COMPUTER SIMULATION OF DOSIMETRIC MEASUREMENTS OF ULTRAVIOLET RADIATION

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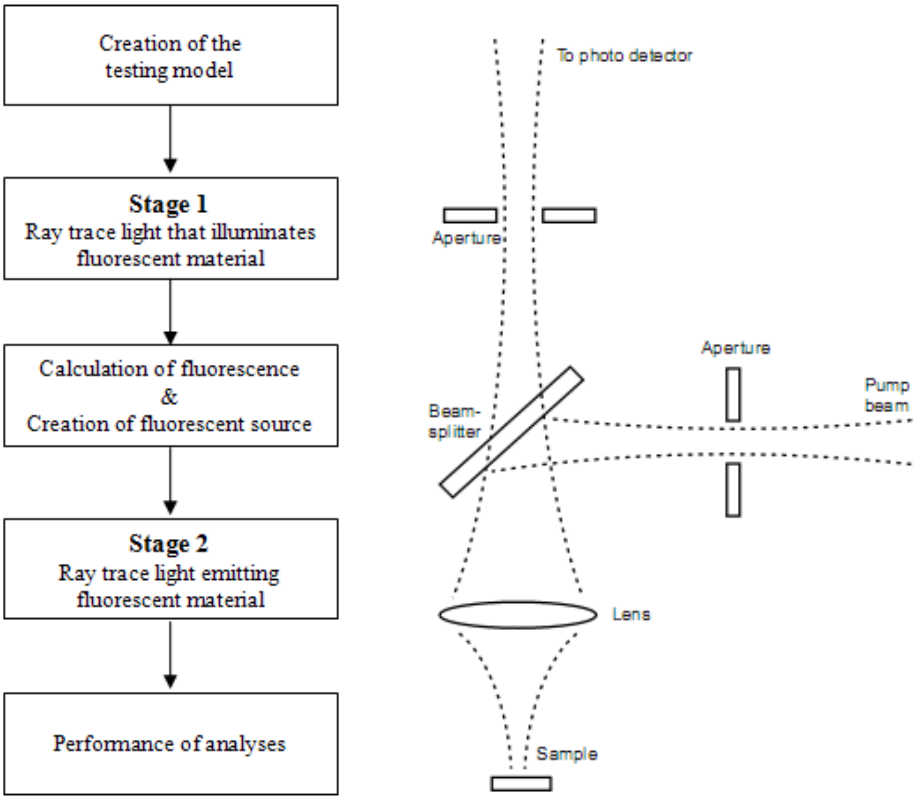
UVR can be measured by biological, chemical and physical detectors. Physical detectors include radiometric devices, which respond to the heating effect of the radiation, and photoelectric devices, in which incident photons are detected by a quantum effect such as the production of electrons. Chemical detectors include photographic emulsions, actinometric solutions and UV-sensitive plastic shields. The solar UV irradiation of large portions of the Earth is currently measured using multifrequency imaging detectors on meteorological satellites. Biological techniques of measurement are generally limited to the use of viruses and microorganisms. The bacteriophage T7 has been described for use as a UV biosensor [1]. It has been used to monitor ambient UV radiation, and when combined with an appropriate optical filter, a spectral response similar to the action spectrum for erythema in human skin can be achieved [2].

Aim of the research is to simulate of the process of physical dosimetric measurements of UVR. Urgency of this work is consisted in difficulty of physically organization of ultraviolet radiation (UVR) measurements, specially this fact is attached to UV-B (wavelength range is 280…320 nm), so it is necessary to provide high requirements of security measures.

