The polarity of the solvent is important for the supramolecular self-assembled morphology, leading to the remarkable properties and functional capabilities of biological systems. The controlled construction of nanostructures using supramolecular chemistry requires mechanistic studies and a deeper understanding of non-covalent interactions to meet the needs of emerging applications. In recent years, utilizing an advancing understanding of molecular design, building blocks have been employed to self-assemble into helical functional materials with controlled morphology at the nanoscale. Among these building blocks, amino acids and peptides are of special importance, owing to their inherent chiral centers, which allow the fabrication of supramolecular helical structures. It is well documented that proteins can be denatured when exposed to a small amount of solvent, as the formation of self-assembled aggregates take place, which may be a factor in some diseases such as Alzheimer’s and type II diabetes.

Symmetry breaking is one of the most fascinating phenomena in nature, as it leads to the specific handedness (either right or left) of biological structures. Nature is able to translate molecular chirality into supramolecular handedness, thereby creating functional helical structures of nanoscopic and macroscopic dimensions. This supramolecular helicity in nature has important implications in many underlying biochemical phenomena, including the mechanisms by which pathogens infect host cells and the progression of complex diseases.

There is unique insight that may be provided by a study of pH, temperature, ultrasonication, or the presence of enzymes, and other external stimuli may influence the symmetry of natural chiral objects and thermo-controlled switching of handedness in supramolecular materials. Such systems may provide direct visualization of new chiral supramolecular polymers and provide an illustration of chirality control, with right- and left-handed preference controlled by either pH or temperature. The control of the helicity in supramolecular ensembles has important mechanistic implications in supramolecular chemistry, and is intimately connected with the transmission of chirality, which is of high significance in life sciences.

Among various factors, both the pH and underlying thermodynamics of biological sub-compartments are known to facilitate a range of biochemical reactions. Although the role of these biochemical parameters on the helicity of macromolecules in higher order organisms remains complex, these factors have been noted to influence the helicity of the simplest life forms such as viruses. For instance, the mechanism of the infectivity of tobacco mosaic virus relies on the loss of the helicity of its protein capsid and release of the infecting RNA molecule after entering the host cell, owing to a change in the pH. Therefore, considering that pH and temperature may act as versatile stimuli for the control of chirality and helicity of both natural and synthetic processes, this current work describes a biomimetic system whose helicity may be reversibly controlled by either pH or temperature, providing an illustration of chirality control with right- and left-handed preference controlled by either pH or temperature.
controller on demand. Notably, the interconversion of chirality between left-handed (M-type) and right-handed (P-type) supramolecular helices through control of the pH and temperature remains a significant challenge.

In this regard, we report that the helicity of supramolecular assemblies associated with a specific chirality can be switched to the opposite handedness through chiral-center control as a function of pH as well as thermodynamic stimulation with a small π-conjugated naphthalenediimide (NDI) molecule. This is observed via a change in the circular dichroism, as shown in Figure 1. We have synthesized an NDI-appended L-glutamic acid (NDI-L-Glu) bola-amphiphile that possesses two important features, leading to the formation of helical structures: (i) the aromatic core of the NDI optimizes the dispersive interactions (π–π stacking interactions) between the cores within a construct and (ii) the L-Glu pendants support the formation of a helical structure through strong hydrogen bonding. This arrangement prevents crystallization, and favors the directional helical growth of microstructures in three dimensions. Akin to natural systems, this fascinating helical assembly formation is reversible, displaying a pH and thermo-dependent switching of the optical activity between left- and right-handed helices without losing activity. This system provides direct visualization of new chiral supramolecular polymers and provides an illustration of chirality control, with right- or left-handed preference controlled by either pH or temperature.

