Supramolecular Pillars in Stimuli Responsive Vesicles

Brenda Andrade Literature Seminar October 30, 2014

Controlled release technologies have received considerable attention throughout the years for their applicability in fields of such as adhesives, drug delivery, visual indicators and pesticide/herbicide distribution. Vesicles are one type of transport vehicle that is intrinsically stimuli responsive because of its spontaneous non-covalent assembly. To achieve stimuli responsive vesicles, preparing amphiphilic chemical agents that are driven to self-assembly and have properties such as cleavable bonds, redox active groups, or undergo architectural reorganization thought conformational changes that induces a disruption in vesicle formation. Examples of these types of chemical agents are supramolecular amphiphiles. Supramolecular amphiphiles are agents that form host-guest complexes through non-covalent interactions that lead to an assembly that possess a hydrophobic and a hydrophilic domain. These systems are intrinsically stimuli responsive due to their non-covalent interactions bonding and therefore are gaining traction for this application.[1]

A new class of supramolecular macrocycles that are being applied to the construction of various assemblies such as, supramolecular polymers, molecular machines and artificial transmembrane channels are pillar[n]arenes (P[*n*]As).[2] Introduced in 2008 by Ogoshi and co-works, P[*n*]As are cyclic oligomers of para-linked hydroquinones. Their synthesized in a one step Friedel-Crafts type reaction of para-substituted hydroquinone with paraformaldehyde in the presence of a Lewis base resulting in a columnar structure with a ridged hollow electron-rich interior (Figure 1).[3]

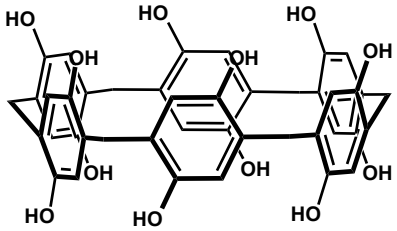

Figure 1. Three-dimensional representation of the chemical structure of Pillar[6]arene.

These hollow pillar-like structures yield macrocycles of 5 to 15 hydroquinone units in length. P[*n*]As and have been shown to complex with a variety of cationic organic salts such as trimethyl ammoniums, pyridiniums and paraquat.[4] Their ability to form strong host-guest complexes has prompted the use of P[*n*]As in the development of stimuli responsive vesicles. In 2012, Huang and co-workers were the first to report the synthesis of a pillararene system that would form vesicles when an ammonium azobenzene derivative formed the proper host-guest interactions. This system was demonstrated to undergo hierarchical reorganization when a photo stimulus was applied and prompted the development of a variety of stimuli responsive pillararene vesicle systems (Figure 2). [5]

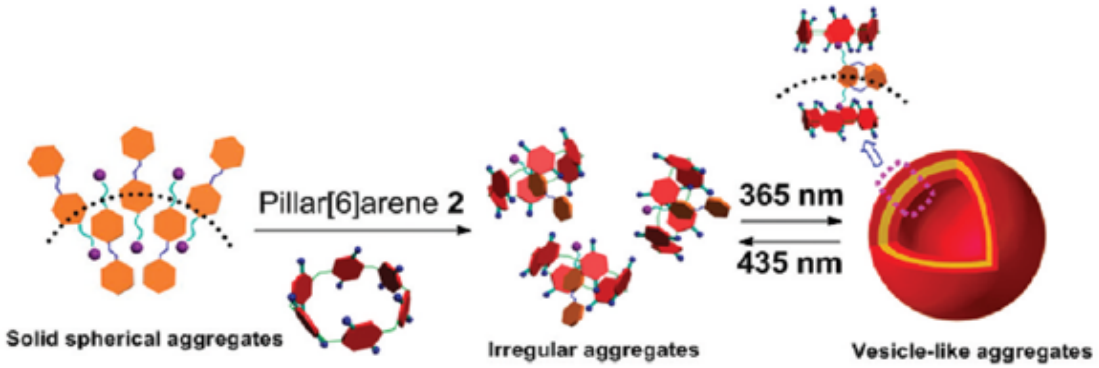

Figure 2. Schematic representation of P[*n*]A photo-responsive vesicles.

Although Huang's work demonstrated that P[*n*]A systems could be used to form vesicles in a supramolecular fashion, one limitation to the system was the lack of water solubility. This led to the use of water-soluble ionically functionalized P[*n*]As a stradegy that was used by other groups to build amphiphilic P[*n*]A systems.[6]

Since Huang's work, P[*n*]A systems that are responsive to other stimuli such as pH, enzymatic cleavage, and redox conditions have been employed. [7-10]The combination of water soluble P[*n*]As combined with the use of biocompatible stimuli allows these vesicles to be used in drug delivery application. Using a redox responsive system, P[*n*]A vesicles were shown to encapsulate doxorubicin, penetrate in to cells and affect viability.

P[*n*]A host-guest systems have been show to form vesicle-like structures with a stimuli responsive behavior. Their facile modification has allowed researchers to apply them to a variety of environments with a diversity of stimulus. Moving forward, the challenge for P[*n*]A supramolecular vesicles is to stand out above existing supramolecular systems one potential route for this would be the application of these systems to a set of unique chemical problems yet to be addressed by supramolecular vesicles.

References

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