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Editorial: Global excellence in nanotechnology: United States

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Editorial on the Research Topic
Global excellence in nanotechnology: United States

The Frontiers Research Topic, Global Excellence in Nanotechnology, consists of i) a seminal paper for the structural and functional biological chemistry, electron imaging community that utilizes liquid cell–transmission electron microscopy (LC-TEM) analysis in which the authors study the electron beam induced damage in fluorescently labeled, functional, nanoscopic, bilayer membranes, ii) a significant paper in furthering the design of optoelectronic devices based on nanoribbons of graphene, a green electronic material, and iii) a paper presenting the novel use of lutein nanodisks to transport and provide protection from UV photo damage to human retinal cells.

Moser and Evans' paper, *Inactivation of Fluorescent Lipid Bilayers by Irradiation With 300 keV Electrons Using Liquid Cell Transmission Electron Microscopy*, details important work for the structural and functional biology community that was completed at the U.S. Department of Energy's Pacific Northwest National Laboratory's Environmental Molecular Sciences Laboratory (Moser and Evans). The researchers highlight the importance of the LC-TEM technique for understanding dynamics, structure and function of biological and soft matter systems. In the work the researchers make a detailed study of the electron flux thresholds that do not result in a functional change in hydrated lipid bilayers through the use of concomitant liquid-cell transmission electron microcopy (LC-TEM) and fluorescence imaging measurements on a well-studied fluorescently labeled bilayer membrane system. The authors give an overview of the difference between dose and electron flux as well as point to the free radical mechanisms that are primarily responsible for degradation in hydrated biological systems. The carefully designed studies utilized a 19:1 ratio mixture of the well-studied 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC) and fluorescently labeled 1,2-dioleoyl-sn-glycero-3-phosphoethanolamine-N-carboxyfluorescein (DOPE-CF) to prepare 10 nm thick membrane lipid bilayers using Langmuir-Blodgett (LB) deposition. The well-known consistency of these systems, established by examining the potential influences of background, photobleaching, and exposure to vacuum, enabled the researchers to quantify primary or secondary degradation of the fluorescent tag or the supporting lipid bilayer through changes in local fluorescent intensity. The paper issues an important warning for those using transmission electron microscopic imaging in studies of liquid, cryogenic, and other material samples. Function can be affected at very low electron flux levels compared to those widely used with electron imaging techniques. In fact, the researchers demonstrated that decreases in fluorescent intensity were as high as 25% after exposure to a flux of 0.0005 $e^{-}/Å^{2}$ irradiation and higher than 90% after irradiation with a

flux of 0.01 $e^{-}/Å^{2}$. These thresholds are the first reported for the LC-TEM technique and far below typical values used by researchers that use the technique in diverse fields. The paper is a seminal study to further enable ground breaking, nanoscale structural and functional biology studies using TEM.

Graphene nanoribbons possess a tunable bandgap and high, charge carrier mobility making them excellent candidates for construction of quantum optoelectronic devices. The second paper in the Research Topic, by Ge and Fisher from UCLA, focuses on calculation of the optical properties of this important material, and report the first values for bilayers of this nanooptoelectronic system (Ge and Fisher). The paper entitled, *First-principles calculations of the optical response of single-layer and bilayer armchair graphene nanoribbons*, gives design insight into lowering the bandgap and the effects of the second layer's angle on optical properties. The researchers used mean-field density functional (DFT) calculations to show that the band gap decreases (red shifts) as does the onset photon absorption energy as a function of nanoribbon width for 3n, 3n + 1, and 3n + 2 families with the latter showing the lowest decrease in band gap and onset of photon absorption energy. The results for the bilayers showed a marked difference for all three families having a lower band gap and onset photon absorption energy than single layers. The researchers also showed that the α configuration had a lower band gap and onset photon absorption energy than the β alignment in all three families. The results show that changes in width, number of layers, and edge alignment as well as simple configurational changes between the ribbon layers can affect the design parameters for optoelectronic devices. The work also clearly illustrates the importance of computational work to engineering device design.

In the final paper of the collection, *Lutein nanodisks protect human retinal pigment epithelial cells from UV light-induced damage*, researchers from the University of Nevada Reno develop a novel approach for a potential nanotherapeutic delivery of the carotenoid lutein utilizing lutein nanodisks (Moschetti et al.). The work utilized a formulation of reconstituted discoidal high density lipoprotein as a means to solubilize the hydrophobic lutein active pharmaceutical ingredient. The researchers demonstrated that these lutein nanodisks were effective mediators to deliver lutein to spontaneously arising retinal pigment epithelial 19 (ARPE-19) cells. This was shown through the examination of the protective effect on the ARPE-19 cells' viability under UV irradiation conditions. Additionally, the nanodisk delivered lutein was also confirmed through a 14% reduction in UV-induced reactive oxygen species (ROS) in lutein-nanodisk exposed ARPE-19 cells compared to those that had not been incubated with the lutein nanodisks. The lutein nanodisks have the potential to deliver lutein in humans which could potentially counteract the effects of low lutein levels and have a profound impact on age-related macular degeneration. Overall the three contributions exemplify the wide ranging applications of nanotechnology and the excellence of the researchers working in the field.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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