3rd National Congress on Physical Sciences, 29 Sep. – 2 Oct. 2016, Sofia
Section: The Role of the Physical Sciences for the Bulgarian Industry and ...

Applications of Mobile Optoelectronic Devices in Veterinary Medicine and Food Industry

V. Plachkova[1], **P. Petrov**[2], **Ch. Zemyarski**[3], **M. Nenchev**[1], **M. Deneva**[1]

[1]Department of Optoelectronics and Laser Engineering,
Technical University–Sofia, Branch Plovdiv, 25 Tsanko Diustabanov Str.,
4000 Plovdiv, Bulgaria
[2]MIVAMA EOOD, Plovdiv, Bulgaria
[3]Animalvet Ltd., 81 Petar Bogdan Str., 4150 Rakovski, Bulgaria

Abstract. The mobile optoelectronic devices for applications of veterinary medicine and food industry for the study of liquid samples were improved. These devices are characterized by precision, rapid-acting and easy feasibility. Mobile fluorescence analyzer- experimental setup was constructed. This device uses a rapid and easily available method for fluorescence field spectroscopy of liquid samples from animals. Optimal wavelength of fluorescence analysis of sick ruminant is 245 nm. The fluorescence method is suitable for early diagnosis of samples to detect the existence of bacteria in the body of animals before the presence of symptoms of the disease, which causes the respective bacteria or virus.

Experimental setup was constructed of broad spectrum fiber-optic module with rod lenses. Broad spectrum fiber-optic module with rod lenses is useful in the analysis of spectra of scattering of various liquid samples in the food industry. The effect of scattering in different brands of juices was investigated. Precision was shown and that allows the module to successfully be applied in the food industry for analyzing liquid samples. Broad spectrum fiber-optic module with rod lenses performs rapid-actin tests of samples and using the effect of scattering it detects impurities in natural food liquid products.

1 Introduction

Applications of mobile optoelectronic devices which investigate biomedical samples from the veterinary medicine and food industry is essential for the successful development of these sectors in the future. In recent years substantially increased interest by leading manufacturers of spectrometers was the development of special applications for their products not only in the food industry but also in the agriculture [1,2]. The objective of the mobile optoelectronic devices is to offer modern methods using quantum optoelectronic and diagnostics for fast and reliable analysis and early detection of the presence of undesirable and harmful to the

animal organism bacteria and viruses and unregulated additives which are widely used in food products.

It have to be mentioned that, its common that diagnosis by symptoms on animals can be wrong resulting in no improvement or even cause the necessity for livestock to be scrapped [3,4]. Mobile devices allow tests for problematic animal diseases to be carried out on the farm. This will allow the benefits of safely raising livestock and reduce their mortality by high accuracy diagnostics.

In the food industry mobile devices are aimed at determining the quality of food. Particularly effective and informative to examine the milk, honey and vegetable oils [5,6]. Mobile devices are based on the detection of impurities in the mass-regulated food products aimed at improving product quality manufacturers deviating significantly from the biological composition of food.

2 Mobile Fluorescence Analyzer – Experimental Setup

The basic scheme for observing and measuring the fluorescence signal is shown in Figure 1. Since fluorescence is often very weak in all directions its a serious problem for the receiver to detect signals [7]. The useful fluorescence signal is measured in a direction which is less than 45° relative to the excitation radiation. For measurement of the fluorescence it is preferably used as acting source a laser diode (LD) as his spectral width is very small. The LED has a relatively wide spectral width of radiation from 30–40 nm and usually angular distribution of the radiation is in their large angular range of $\pm 30^{\circ}$. It was selected to work with LD with a wavelength of 245 nm, since in preliminary studies it was found that bacteria and nutrients in the body of small ruminants have low emission wavelength. The source irradiates the sample and its emission wave-

