlled temperature 21±1ºC.

The measured complex dielectric permittivity spectra of soil samples moistened with distilled water were presented in Fig. 1. It can be seen that the real part ε' of dielectric permittivity (Fig.1a.) increased with the moisture content of the samples (from about 5 for air-dry sample to 35 for the saturated one). Moreover, the permittivity values decreased with the increase of frequency, especially at frequencies below 0.25 GHz. This significant dispersion was caused by the mentioned low-frequency interface relaxation mechanisms. We can also see that bulk electrical conductivity dominated ε'' up to even 0.5 GHz.

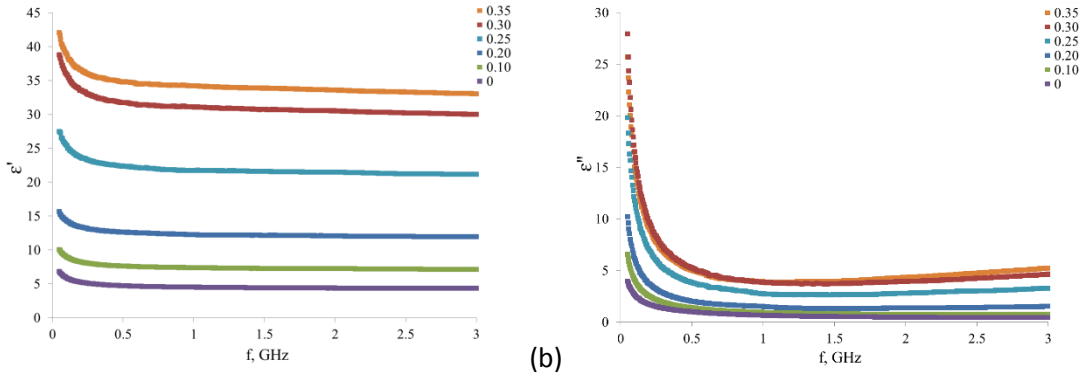
The impact of various dielectric relaxation mechanisms on soil complex relative dielectric permittivity can be characterized by several types at dielectric models. For the tested soil, the obtained permittivity spectra could be described by three-pole Debye model:

$$\varepsilon = \varepsilon_\infty + \sum_{i=1}^{3} \frac{\Delta\varepsilon_i}{1 + j\omega\tau_i} - j\frac{\sigma_b}{\omega\varepsilon_0}, \quad (1)$$

where ε_∞ is the high-frequency dielectric permittivity, and $\Delta\varepsilon_i$ and τ_i, are dielectric relaxation amplitude and time of an *i*-th pole, respectively. In this way, two low-frequency poles and a high-frequency third pole associated with dielectric relaxation of free water dipoles were obtained. For all tested samples, low RMSE values were obtained (from $1 \cdot 10^{-2}$ to 0.06 in the worst case for 35% content water).

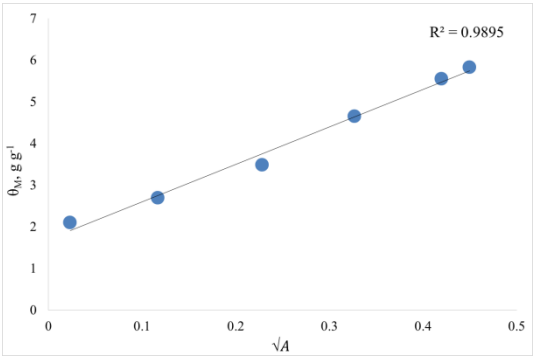
The low-frequency poles were indentified at frequencies of about 70 MHz and 500 MHz. The exact relaxation frequency values and relaxation amplitudes depended on the water content. Based on the obtained relaxation frequencies, the second pole could be associated with bound water effects, while the first one could be caused by the Maxwell-Wagner effect and the interfacial phenomena. The third high-frequency pole depended on the relaxation of free water. The impact of the free-water relaxation on the value of the real part of dielectric permittivity is equal to a sum of the dielectric relaxation amplitude of the third pole and high-frequency dielectric permittivity limit:

$$A = \Delta\varepsilon_3 + \varepsilon_\infty. \quad (2)$$



(a) (b)

Figure 1. The real (a) and imaginary (b) parts of complex dielectric permittivity of soil samples moistened with water content given in the legend (g g $^{-1}$ on a dry mass basis).



