Polymer Chemistry

ROYAL SOCIETY OF CHEMISTRY

REVIEW

View Article Online
View Journal

Cite this: DOI: 10.1039/d6py00173d

Foldamers: design principles, building blocks and applications

Anna H. P. Cronjé, Rueben Pfukwa and Bert Klumperman *

This review article explores foldamers, a class of synthetic oligomers designed to mimic the structural and functional diversity of natural proteins. We begin by defining foldamers and outlining their significance, tracing the historical development of the field and highlighting key milestones that shaped its progress. The article examines the fundamental design principles of foldamers. Particular attention is given to backbone building blocks, the intra- and intermolecular interactions that stabilise folded structures, and the influence of side-chain functionality and stereochemistry. The growing contribution of computational methods in predicting foldamer conformations and dynamics is also addressed. A central part of this review is devoted to structural diversity, guiding the reader through foldamer architectures ranging from phenylene–ethynylene and aryltriazole systems to oligoamides, oligoureas, indolocarbazoles, and other notable scaffolds. This structural journey sets the stage for a survey of applications, which include foldamer-based anion receptors and transporters, cation sensors, biomolecular recognition capsules, and systems for protein complex and surface recognition. We also highlight developments in foldamer-based stimuli-responsive materials and other emerging applications.

Received 21st February 2026,
Accepted 11th June 2026

DOI: 10.1039/d6py00173d

rsc.li/polymers

1 Introduction

Foldamers represent a groundbreaking class of synthetic polymers engineered to adopt well-defined three-dimensional structures through precise control of their monomer sequence and chemical interactions. Unlike natural proteins, which are composed of amino acids and fold into intricate structures essential for biological functions, foldamers are constructed from abiotic building blocks and designed to mimic protein-like folding behaviour.[1] These artificial macromolecules offer unprecedented opportunities for creating molecular architectures with tailored properties and functions, bridging the gap between traditional small molecules and biological macro-

Stellenbosch University, Department of Chemistry and Polymer Science, Private Bag X1, 7599 Stellenbosch, South Africa. E-mail: bklump@sun.ac.za

Anna H. P. Cronjé

A. H. P. Cronje started her academic journey in 2013 studying BSc (Chemistry and Polymer Science) at Stellenbosch University. She received her BScHons (Polymer Science, Cum Laude) in 2017 from SU. She continued with her MSc (Polymer Science), studying the uptake of SMA based nanoparticle in mammalian cells under the supervision of Prof Klumperman. She then received her Ph.D. (Polymer Science) from SU in 2025 under the supervision of Prof Klumperman and Dr Pfukwa. Her PhD project investigated the effect of solvent polarity on the conformational behaviour of poly(aryl-triazole) foldamers in solution. She is currently transitioning into industry where she hopes to continue her love for research.

Rueben Pfukwa

Rueben Pfukwa is an associate professor in the Department of Chemistry and Polymer Science at Stellenbosch University, South Africa. He earned his PhD in Polymer Science from Stellenbosch University in 2012. His research interests are in the design and synthesis of advanced functional polymer materials for biomedical applications.

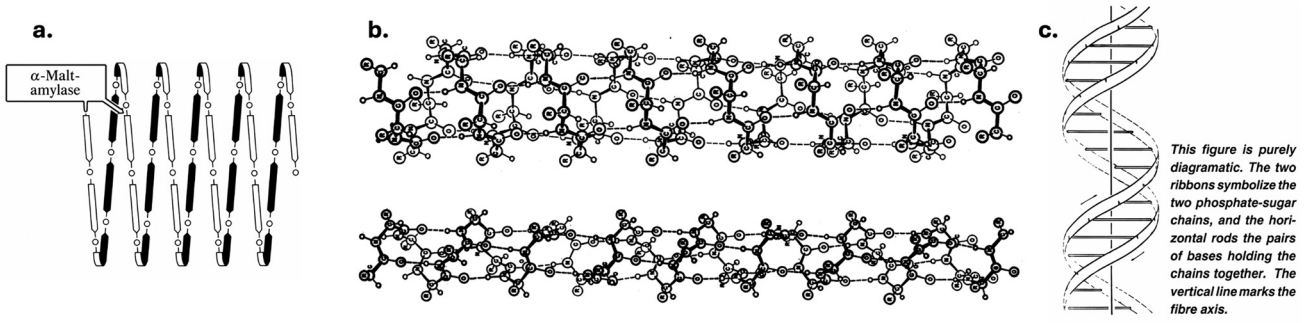


Fig. 1 a. Hypothetical spiral model of an a-linked chain of 30 glucose units, reproduced from ref. 2 with permission from Wiley, C. S. Hanes, The action of amylases in relation to the structure of starch and its metabolism in the plant, copyright 1937. b. 3 : 7 helix and 5 : 1 helix of polypeptides, reproduced from ref. 3 with permission from the National Academy of Sciences, H. R. Branson, R. B. Corey and L. Pauling, The structure of proteins; two hydrogen-bonded helical configurations of the polypeptide chain, copyright 1951. c. Double helix structure of DNA, reproduced from ref. 4 with permission from Springer Nature: J. D. Watson, C. Crick and F. H., Molecular structure of nucleic acids a structure for deoxyribose nucleic acid, *Nature*, copyright 1953.

molecules. The significance of synthetic foldamers lies in their potential to revolutionize diverse fields such as drug discovery, materials science, nanotechnology, and biotechnology.