Material and methods. With simulation it is possible to reduce the number of real experiments. So it is more ethical and it allows also controlling all the test environment parameters, to repeat the same test changing for example flourophore concentration or activation spectrum without interfering with the other test parameters. Finally using simulation is also reducing the cost for the development because measurement instruments and the use of labs can induce a lot of cost. The challenge for the simulation is the use of realistic parameters for example for the tissue which are sometimes not well known. Another challenge is the simulation time because the pathways of light rays through scattering materials can be very complex.



a) b)

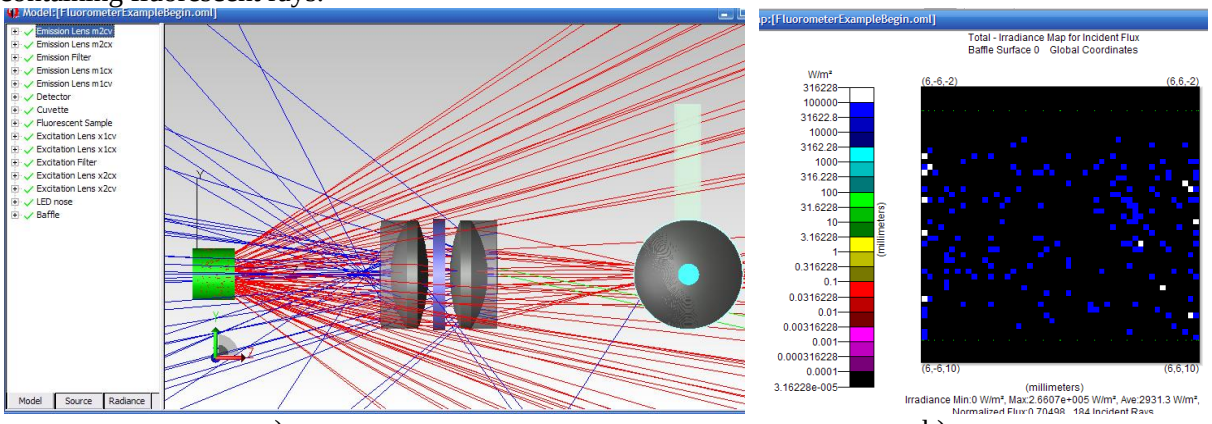
Figure 1 – a) Block-scheme of fluorescence modeling algorithm;
b) The experimental set-up for photoluminescence measurements

Computer program TracePro is a comprehensive, versatile software tool for modeling the propagation of light in imaging and non-imaging opto-mechanical systems [3]. Models are created by importing from a lens design program or a CAD program or by directly creating the solid geometry in program TracePro. Sources propagate through the model with portions of the flux of each traced ray allocated for absorption, specular reflection and transmission, fluorescence and scattering. Significantly it is noted that method of mathematic simulation is used in this software is Monte Carlo.

At the first stage of the ray trace, excitation rays illuminate the fluorescent material. The rays must be in the excitation portion of the fluorescent material spectrum and the model geometry must allow the fluorescent material to be illuminated. A byproduct of this first stage of the ray trace is that program TracePro automatically creates source files which contain rays generated by the fluorescing material. The second stage of the ray trace uses the newly created source files to trace the fluorescing rays themselves. Program TracePro allows you to choose whether the two stages of the ray trace should be performed together as shown on the figure 1 (a). If we decide to organize the physical experiment, we should collect the set-up for fluorescence analysis (figure 1 b).

According to the algorithm of computer simulation we perform fluorescence analysis in the program TracePro.

Results being discussed. We presented model which simulated in the program TracePro in the figure 2 (a). This research model has a cuvette containing fluorescent material that is illuminated by light at excitation wavelengths of the material. The material then fluoresces, generating source files containing fluorescent rays.



a) b)

Figure 2 – a) Model for providing of dosimetric measurements UVR;
b) The result of computer simulation fluorescence analysis

Using the function “Irradiance/Illuminance Map” in the program TracePro we get data about intensity of UVR from different sources on the chosen surface. In the figure 2 (b) we see irradiance map from the “Baffle surface 0”.

Conclusion. The results of computer simulation of dosimetric measurements of UVR show that the fluorescence analysis allows to get the characteristics of irradiation by simply mean. Physical measurements of dosimetry of radiation of optical range of frequencies are difficulty and they have low precision of measured data.

Reference list:

1. Kohen, E. Photobiology / E. Kohen. – New York & London: Academic Press, 1995. – 250 p.
2. IARC Working Group on Risk of Skin Cancer and Exposure to Artificial Ultraviolet Light / WHO International Agency for Research on Cancer. – France: IARC, 2006. – 76 p.
3. TracePro – software for opto-mechanical modeling / User's Manual. – Lambda Research Corporation, 2010. – 537 p.