The relation between water (θ_M) and √A for the applied moistening liquids were presented in Fig. 2. As expected, there was a strong positive correlation between dielectric parameter describing free water relaxation and water content. It was also observed that dielectric relaxation parameters of the two low-frequency poles also depended on moisture content.

Figure 2. The dependence of θ_M on $\sqrt{A}$ for the tested moistening liquids.

Conclusions

1. The three-pole Debye dispersion model gave a good fit to the experimental data.
2. The free water relaxation and both low-frequency poles depend on water content.

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THE PRACTICAL APPLICATION OF BOEHM'S AND POTENTIOMETRIC TITRATION FOR ANALYSIS THE SOLID PHASE OF SOIL

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Keywords: solid phase of soil, Boehm's titration, potentiometric titration, surface charge, surface functional groups.

Abstract

The solid phase of soil is mineral, organic and organic-mineral particles with varying degree of fragmentation. It affects the physical properties of the soil, such as: granulometric composition, porosity, density, etc. and the physico-chemical properties, such as sorption [1].

The aim of research was to analyze the practical application of Boehm's and potentiometric titration for analysis of the solid phase of soil.

Experiment materials were Black Soil and Orthic Luvisol (developed from slightly loam sand), which was taken from the A-horizon (0-20 cm). Samples of soil, without stones and roots, dried, ground and sieved through a 1 mm mesh. The two methods were used: Boehm's and potentiometric titration. In Boehm titration, the ratio of soil/solution was 1:5. The solutions were Boehm's reactants ($NaHCO_3$, Na_2CO_3, NaOH or HCl). The mixtures were mixed, filtered and titrated by HCl or NaOH [2]. For the potentiometric titration was used Titrino 702 SM.

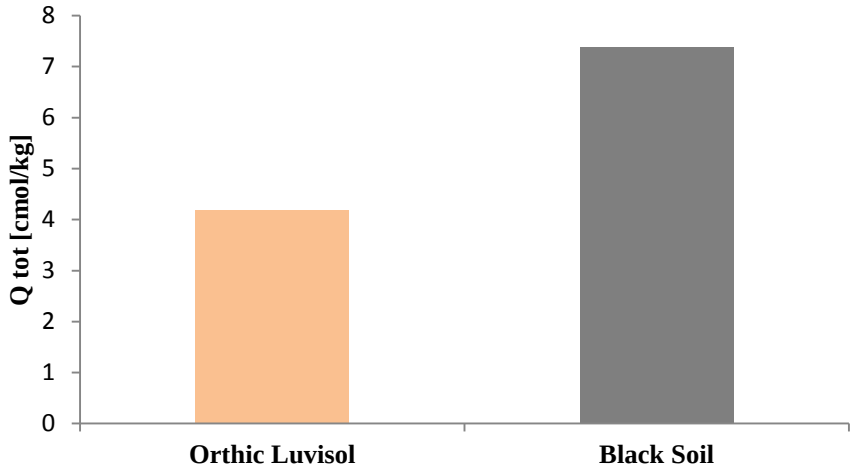

Fig.1. The effect of type of soil on the total surface variable charge of soils. Explanation: Q_{tot} is the total variable surface charge at pH=7.

The total variable surface charge was calculated based on the results obtained from potentiometric titration. This parameter allows evaluating the ability of sorption and ion exchange capacity of the soil. The increase of the total variable surface charge increases sorption properties of soil [3]. It depends on content of clay and silt fraction, content of total organic carbon and pH of soil.

