

Halogen bonding assembly of an iodide-binding triple helix

Wind turbines, spiral staircases, and springs—these are a few examples of helices in everyday life. The helix is also a reoccurring concept in mythology, spanning many cultures. In biology, helices are both essential and pervasive. Collagen, the most common mammalian protein, is a triple helix of three single helical polypeptides. DNA is a double helix of two polynucleotides. Everywhere we turn, the helical motif serves to confer form and function to simple building blocks.

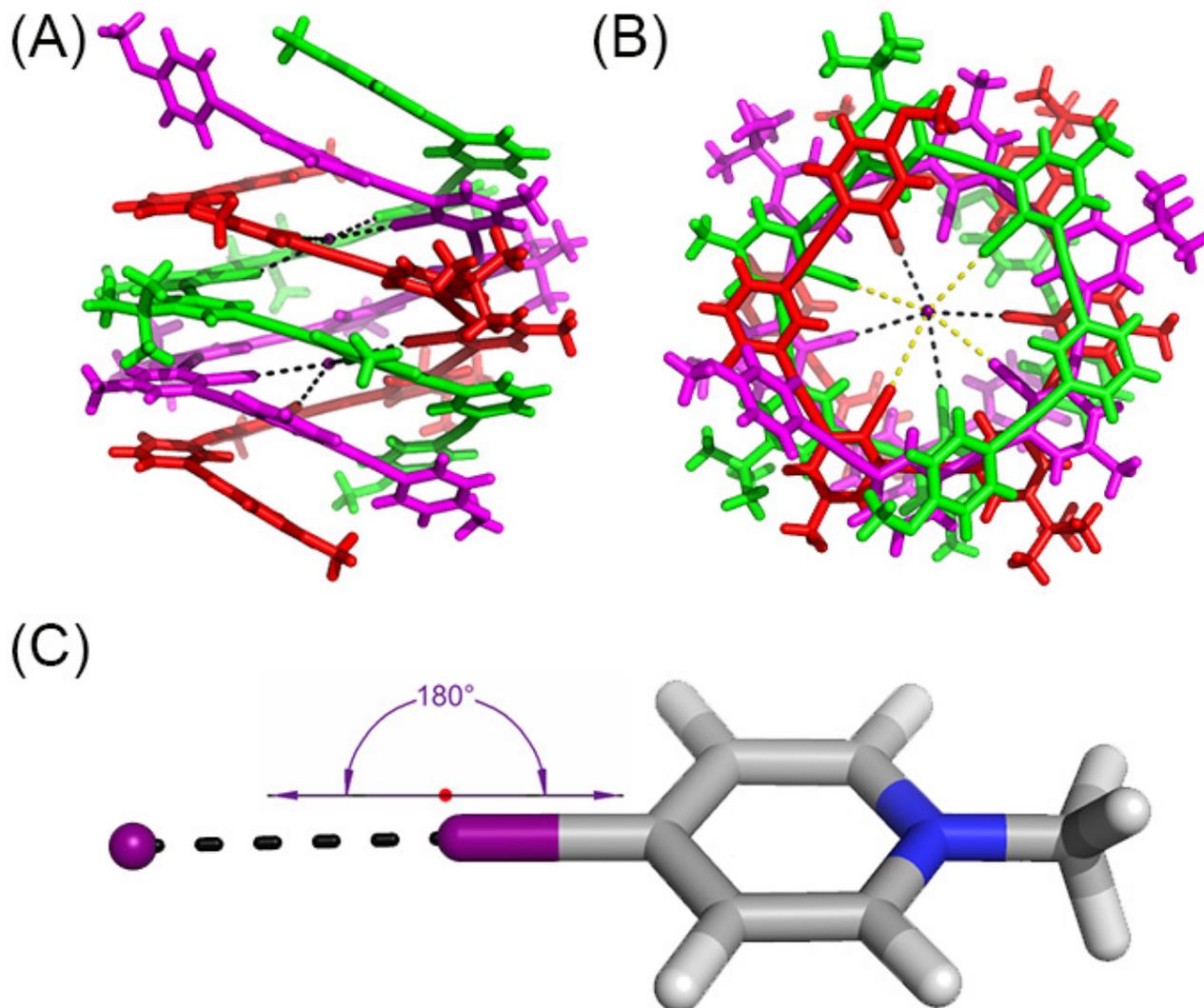


Fig. 1. Tricolored representations of the triple helicate encapsulating iodide and schematic of halogen bonding (from X-ray crystal structure, black dashes denote halogen bonds). (A) Side view of three molecular strands wrapping around a common helical axis. (B) View down the helical channel of the triple helix (yellow dashes denote the upper bound iodide, black dashes denote the lower bound iodide). (C) Example of a single halogen bonding site, illustrating the near-linear binding preference.

In a recent cover story featured in the scientific journal *Angewandte Chemie International Edition* (2016, 55, 12398–12402), we present one of the few examples of a triple helix (three separate strands) wrapped around two iodide anions (Fig. 1A–B). In general, molecules tend towards disordered states. As a result, biology constantly battles this tendency towards chaos to develop well-ordered molecular assemblies like helices, which provide structure (like collagen), organize and store information (like DNA), or perform work. Inspired by Nature, supramolecular chemists have developed increasingly sophisticated and functional molecular assemblies over the past 50 years. Thus far, strong covalent and dative bonding, electrostatic interactions, ion-pairing, and hydrogen bonding have been extensively utilized to establish and maintain molecular architectures.

To encourage the cooperative helical assembly of three distinct molecular strands and two iodide anions, we employed a new approach that used halogen bonds. Like hydrogen bonding, halogen bonding is a reversible, attractive interaction between two molecular/atomic entities. This attraction can be quite strong, but unlike hydrogen bonding, halogen bonding is more stringently linear (Fig. 1C). When hydrogen bonding helices encapsulate spherical anions (like chloride, bromide, or iodide), the number of participating strands can vary due to the angular flexibility of the hydrogen bond. In contrast, we have found that our triple helix consistently self-assembles around iodide in various organic and aqueous-organic solvents, high temperatures, and the solid state. Furthermore, we attribute this consistency to the linearity of halogen bonding, which limits the number of possible helical arrangements.

Our halogen bonding triple helix was fully characterized in the solid state via single-crystal X-ray diffraction. X-ray crystallographic techniques conveniently determine the connectivity of atoms in 3D space. To characterize our structure in solution, we used variable temperature ^1H NMR, 2D NOESY, and 2D DOSY spectroscopic techniques. These methods, which rely on the resonance frequencies of various nuclei when placed in a strong magnetic field and irradiated with electromagnetic radiation, allow for structural determinations of complicated molecular assemblies in solution.

Each molecular strand possesses alternating electron-rich and electron-poor aromatic rings and three halogen bonding sites. ^1H NMR spectroscopy confirmed that without iodide, these strands randomly move in solution. When iodide is introduced, the halogen bonding sites point inward to cooperatively encapsulate iodide (Fig. 1B). The inner cavity of the helix resembles a channel through which iodide can ostensibly travel. Our findings have implications in molecular self-assembly, as prior to publication halogen bonding had not been utilized to drive the assembly of higher-order helices. The functionality of the inner channel of our helix, which is lined with halogen bonding sites, is currently the subject of study in our lab. We are interested in developing our helix into a synthetic anion channel, which will serve as a biophysical research tool.

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Publication

[A Halogen-Bond-Induced Triple Helicate Encapsulates Iodide.](#)

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