Docket #: S17-440

Upconverting Nanoparticles as In Vivo and In Situ Optical Electric Field Sensors

This nanoparticle platform for electric field detection is the first inorganic platform to use both intensity and spectro-ratiometric (relative color change) readout for the determination of local electric fields in vitro, in vivo, and in situ. These nanoparticles can be incorporated into the system either through natural uptake (e.g. digestion or absorption) or artificial introduction (e.g. injection, electroporation). By combining upconverting lanthanide ions with piezoelectric hosts and/or voltage responsive dyes, the generated optical platform displays intensity and spectrum changes in the presence of electric fields. These particles enable local (down to 10 nm spatial resolution) mapping of electric fields with exceptional photostability. This invention can image and quantify in vivo and in situ electric fields in biological and material systems up to fields of ~100 kV/cm. Feasibility studies demonstrate that this platform is more robust as compared to other optical technologies for voltage sensing which are limited by photodegradation, poor SNR, toxicity, and weak stimuli response.

Stage of Research

- Demonstrated feasibility of this nanoparticle platform

Applications

- **Biological Systems**
    - Probing electric fields of biological relevance in living organisms
    - Characterizing cardiomyocyte activity
    - Studying neural networks
    - Optical imaging of action potential and brain activity
    - Studying animals' electric fields for direction and prey sensing

- **Physical Systems**
    - Monitoring devices such as batteries, semiconductor devices, electric motors, printers, generators, etc.

Advantages

- **All optical, inorganic platform**
- **Innovative fabrication process** for adding voltage sensitive dyes to upconverting nanoparticles
- **Sensors are embedded in the material matrix** rather than mounted on the exterior of equipment
- **Advantages compared to current optical technologies for voltage sensing:**
    - No photodegradation (photoblinking and/or photobleaching)
    - Higher SNR (signal to noise) ratio
    - Higher electric field response
    - Higher spatial resolution

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