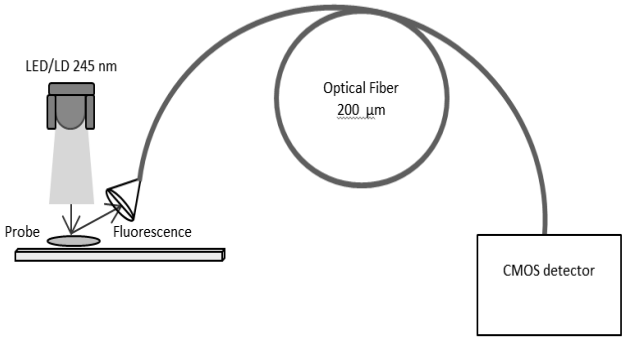

Figure 1: Scheme of the experimental setup.

length is transmitted through the optical fiber to a CMOS detector. The sensitivity of the CMOS detector is in the range of 200 nm to 1100 nm. Its resolution is about $\delta\lambda = 5$ nm [8].

The components contained within the experimental setup which is shown on Figure 1 have a relatively small size. This advantage allowed a fluorescence analysis to be carried out at a farm. It was chosen to make measurements in the field, in order to avoid damage to the samples in transit and thus to ensure the more reliable fluorescence assay.

Samples taken from sick animals were tested using fluorescence spectroscopy. The study was conducted after establishing a diagnosis by symptoms of veterinary medic. A key moment in the field of fluorescence spectroscopy proved the fact that it was found the presence of bacteria, which cause infection [9-11]. Using standard methods in a biochemical lab a veterinary specialist afterwards confirmed the results which gave ground to the team to further improve the method for rapid and early fluorescence spectroscopy.

Tests were equally effective for blood and abscess samples, vaginal and nasal discharge. Fluorescence spectroscopy was carried out on site, samples were not carried in the laboratory because of the mobility of the device, which is an advantage. The method can be applied for mass testing because the pattern for fluorescence spectroscopy is affordable and easy to operate. Fluorescence spectroscopy can replace labor-intensive and very consumable testing trivial microbiological laboratories. The three main advantages of Fluorescence spectroscopy are: (i) the method is rapid; (ii) it requires no consumables; (iii) it is mobile. The fluorescence method is suitable for the early diagnosis too. Before the presence of symptoms of the disease, which causes the corresponding bacterium samples can be taken to detect the presence of bacteria in the body even in small quantities [8].

3 Broad Spectrum Fiber-Optic Module with Rod Lenses – Experimental Setup

The construction of the broadband fiber optic module with rod lenses was carried out after a precise assembly of its parts. The lenses consist of two parts of different glasses to compensate for chromatic aberration and ensure the transmission and focusing of broadband (white) light into the fiber. Each of the lenses needed to cover exact number of pixels so the sum could cover the photodiode array. The lenses were arranged in a common module, with a broad spectrum light source and a quartz cuvette. Light from the source impinging on each lens is lead out via an optical fiber to a photodiode matrix [12]. The detection unit is based on a 128-pixel CCD linear array with an integrated low-noise charge-amplifier

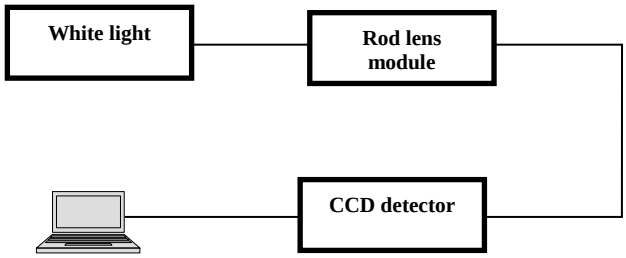

Figure 2: Block diagram of the broadband fiber optical module with rod lenses.

featuring high sensitivity, a low dark current and high stability [13]. Two high-speed capacitive-based analog-digital converters (ADCs) transform the analog data from the CCD sensor. The spectral width of each lens is displayed on a computer using specially written software tailored for specific model CCD. Block diagram of the broad spectrum fiber optical module with rod lenses is presented in Figure 2. Broad spectrum fiber optic module with rod lenses provides fast and qualitative measurements in biosensorics for testing different substances and bacteria as well as other organic products. Several independent from each other particles can be tested with a broad spectrum source. This will facilitate research in biophotonic schemes and can reduce costs [14].