The concept of foldamers dates back to the early to mid-20th century. The first hypothetical "spiral" model of α-Malt amylase was proposed by Charles Hanes in 1937 (Fig. 1a).[2] In 1951, Branson and his colleagues proposed the two hydrogen bonded helical configurations of polypeptides (Fig. 1b).[3] Shortly thereafter, Watson and Crick proposed the double helical structure of deoxyribose nucleic acid (DNA) (Fig. 1c).[4] These findings led to a major breakthrough in molecular biology and resulted in a spike in research of amino acid polymers through the 60s to 80s.[5–8] Polymer chemists also found these structures in synthetic polymers. In the 1950s, Natta and co-workers first recognised that branched polyolefins can form helical conformations in their crystalline regions.[9] In 1960, Pino and Lorenzi found experimental evidence of these structures in solution and later, others also reported this.[10–15] The helical conformations of other synthetic polymers, such as polyisocyanides,[16] polychloral,[17] chiral polysilanes,[18] soon followed.

In 1992, Percec and co-workers reported on a synthetic polymer able to self-assemble into disc-like and column-like supramolecular structures similar to that of the tobacco mosaic virus (Fig. 2a).[19] In 1996, Gellman and co-workers reported on a β-peptide oligomer which folded into a helical structure different to that of the α-helix, which expanded the repertoire of foldamer building blocks beyond natural amino acids (Fig. 2b). Gellman's group was also the first to use the term "foldamer" to describe polymers that have the propensity to fold into predictable secondary structures.[20] At the same time, polymer chemists synthesized polymers that could solvophobically be driven to form helical structures such as oligoarylenes by Hanan and co-workers in 1995,[21] and oligo(aryleneethynylene)s by Nelson and co-workers in 1997.[22]

In 2001, Hill and co-workers redefined foldamers to refer to oligomers that fold into conformationally ordered states in solution, of which the structure is stabilised by noncovalent interactions between nonadjacent monomer units.[1] Since then, two research streams have focused on peptidomimetic/nucleotidomimetic foldamers[20,23,24] and abiotic foldamers. Peptoids have been studied as peptide mimics since the introduction of their efficient synthesis through submonomer solid-phase synthesis by Zuckerman and colleagues.[25] Peptoids are oligomers of *N*-substituted glycines which have the ability to fold into several secondary structures and have applications in metal binding, catalysis[26] and medicine.[27] There are dedicated reviews on peptoids and their potential as pharmaceuticals,[28] tools and sensors and recent advances on peptoids as antimicrobials.[29] This review, however will focus on abiotic foldamers.

The motivation for studying foldamers stems from the inherent limitations of natural proteins and small molecules in addressing complex biomedical and material science challenges. Although proteins offer remarkable specificity and functionality, their synthesis and modification are often

Bert Klumperman

Bert Klumperman studied Chemical Engineering and Chemistry at the University of Twente (Enschede, NL) and holds two doctorates (PhD from Eindhoven, NL; DSc from Stellenbosch, SA). He has worked for 9 years in industry and now for 30 years in academia. He is a Distinguished Professor in Polymer Chemistry and received many awards, including the National Science and Technology Forum (NSTF) Lifetime Award and the John FW Herschel medal of the Royal Society of South Africa. He is co-founder and CTO of Nanosene (Pty) Ltd, a spin-out company from Stellenbosch University, based on research in his academic research group.

