Article 9 - Supramolecular template-directed synthesis of triazole oligomers

Fasano, F.; Bolgar, P.; Iadevaia, G.; Hunter, C. A. Supramolecular Template-Directed Synthesis of Triazole Oligomers. Chemical Science 2022, 13 (44), 13085–13093. https://doi.org/10.1039/d2sc04155c.

Figure 1:

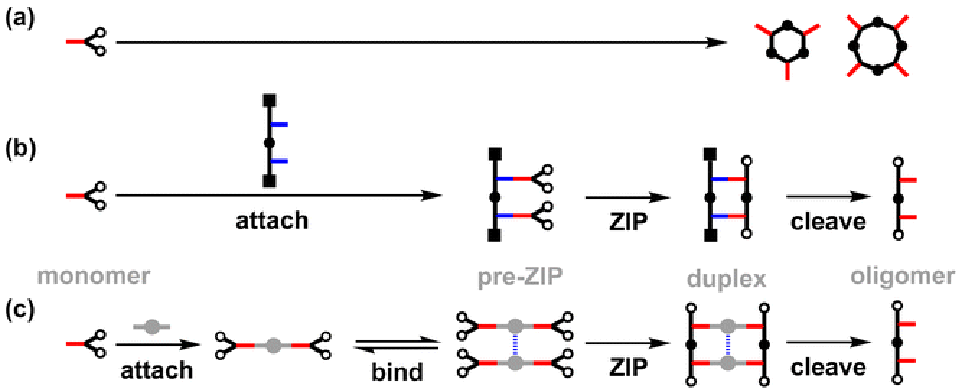

Figure 1 shows three ways to make oligomers:

(a) In untethered oligomerization, monomers (red) form a mix of cyclic structures on their own.
(b) In covalent template-directed synthesis, monomers are attached to a template (blue), react to form oligomers, and are then released.
(c) In supramolecular template-directed synthesis, monomers are attached to a linker (grey), bind through non-covalent interactions, react to form oligomers, and are then released from the template.

The figure compares these methods for making oligomers with different guiding techniques.

Synopsis:

In the 2022 study "Supramolecular Template-Directed Synthesis of Triazole Oligomers," researchers Francesco Fasano, Peter Bolgar, Giulia Iadevaia, and Christopher A. Hunter explored an innovative method for constructing specific sequences of triazole oligomers—chains of molecules linked by triazole units—using a supramolecular template.

Traditional chemical synthesis often faces challenges in controlling the precise arrangement of monomer units, especially when aiming to create complex structures with high specificity. To address this, the researchers employed a supramolecular template composed of two zinc porphyrins and a diamine ligand known as DABCO. This assembly acts as a scaffold, guiding the monomer units into the desired sequence during the synthesis process.

The monomers used in this study were designed with two reactive groups: an alkyne and an azide. These groups facilitate a copper-catalyzed azide-alkyne cycloaddition (CuAAC) reaction, commonly referred to as a "click" reaction, which efficiently forms triazole linkages between monomers. By attaching these monomers to the supramolecular template via ester bonds, the researchers ensured that the monomers were positioned correctly to undergo the click reaction in a controlled manner.

Upon introducing DABCO, the zinc porphyrins self-assembled into a sandwich-like complex, bringing the attached monomers into proximity. This arrangement facilitated the intramolecular CuAAC reaction, leading to the formation of a duplex structure containing two identical triazole oligomer chains connecting the porphyrin linkers. To prevent unwanted reactions between different molecules, a chain-capping agent was used, ensuring that the reactive ends of the oligomers did not lead to intermolecular coupling.

A significant finding of this study was the effective molarity for the intramolecular CuAAC reactions on the template, measured to be between 3–9 mM. This value indicates the efficiency of the templated reaction compared to an untemplated scenario. Additionally, because the triazole backbone has a directional nature, the resulting duplex was obtained as a mixture of parallel and antiparallel isomers in a 4:1 ratio.

After the oligomerization process, the ester bonds connecting the oligomers to the template were hydrolyzed, releasing the synthesized triazole oligomers. This step effectively regenerated the original template, allowing for its potential reuse in subsequent synthesis cycles. The final product, a phenol 2-mer, was obtained in excellent yield, demonstrating the efficiency and precision of the supramolecular template-directed approach.

A key figure in the article illustrates the entire process:

1. Template Assembly: Depicts the formation of the sandwich complex with zinc porphyrins and DABCO, along with the attachment of monomers via ester bonds.

2. Oligomerization: Shows the intramolecular CuAAC reaction leading to the formation of the triazole-linked duplex structure.

3. Product Release: Illustrates the hydrolysis of ester bonds, releasing the triazole oligomers and regenerating the template.

This visual representation encapsulates the elegance and efficiency of the supramolecular template-directed synthesis method.

The study's findings highlight the potential of supramolecular templates in directing the synthesis of complex molecular structures with high precision. By utilizing non-covalent interactions and self-assembly principles, this approach offers a versatile and reusable strategy for constructing specific oligomer sequences, which could have significant implications in materials science, molecular engineering, and the development of novel polymers.