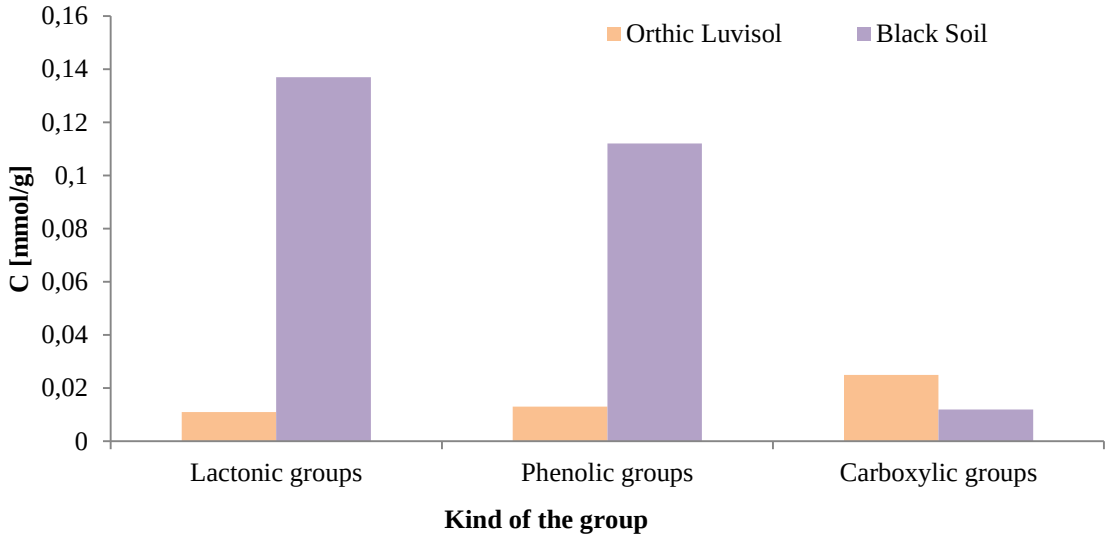

Fig.2. The effect of type of soil on the concentration of different kinds of surface functional groups. Explanation: C is the concentration of surface functional groups.

The concentration of different kinds of surface functional groups was calculated based on the results obtained from Boehm's titration. This method allows evaluating content of groups which are responsible for the sorption capacity of the soil [4]. The increase of content of the surface functional groups increases sorption properties of soil. The Black Soil has higher surface functional groups concentration than Orthic Luvisol. It depends on content of clay and silt fraction and content of total organic carbon [5].

Conclusions

1. Boehm's titration allows evaluating the concentration of the surface functional group: carboxylic, phenolic and lactonic groups. The potentiometric titration allows evaluating the values of the total variable surface charge.
2. It is possible to assess ability of sorption and ion exchange capacity of the soil based on results of Boehm's and potentiometric titration. The concentrations of the total variable surface charge and surface functional groups depend on soil type.

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DESIGNING A SIMULINK LIBRARY FOR SOLAR ENERGY APPLICATIONS

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Keywords: solar systems, simulation, MATLAB, Simulink

Abstract

The development of the solar system highly speeded up in the recent years. For this reason, several experiments were made and a number of prototype systems were built. With the aid of a computer assisted modelling methods the costs can be reduced, but such algorithms were created for a specific task and they not provide too much flexibility.

In this paper, the goal is to create a development environment for solar systems, where one can make unique devices based on a set of predefined building blocks [1]. There were attempts to create a similar system.

The MATLAB+Simulink [2] software package, made by MathWorks, is an ideal choice for the base of this environment. Ordinary differential equations, which are the most obvious descriptors of such devices, can be solved with these programs by long-time tested, proven-to-work numerical methods. The Simulink is a block oriented modelling tool for simulations and it supports all necessary basic element of a complex system, such as a solar energy device.

The first step of the development was to create a simple mathematical model of a solar thermal collector. The Hottel-Vhillier model [3] was chosen due its simplicity. The model was validated using the previously measured data (Fig. 1).