The purpose of the design of broad-fiber optical module with rod lenses is to provide a high-speed testing of liquid samples. The application of fiber-optic module with rod lenses thoroughly examined the analysis of spectra of scattering of various liquid samples of the food and cosmetics industry. The broad spectrum fiber-optical module with rod lenses is a unique solution for optimization experiments, especially when analysis requires multiple measurements [12].

4 Results and Discussion

Fluorescence analysis was carried out at the dairy farm. I was selected to make field measurements in order to avoid damaging the samples in transit and thus to ensure the more reliable fluorescence assay. With the above described models were studied various liquid samples from sick cows such as vaginal secretions, blood, nasal discharge and abscess.

In fluorescence analysis of a blood sample were registered emission wavelengths of Fusobacterium necrophorum, Corynebacterium pyogenes (characterize hoofed cow disease) and Mannheimia haemolytica (characterize pneumonia in cattle) under fluorescent analysis of a sample of the abscess were registered emission wavelengths of E. Coli and S. Au-

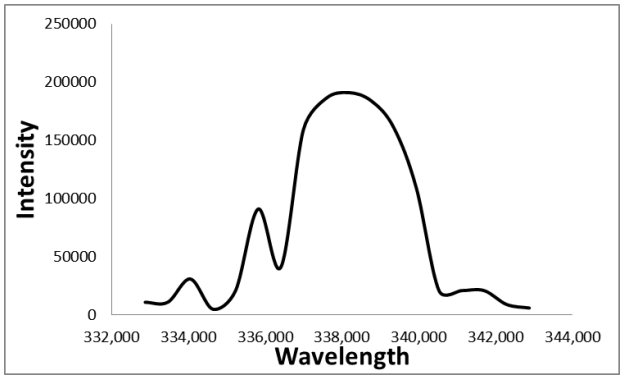

Figure 3: Fluorescence spectroscopy of Fusobacterium necrophorum with the emission wavelength of 590 nm at a wavelength of excitation $\lambda = 245$ nm.

reus (characterizing infectious contamination). In fluorescence analysis of nasal discharge was registered emission wavelength of β-Hemolytic Stafilococcus (characterize viral infection of the nasal passages) under fluorescent analysis of vaginal secretions were registered Streptococcus pyogenes and E. Coli (characterize vaginal infection) [8].

Samples of sick cows were analyzed. They were made by veterinarian out at the dairy farm where the fluorescent analysis system was positioned. In Figure 3 and Figure 4 are clearly visible the emission wavelengths of Fusobacterium necrophorum, and Corynebacterium pyogenes, which

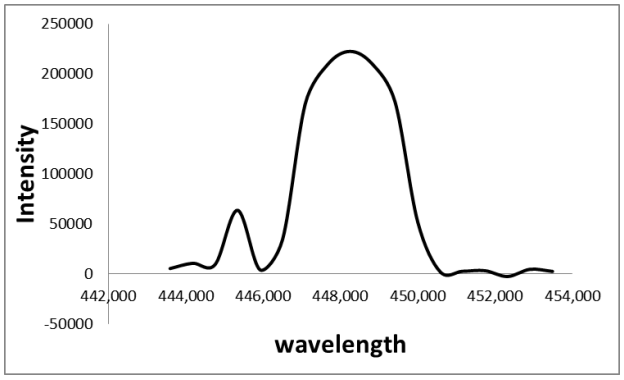

Figure 4: Fluorescence spectroscopy of Corynebacterium pyogenes with the emission wavelength of 338 nm at a wavelength excitation $\lambda = 245$ nm.

