CICECO – Aveiro Institute of Materials (PHANTOM-G research group), Universidade de Aveiro (UAVR - Portugal) is coordinating the project. 8 other partners participate in NanoTBTech

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The Horizon 2020 FET-OPEN-funded project NanoTBTech is leading the change towards new thermal bioimaging technologies!

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Nanoparticles-based 2D thermal bioimaging technologies

TEMPERATURE CHANGES PATTERN: DETECTING··· AND HEALING

At the dawn of the medical science, way before the formal appearance of the scientific method, the Roman physician Celso/Celsius had already identified calor – local increase of temperature- among the cardinal symptoms revealing inflammation process, (together with rubor , tumor and dolor). During the subsequent two thousand years of biomedical history, humankind has acquired deeper knowledge about the relationship between a great number of health disorders, and anomalous temperature distributions in the affected organs. For instance, tumoral tissues have shown to display different thermal relaxation dynamics than healthy ones.

In living organisms, for instance, temperature is continuously fluctuating, as it relates to many cellular functions, including gene expression, protein stabilization, enzyme-ligand interactions and enzyme activity. Intracellular temperature depends on the chemical reactions occurring inside cells, which are accompanied by either heat release or heat absorption, with the concomitant modification of the temperature.

Temperature changes and their spatial distribution are not just very relevant parameters that clinical physicians wish to accurately detect and quantify. Indeed, by purposely inducing a temperature change in a controlled local way, great heating can be achieved. In particular, hyperthermia is a harmless precision medicine method to kill malignant cells by thermal ablation and thermally-modulate the tumour microenvironment in order to have synergic effects with standard cancer treatments. Currentlly, hyperthermia can be induced either by irradiation with a NIR laser or by an AC magnetic field. However, the challenge is now to reach real-time thermal control over treated tissues, thus achieving a minimally invasive precision therapy with little collateral damage.

NanoTBTech is leading the change towards new thermal bioimaging technologies

THE CHALLENGE AHEAD: THE RIGHT WAY TO MEASURE TEMPERATURE

The venture of temperature measurements for biomedical technology has a two-pronged promise to fulfil, namely detection and spatial mapping of temperature gradients for a better and earlier detection of diseases, and real-time monitoring of hyperthermia treatments to avoid them causing more harm than good. To tackle those two complex issues, the key technology needs are non-contact thermometry granted with sub-micrometer resolution, providing high sensitivity thermal readout in a real-time mode.

Techniques able to go clearly below 1 μm at cellular level and smaller than 1 cm for in vivo targets are urgently needed, as the traditional contact-based sensors and mid infrared thermometers are not suitable for measurements at such small scale . Modern medicine have reached a point where the use of traditional thermometers does not satisfy neither contactless nor submicrometric spatial resolution, that are required, for instance, to monitor the aforementioned intracellular temperature fluctuations.

THE NANOTBTECH APPROACH: A RADICAL BET FOR LUMINESCENCE-BASED THERMOMETRY

The main pathways of our original approach are small size probes (luminescent nanoparticles), no-invasiveness of the methodology (NIR-to-NIR deep-tissue luminescence thermometry), and real-time readout. The planned outputs are:

- Fabrication of nontoxic, long-circulating “stealth”, functionalized, tumour-targeted and luminescent nanoparticles with high thermal sensitivity values.
- Coupling luminescence 2D time-resolved thermal imaging and optical microscopy imaging under NIR irradiation (or AC magnetic field) in two different simple and compact prototypes to (a) monitor local hyperthermia in cells and (b) to study in vivo time-gated and 2D hyperspectral magnetic- or optically-gated thermal transient thermometry in depth tumoural models.

Our ambition is to develop a dedicated imaging platform with unprecedented performance leading to major advances in 2-D thermal imaging technologies.