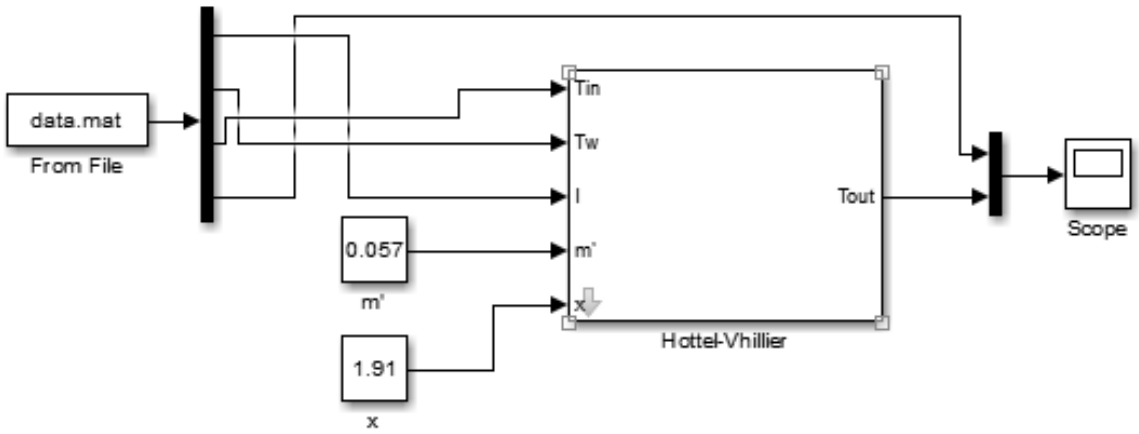

Fig. 1. Hottel-Vhillier model during the validation process

The next step was to create a simple control loop, which can ensure the working of the Simulink environment and to experiment with the structure of a Simulink library. The first implemented control algorithm was the on-off algorithm (Fig. 2). This is a quite simple two-state control method. The method was realised and validated successfully.

Using the control unit and the physically-based model of a solar thermal system showed the possibility of creating a Simulink based modeling environment for solar energy applications and the compatibility of a custom made Simulink library with the default Simulink elements.