![Image](https://example.com/image1.png)

**Figure 1.** a) SEM images of the helical supramolecular microstructures of NDI-L-Glu at pH 3.0 (left-handed twisted ribbons), 7.0 (a mixture of left- and right-handed ribbons), and 9.0 (right-handed ribbons). b) Schematic representation showing the stacking of dimers: acidic pH, resulting in left-handed helix; physiological pH, which is initiated by both left- and right-handed oligomers due to the equilibrium between; alkaline pH, which resulted in right-handed helical superstructures. c) Circular dichroism spectra of NDI-L-Glu at and acidic (pH 3.0), neutral (pH 7.0) and alkaline (pH 9.0) conditions. Part of the figure was adapted from Ref. [8].

**What are the critical issues and what are the future perspectives that need to be addressed for the field to progress?**

From a future perspective, the exploration of potential pathways for the new nanostructured materials with tailored one-, two-, and three-dimensional morphology still requires extensive investigation, and possible applications are still in their infancy. Various parameters drive supramolecular self-assembly of small organic molecules, including the nature of the solvent, temperature, and molecular design to control electronic and functional properties. These stimuli cause changes in the chemical structure, leading to changes in supramolecular structures. Thus, molecular morphological transformations of self-assembled superstructures can be tuned and modulated effectively to produce advanced organic functional supramolecular structures on the nano to micro level. The self-assembly of chiral supramolecular structures into a specific shape and handedness is extremely challenging. Nevertheless, the rational design of chemical entities that self-assemble into stable and dynamically ordered chiral/helical superstructures is essential if supramolecular materials are to be implemented in applications such as biomedicine, catalysis, optoelectronics, and materials chemistry.

In soft materials, such as amphiphilic lipids and liquid crystals, the competition between local chiral interactions and global constraints imposed by the geometry of the self-assembled structures presents specific challenges for the assembly of controlled materials and aggregation induced quenching effects are also important in the design of mechanochromic luminescent materials.

We demonstrate that the combination of achiral tetraphenylnaphthalenetetracarboxylic dianhydride (TPTCDI) with a chiral bola-amphiphile, bearing four even or odd-long alkyl chains via amide linkages in the molecular structure, allows the entire process of induction and control of supramolecular chirality into well-defined helical superstructures by solvophobic control. TEM and SEM images confirm that these twisted ribbons are indeed formed by right- and left-handed helices with an even or odd number of carbon in the alkyl chains, respectively. These findings thus represent an important milestone, and the reported supramolecular chiral system (controlled one handed helix) is particularly interesting, as it is based on an AIE-active component, offering potential applications in the design and fabrication of new materials for optoelectronic devices, and mechanochromic luminescent materials.

**What is, in your personal opinion, most critical to teach students in university chemistry courses?**

Fundamental to any subject is critical thinking and reading along with effective writing, which are necessary in the chemistry classroom as well as for success in life. To enter the chemical industry or to pursue a PhD degree in a chemistry field, teaching programs need to provide nationally competitive classroom and practical laboratory-based teaching with ex-
cellent dynamic research programs. In recent years, it has become very important to introduce chemistry to biology students because biological sciences have increasing importance in the chemical processes that inspire critical biological functions.

The develop modern nano- and biotechnological devices, it is very important to teach the next generation of importance in chemistry along with good research skills. As students often wonder how a chemistry course at the university level is different from the general chemistry they have learned in high school, one needs to guide university students, giving good examples and showing how the course materials in university offers greater depth than at school. Teachers should give more concepts in chemistry to solve an integrated, quantitative problem.

I personally believe that students will gain more knowledge with problem-based learning (PBL) than with PowerPoint presentations or any other mode of teaching. With PBL, students can be greatly involved and are required to attend classes regularly. Thus, the problem-solving concept is required to begin to develop the critical, creative, and complex intelligence skills of chemistry students. These skills are required in both the classroom and lab components of the courses. Another thing that can easily be adopted to attract more students to attend teaching and laboratory classes is fieldwork, where students and teachers can take tutorials and have open discussion with students. Thus, I feel that teaching classes, laboratory work, and fieldwork are the three main elements that can produce the best students.

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