Eco-photonics:

Micro-encapsulated probe as implantable sensor for monitoring the physiological state of water organisms

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***Abstract* — Nowadays there is a growing interest to the natural evolutionary changes and especially those driven by environmental pollution and climatic variations. Climate change in combination with human activities largely influences the environment and especially aquatic ecosystems. We develop an approach for non-invasive screening of stress felt by water organisms due to environmental variations. In particular, we offer real-time quantitative assessment of internal temperature and pH in small aquatic species, such as shrimps, fish and fish embryos. The approach is based on the measurements of fluorescent and luminescent spectra obtained, respectively, from micro-encapsulated fluorescent dyes and upconversion particles embedded into the aquatic animals *in vivo*.**

Keywords—micro-encapsulated probes, sensors, upconversion particles, fluorescence, luminescence, eco-photonics, aquatic organisms, environmental monitoring, climate change

I. Introduction

Nowadays there is a growing interest to the natural evolutionary changes and especially those that driven by environmental pollution and climate change. Climate change in combination with human activities largely influences the environment and especially the aquatic ecosystems. We develop an approach for non-invasive screening of stress felt by water organisms due to environmental variations. As an example we present the results of real-time quantitative assessment of internal temperature and pH in aquatic species.

II. Experimental Approach

Laser light was used to excite encapsulated SNARF-1-D with sequential emission signal acquisition in the green channel (587 nm) and the red channel (627 nm) for further ratiometric pH measurements. Images of micro-encapsulated biomarkers MBMs (probes) in buffers and inside animals consist of three channels: a 587-nm channel, a 627-nm channel and a white light channel [1,2]. In a similar manner to [1,2] luminescent signal from upconversion [Y2O3: Yb, Er] particles UCPs [3] was excited by a semiconductor laser ITC 4005 (λ = 975 nm). The luminescence spectra were measured from the surface of the biological sample through an objective, a dichroic mirror, and optical fiber; photoluminescence signals were recorded by the spectrometer with an acquisition time 200 ms.

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III. Results

The obtained images of fluorescent and luminescent signals produced, correspondingly, by MBMs and UCPs injected to the Zebrafish and shrimp, respectively, are shown in Figure 1.

Fig.1. Zebrafish showing specific places where pH was measured with fluorescent MBMs (left); Image of *C. multidentata* shrimp with injected UCPs *in vivo* after illumination with laser light (right).

IV. Summary

The developed technique can be adopted for studies of various biosystems from terrestrial and aquatic invertebrates to fish and fish embryos. The proposed approach has strong potential to simultaneously measure a range of physiological characteristics using a set of micro-encapsulated probes and to finally bring toxicological bioassays and related research fields to a new level of effectiveness and sensitivity.

References

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