Freeform Molecular Helices as Tiny Molecular Springs

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Abstract. In nature, shape defines the attributes of flexible polymers (e.g. proteins, DNA, RNA, etc.), many of which fold into helical geometries. These species are often only stable under narrow conditions; too much heat or an acidic/basic environment often promotes the denaturing of said helical structures, which poses a challenge for extensive applications. To move past these strict limitations we are inventing methods to create large polymeric structures with well-defined shapes that we can regulate. Long freeform organic helices have not yet been created and pose an exciting route to synthesizing shape-persistent polymers. Such helices are expected to hold their shape while extending/compressing readily along one direction, which makes them viable candidates for molecular springs. They have the potential to act as strong, flexible and shock absorbent material as well as the ability to extend and contract upon change in voltage, allowing them to act akin to little motors or impact sensors. By meeting the challenge of chemical synthesis of such freeform helices with a building block approach, much like a LEGO set, we can efficiently control the resulting shapes. Molecular building blocks are synthesized such that there will only be one possible orientation for the pieces to couple together. Furthermore, these monomers can be functionalized to tune solubility and self-assembly properties of the formed helices. Our reactions to generate freeform helices are highly selective for the sole reason that the LEGO pieces cannot join together in any other fashion.