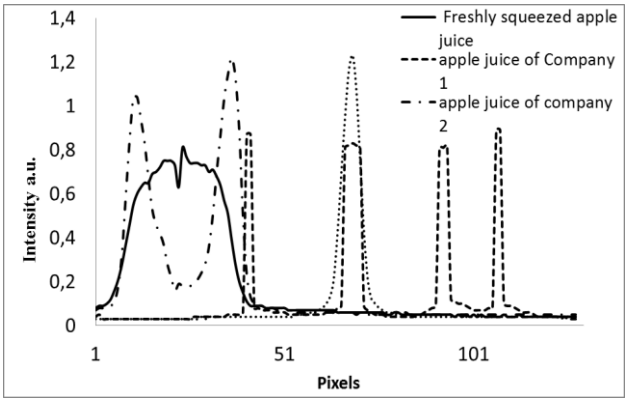

Figure 5: Fluorescence spectroscopy of Mannheimia haemolytica with the emission wavelength of 448 nm at a wavelength excitation $\lambda = 245$ nm.

were registered in a blood sample of one of the cows. Thus the diagnosis was confirmed by a veterinary specialist in emerging hoofed disease.

In Figure 5 is clearly visible emission wavelength of Mannheimia haemolytica which was registered in the blood sample of one of the cows. This bacterium is the causative agent of respiratory infection. Definitely the disease was in its early stages, as the veterinary specialist didn't found any symptoms for pneumonia but a standard test did. Fluorescence spectroscopy of this particular bacterium proves that the method is suitable for early diagnosis of the presence of bacteria before symptoms of the disease start to appear.

The excitation spectra for all studied samples of healthy cows (blood sample, sample of the abscess, a sample of vaginal and nasal discharge) is 245 nm. Bacteria in the body of small ruminants have low emission wavelength. They were recorded with emission wavelengths set at: 590 nm for Fusobacterium necrophorum [15], 338 nm for Corynebacterium pyogenes [16], 579 nm for E. Coli [17], 330 nm for S. Aureus [18], 350 nm for Streptococcus pyogenes [18] and 448 nm for Mannheimia haemolytica [19].

The constructed broad spectrum fiber optic module with rod lenses can be used to determine the scattering spectra of liquid samples. In the construction of the module is included quartz cuvette, where the desired sample is poured and then irradiated with white light [12].

The problem with the quality of the juices in the food industry is of great importance since it is a mass product. With the broad spectrum fiber-optic module with rod lenses was conducted detailed comparison be-

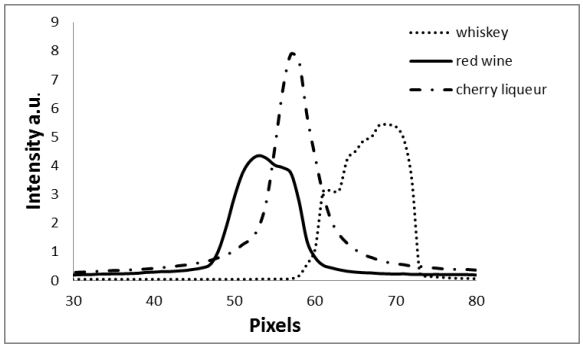

Figure 6: Angular scattering comparison between natural apple juice and apple juice made by two different companies.

tween the juices of 3 different companies and freshly squeezed juices. Figure 6 shows that the spectrum of scattering juices of any of the companies does not absolutely match spectrum of scattering of freshly squeezed apple juice. Best results gave the sample of juice taken from Company 2. Samples from natural juices of the other two companies differ significantly from freshly squeezed apple juice.

From the analysis of samples of natural apple juice can be concluded that most of the manufacturers of juices working with preservatives and dyes, but not with natural products. Given the sensitivity of the module to tiny particles it can be said that the composition from the factory juices almost absent organic compounds from apple [12].

Each of rod lens accepts light from various angles of scattering from the included in the composition of the tested sample particles.

