Biomimetic and Bioinspired Materials for Applications in Biophotonics

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Biomimetic and bioinspired materials present an emerging field in the areas of biomedicine, bioengineering, and biological sciences. One of the current trends is the production of biofunctional materials that are able to interact with light and thereby enable applications in therapy, biosensing, and bioimaging. The aim of this special section is to present some of the current state-of-the-art research activities on the use of such materials in relation to the field of biophotonics.

Two of the papers are review articles, which focus on the opportunities and current challenges of nanomaterial-based applications towards life sciences. Vázquez-González and Carrillo-Carrion present a review article on “bio-inspired” or “bio-mimetic” analytical platforms based on quantum dots (QDs) with great potential in the field of detection of heavy metal ions. They provide an overview on state-of-the-art strategies for surface modification of QDs, which together with the photophysical properties of QDs allow for highly sensitive assays. Three main analytical mechanisms based on the interaction of QDs and light are discussed: quenching and enhancement of the photoluminescence, and charge and energy transfer.

Del Pino provides a review article on the relevant parameters and some of the most promising applications resulting from the interactions between electromagnetic (EM) fields and nanoparticles. This review focuses on EM-active nanoparticles, which upon coupling with light or magnetic fields can provide highly useful responses, such as photoluminescence, nanoheating, energy or charge transfer, magnetic resonance, optoacoustic signal, etc. Several examples of bio-functional materials (that is, functionalized nanoparticles towards bio-applications) and corresponding applications in therapy, bioimaging, and biosensing are given. A significant part of this review discusses how current synthetic methods allow for tailoring the coupling and response of materials toward EM fields. Indeed, this topic connects very well with the report of Fujimoto et al. on the use of titanium oxide powder, localized on the tip of a quartz optical fiber, as a medium for transduction of optical energy emitted from a 980 nm semiconductor laser into heat. The authors propose high-power tip-functionalized semiconductor lasers with emission within the NIR window (also called biological window) as an alternative surgical tool for the clinic. By means of this interesting approach, extremely high temperatures can be produced at the tip of the fiber, which may find very useful applications in surgical procedures such as drilling holes in bone.

Maawy et al. present a study on the effectiveness of PEGylation of near-infrared dyes conjugated to a chimeric anti-carcinoembryonic antigen antibody, as an approach to enhance labeling of prostate tumor models. Their results suggest the potential for clinical applications of this optical probe...
in fluorescence-guided surgery. This work highlights two of
the most relevant trends within the scope of this special sec-
tion of JBO: first, materials with NIR features are highly useful
for bioimaging purposes, as well as for therapeutic ones, due
to the high penetration of NIR light in biological tissue; second,
even the best performing photons' materials typically require
additional surface modifications such PEGylation to improve
their biofunction capabilities.

Li and Schneider, using a combined multiphoton imaging-
UV/Vis spectroscopic analysis, investigate the effect of gold
nanoparticles diameter on their cellular uptake. The optical
properties of gold nanoparticles, which extinction coefficients
are orders of magnitude stronger than common organic dyes,
allow for this quantitative study. Owing to the strong absorp-
tion of gold nanoparticles, the concentration of free gold nano-
particles that remained in the cell medium (therefore, not
internalized by the cells) was quantified by absorption spec-
troscopy. On the other hand, multiphoton sources produce
bright luminescence, as well as other processes such as sec-
ond harmonic generation and light scattering, from gold nano-
particles and thereby allow for quantification of the cellular
internalization of gold nanoparticles.

Cywinski et al. report on the engineering of nanoconju-
gates composed of cadmium selenide quantum dots, euro-
pium complexes, and biotin. These conjugates provide
long-lived photoluminescence by the europium complexes,
and may serve as useful platforms in diagnostic and imaging
applications. This work highlights how tailoring the surface
of nanoparticles—in this study, Europium onto polymer-coated
QDs—can improve their "bio-performance" (e.g. long-lived
photoluminescence emission).

Overall this special section provides an ample overview of
current strategies for the functionalization of materials (mainly
focused on inorganic nanomaterials), as well as their most
relevant applications in biophotonics. We hope that this
collection of papers will be of interest to the biophotonics com-
community. We thank the investigators for their outstanding
contributions.

Bahman Anvari received his BS in biophysics from UC Berkeley and
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