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PPV organization in membrane assemblies

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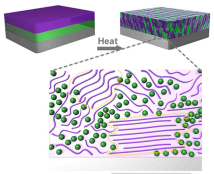
Background

Organic photovoltaics (OPVs)

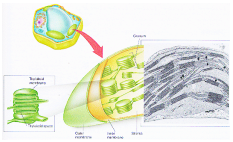
Organic photovoltaics have the potential to be flexible, lighter, and lower cost versions of their inorganic counterparts. However, with the present OPV technology, performance has been limited due to low material stability, which leads to poor power conversion. Current research with bulk heterojunction (BHJ) photovoltaics, such as fullerene-PPV films, has shown power conversion efficiencies approaching 10%, but performance suffers from poor structural stability at elevated temperature.



Treat, N. D.; Brady, M. A.; Smith, G.; Toney, M. F.; Kramer, E. J.; Hawker, C. J.; Chabinyc, M. L., Adv. Ener. Mater. 2011, 1, 82 - 89.

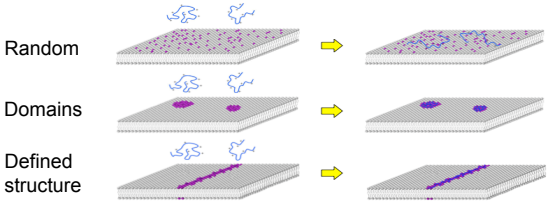
Energy capture systems in biology

Energy capture and conversion in biological systems take place within organized supramolecular assemblies (e.g., thylakoid membranes of chloroplasts). While the importance of such structures in light harvesting systems is not fully understood, highly organized lipid assemblies may provide a clue towards efficient pathways for energy capture and conversion.



Goal

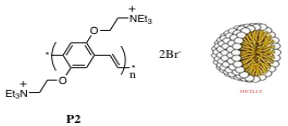
Our goal is to develop materials and methods that induce order and stabilize conducting polymer and fullerene assemblies using self-organizing systems. Using lipid bilayers we orient and organize the carrier materials using phase separation, interfacial interactions, and templated architectures.

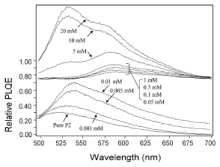


Results

Water-soluble photoconductive polymer

A cationic polyphenylene vinylene (P2) was developed (H.-L. Wang), which displays enhanced fluorescence upon interfacial interaction with micelles as a result of induced structural order.

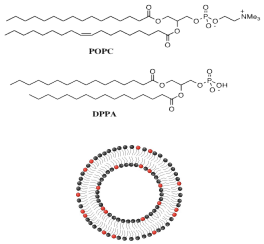


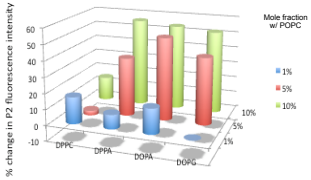


Treger, J. S.; Ma, V. Y.; Gao, Y.; Wang, C.-C.; Wang, H.-L.; Johal, M. S. J. Phys. Chem. B 2008, 112, 760 - 763.

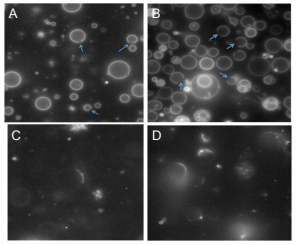
Phase separation and charge interaction with lipid vesicles

Similar to the studies with micelles, P2 adsorption onto negatively charged bilayers showed enhancement in fluorescence (>50%). By using lipid phase separation of DPPA/POPC bilayers we demonstrated selective adsorption and spatial confinement of P2 that does not compromise fluorescence behavior, as compared to homogeneously charged bilayers of DOPA/POPC or DOPG/POPC.





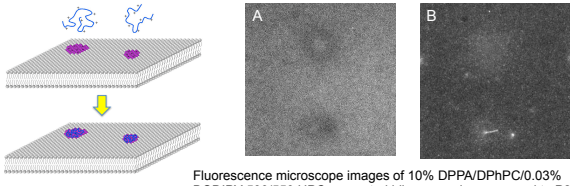
P2 fluorescence intensity increases upon adsorption to negatively charged lipids for both randomly dispersed (DOPA, DOPG) and phase separated (DPPA) containing membranes.



Giant vesicles of A) 5% DPPA/POPC and B) 10% DPPA/POPC labeled with BODIPY 530/550 HPC show phase separated domains (dark regions) rich in gel phase DPPA (TRITC filter). Bottom images, observed with GFP filter, show P2 selectively adsorbs to domains on membrane for C) 5% DPPA/POPC and D) 10% DPPA/POPC ([P2] = 10 μM).

P2 binding on supported lipid bilayers (SLB)

Studies with SLBs confirmed the selective adsorption of P2 onto negatively charged lipid domains. Visible domains ranged in size from microns to tens of microns with round to oval shapes.

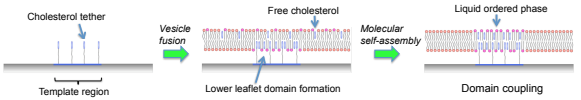


Fluorescence microscope images of 10% DPPA/DPhPC/0.03% BODIPY 530/550 HPC supported bilayer on glass exposed to P2 (3.0 μM) under A) TRITC filter (lipid membrane) and B) GFP filter (P2 fluorescence). Image size 20 μm.

Future plans

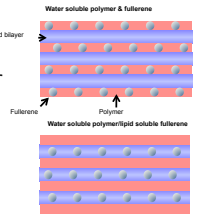
Directed formation of lipid domains

In collaboration with the Center for Integrated Nanotechnologies (CINT) we are developing patterned surfaces to direct the formation of lipid domains in supported bilayers. Our idea is to use the tethered regions to induce selective partitioning of lipids, thus creating defined domain architectures.



Structural order in multilayered films

Complex hierarchical architectures can be further pursued by coupling the templated domain architecture with the self-organizing multilayer assembly of lipid bilayers.



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