Figure 7 shows a difference between the scattering spectra of three widely used alcoholic beverages. It can be seen that the spectrum of intensive

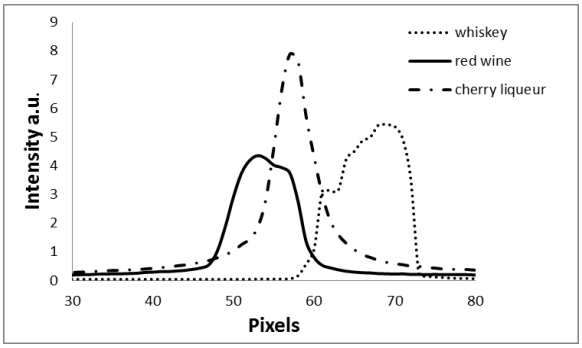

Figure 7: Angle of scattering from various alcohol drinks.

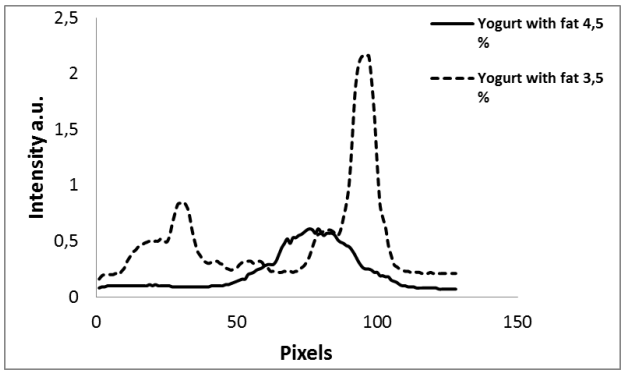

Figure 8: Angle of scattering from milk with different fat content of the same manufacturer.

concentrated cherry liqueur and the wider and less concentrated scattering spectra of the whiskey and red wine using the broad spectrum fiber-optic module. With the module can be done rapid scattering analysis on other types of alcohol.

In Figure 8 is clearly shown the difference in the angle scattering of yogurts with different fat percentage taken from the same manufacturer. Yogurts are not often tested which stimulated the team to perform one [12].

The ability of the broad spectrum fiber-optic module with rod lenses to analyze the scattering of fat in yogurts would have decided a lot of problems in the dairy industry. The system can perform tests on ready-made products and mark them categorized by fat, which means that it would be quite a boon to the end user. Problem with supply of yogurts with unregulated fat would be solved by the module with rod lenses and for this purpose it is not even needed a rich library as percentage of fat to trivial yogurts are standard [12].

5 Conclusions

Mobile optoelectronic devices of veterinary medicine and food industry are absolutely harmless and their operation does not use chemicals or other artificial supplies. They operate entirely on the principle of light diagnostics. Advanced is fast and easily accessible method for field fluorescence microscopy of liquid samples from cattle. The most optimum wavelength for fluorescence analysis of ruminants is 245 nm. The fluorescence method is suitable for early diagnosis of samples for the presence of bacteria in cattle and before the presence of symptoms of the disease, which causes the respective bacteria.

A broad spectrum fiber-optic module using rod lenses for the angular measurement of scattering has been proposed. A precise adjustment of the lenses has been performed. The fibers from the broad spectrum module are arranged in one plane and attached to a linear CCD array. The intensity distributions can be monitored by a suitable software. Using the module, only a small sample is needed to be analyzed thus saving time for the analysis of liquid samples. The broad spectrum module features a sensitivity to low concentrations of particles which makes it convenient for the analysis of liquid samples for the food, cosmetic, medical and other industries which require a given level of sample purity.

Optoelectronic diagnostics allows legitimate intervention before serious spread of a disease thus reducing the morbidity in any interested farm. The aim of optoelectronic systems is to be offered modern methods of optoelectronic diagnostics for fast and reliable analysis and early detection the presence of undesirable and harmful to the body bacteria and viruses and unregulated additives widely used food products.

Health problems and harmful impurities in the mass-regulated food products are a global problem not only in Bulgaria but also in the world. For this reason, this research is aimed in that direction. Subsequent target is established techniques to carry out attempts to export-oriented solution for global problems in veterinary medicine and food industry by establishing contacts with laboratories for biophotonics and sharing of combined experience in veterinary medicine and food industry.

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