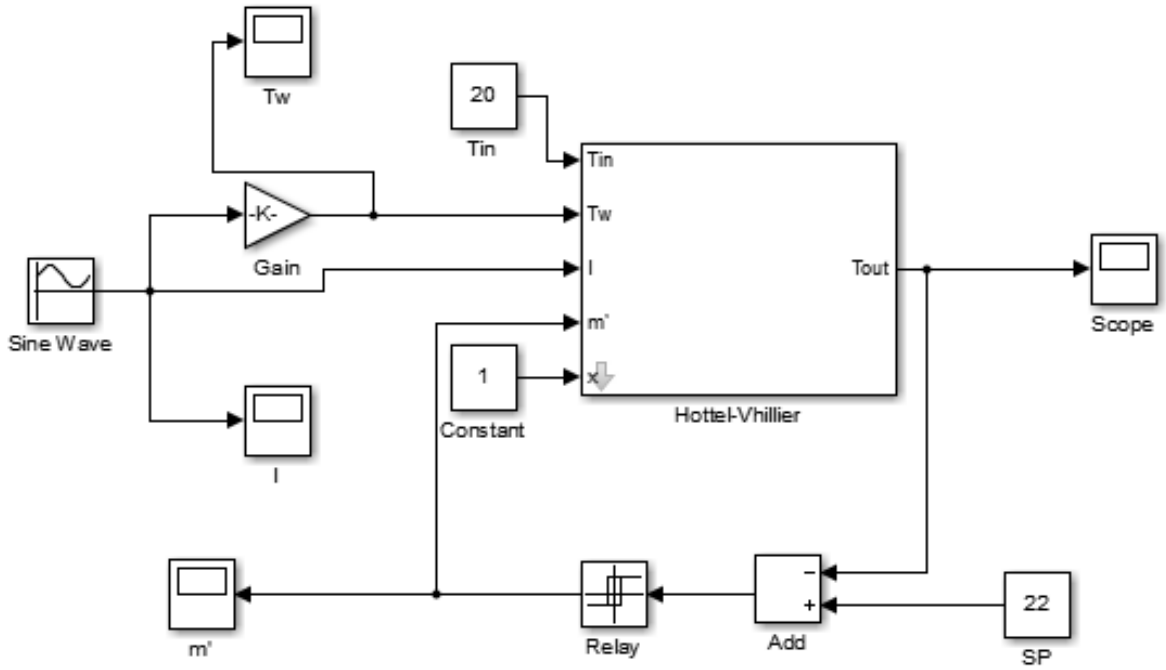

Fig. 2. Hottel-Vhillier model controlled by an on-off controller

In the future, it is planned to realise a simple storage tank so an entire solar thermal system and the various controlling algorithms (P, PID, Fuzzy, etc.) can be compared.

Conclusions

1. A Simulink library modules for solar thermal application was created. That platform allows to study an individually designed system.
2. A basic solar thermal collector was implemented with a controller unit. This will serve as a basis for the extension of several additional components of the solar system, and also to the different control strategies to be applied.

Acknowledgement

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TEMPERING WITH GLAUBERT'S SALT MIXTURE

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Keywords: phase change material, food storage, latent heat, melting point

Abstract

The shelf life of fresh fruits and vegetables can be extended and freshness can be retained when they are stored at optimum temperatures. Refrigerators, pantries and cellars are used in households, in large-scale cold stores are used for storage. Ensuring the optimum constant temperature requires a lot of energy. This paper examines an opportunity to reduce the amount of energy necessary for storage.

During the tempering phase change materials (PCM) can be used, because they have high latent heat.The tempering mechanism is that when the temperature rises above the melting point of the PCM, the material melts, absorbing heat from its surroundings to prevent it from warming. When the ambient temperature drops below the melting point, thereby the PCM emits heat to the environment. So the temperature is a constant, optimal value for foods without the investment of extra energy, while the ambient temperature is changing [2], [3].

In this work among the PCMs, the thermal behavior of the Glaubert's salt (Na_2SO_4 x $10H_2O$) and its mixtures has been studied. This material possesses favorable thermal parameters (melting point 32.4 °C, melting heat 240-254 kJ/kg, thermal conductivity 0.544 W/mK) is readily available, relative inexpensive and unattractive after installation.

However, it should be mentioned due to its good properties, this salt is sensitive to the choice of container and the clean material shows great hysteresis during the overheating or overcooling processes. So, the first task was to stabilize the melting point. The base on experiments the problem was solved by adding 5% borax.

Next step was to measure how the melting point of the Glauber's salt can be shifted to the corresponding value to the different optimal storage temperatures by adding salt [1]. The melting points of the mixtures containing the salt in different ratios were determined by calorimetric measurement. Fig. 1 shows an example of mixture, calorimeter, thermocouples used to measure the temperature, and ADAM module which was used for collection of the measured data in every 2 seconds.

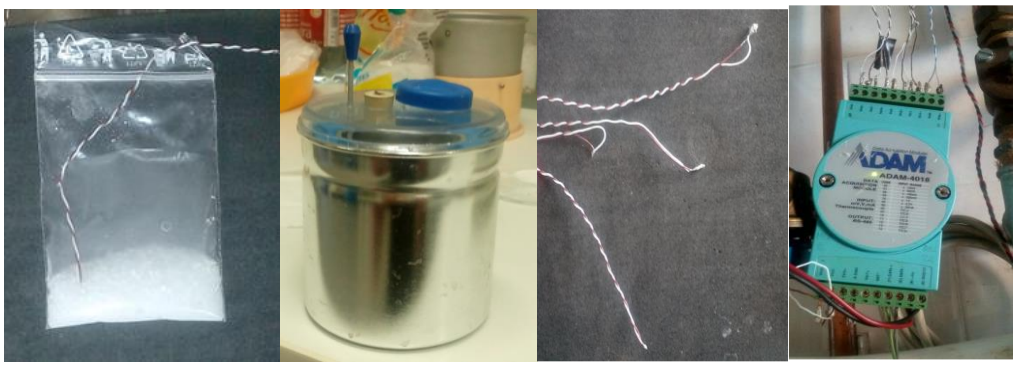

Fig. 1. Mixture sample, calorimeter, thermocouples and data logger module

The ratio of salt was increased from 0 to 50% and the melting points and the latent heats of the mixtures were determined as the function of the salt ratio.

The optimal storage temperature for most of the fresh foods is 0-5 °C in the refrigerators, but there are many exceptions. For apple, citrus, melon, cucumber and potatoes the ideal storage temperature is between 7 and 10 °C, for bananas it is 12-14 °C and in case of tomato this value is 16 °C.

The aim was to determine a phase change mixture with 8 – 10 °C melting point. This temperature is optimal storage temperature for some before mentioned foods. From the mixtures, a mixture with 26.6% saline was the appropriate. This was used for preparation the storage model.

The mixture have poor heat conduction, in a greater extent it would be lost its efficiency. So, the mixture was filled to the cavity chambers of a polycarbonate plate. These walls stuffed in a polystyrene box is gives the food storage model. Fig. 2 shows the wall with the phase-change material and the box with walls.

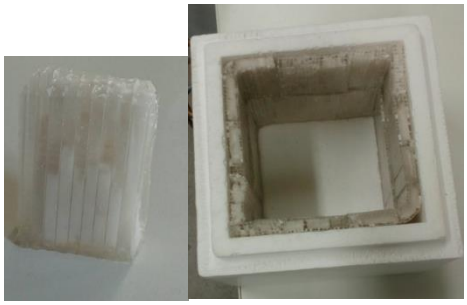

Fig.2. The model of tempering storage

This experimental model were used for energetics measurements. The temperatures were measured in the wall and in the interior air space. The tempering process, when the material inside the box was under and above the melting point, was tested.

Conclusions

1. By increasing the salt ratio, exponentially decreasing melting point were measurable. It can be said that for a given temperature range suitable PCM mixture can be made by Glauber's salt.
2. The latent heat which show the efficiency of the mixture is decreased with increasing salt ratio.
3. The built model was working as expected. By adding this mixture to the walls, the required reduction of the heating or cooling energy can be achieved.
4. It should be noted that for using the mixture in the larger size many problems require solutions yet.

Acknowledgement

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POTENTIAL MECHANISMS OF HEAVY METAL INFLUENCE ON SOIL METHANOTROPHY AND METHANOGENESIS

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Keywords: soil, methane, methanotrophy, methanogenesis, heavy metals

Abstract

The greenhouse effect is a very important phenomenon resulting in an elevated concentration of gases with strong infrared absorption (CO_2, CH_4, N_2O). The increase in the temperature on our planet causes i.e. ocean warming, permafrost melting and changes in all ecosystem activities. One of the greenhouse gases is methane (CH_4) whose rising atmospheric concentration is related to the harmful human activity. Human disturbances are also linked to environmental pollution, including heavy metals. Their main sources are steel industry, energy, mining, or transport; however, they can also accumulate in soils due to agricultural practices.

Soil is one of the most important sources and sinks of CH_4. Taking into account its role in the methane cycle, it fulfills two different functions. Anaerobic conditions cause methane emission into the atmosphere (methanogenesis). On the other hand, under aerobic conditions, we observe methanotrophy with CH_4 oxidation. However, the presence of heavy metals in soil may disturb the processes of CH_4 consumption and production. The main reason is connected with the negative impact of heavy metals on microorganisms carrying out both these contrasting processes.

The aim of the study was to check the effect of soil contamination with heavy metals on methanotrophy and methanogenesis at different moisture levels. The study was based on laboratory observation of added methane (1% v/v) consumption during incubation of soil samples. Three soil moistures and two heavy metals (Pb, Cd) in two concentrations were analyzed.

The obtained results show how heavy metal contamination can change the ability of arable soils to oxidize and produce methane under different water contents. Due to its environmental consequences, such studies are needed and important globally.

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