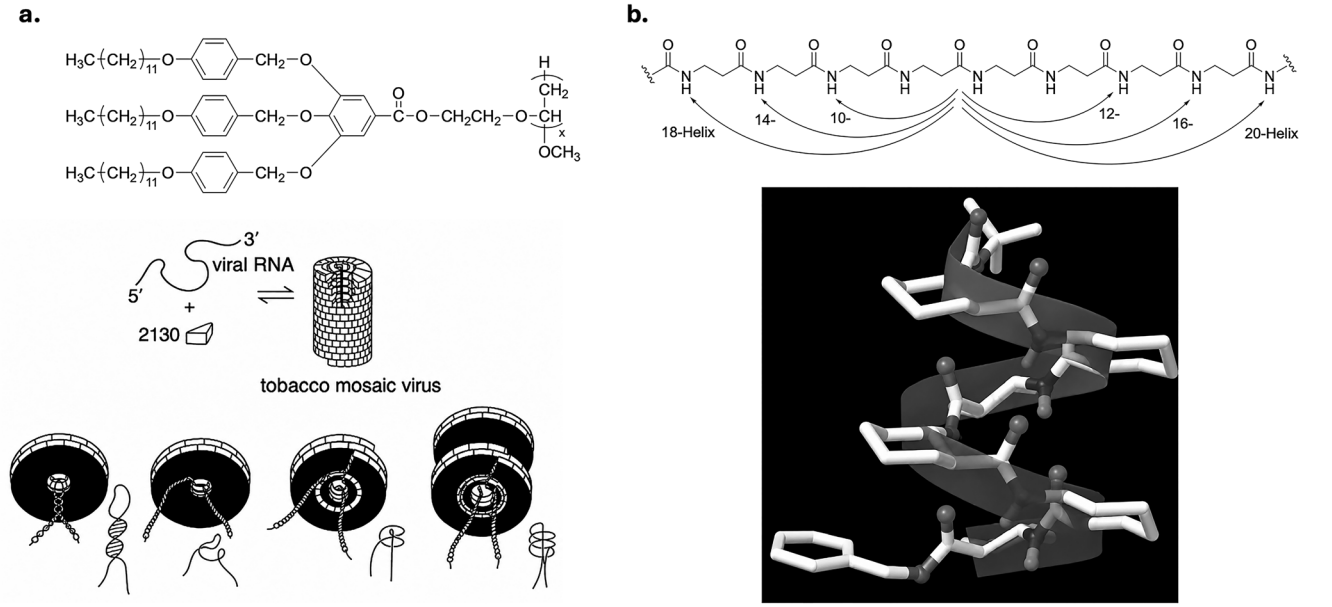


Fig. 2 a. Poly(2-vinyloxyethyl 3,4,5-tris[4-(*n*-dodecanyloxy)benzyloxy]benzoate) and the disc-like and column-like structures of the tobacco mosaic virus, reproduced from ref. 19 with permission from the Royal Society of Chemistry, V. Percec, J. Heck, M. Lee, G. Ungar and A. Alvarez-Castillo, Poly(2-vinyloxyethyl 3,4,5-tris[4-(*n*-dodecanyloxy)benzyloxy]benzoate): a self-assembled supramolecular polymer similar to tobacco mosaic virus, copyright 1992. b. β-Peptide oligomer that self-assembles into a helical structure, adapted from ref. 20 with permission from the American Chemical Society, D. H. Appella, L. A. Christianson, I. L. Karle, D. R. Powell and S. H. Gellman, β-Peptide foldamers: robust helix formation in a new family of amino acid oligomers, copyright 1996.

complex and labour-intensive. On the other hand, small molecules are relatively simple to design and synthesize but lack the structural complexity and diversity of proteins.

The significance of foldamers lies in their potential to bridge the gap between small molecules and biological macromolecules, thereby offering unique opportunities for designing molecular architectures with tailored properties and functions. Foldamers offer a middle ground combining the simplicity of small molecules with the structural complexity and functionality of proteins. By rationally designing foldamer sequences and tuning their folding properties, researchers can develop a variety of molecular architectures with precise control over shape, size, and surface properties. This opens up exciting possibilities for the design of foldamer-based therapeutics,[30] biomaterials,[31] molecular sensors,[32,33] molecular machines,[34] and materials with tailored properties and functions.

2 Design principles of foldamers

Abiotic foldamers represent a fascinating class of synthetic molecules designed to fold into well-defined secondary and tertiary structures that mimic the structural versatility and functional diversity of natural proteins. Unlike traditional polymers that adopt random coil conformations in solution, foldamers are engineered to exhibit predetermined folding patterns driven by specific intra- and intermolecular interactions. These interactions govern the folding process and stabilise the desired three-dimensional structures.

2.1 Backbone building blocks in foldamer design

The design of foldamers relies on carefully selected building blocks, which govern the folding process and stabilises the desired conformations. Building blocks refer to repeating units that constitute the foldamer backbone, and specific arrangements of these units lead to the desired folded structures.

Among the most commonly employed building blocks are aromatic rings,[35,36] and cyclic structures,[37] which restrict the degrees of freedom available to the foldamer backbone. By taking advantage of different arene substitution patterns, these building blocks can be linked together in multiple ways, which introduces a certain curvature angle to be built into the polymer backbone (Fig. 3a). An example of this can be seen by varying the way aromatic oligoamide units are linked together to form helixes with different cavity sizes. When *meta*-disubstituted building blocks are linked to each other the helix has a cavity size of 9 Å (Fig. 3b). However, alternating this block with a *para*-disubstituted building block increases the cavity size to 30 Å (Fig. 3c).[38] Backbone rigidity also plays a crucial role in determining the folding propensity and stability of foldamer structures and therefore aromatic rings and cyclics are perfect backbone building blocks.

2.2 Building blocks for intra- and intermolecular interactions

Other specific building blocks are used to link these aromatic units to introduce patterns of intramolecular interactions that dictate the folding pathway and stability of the foldamer structure. These interactions include hydrogen bonding, solvophobic interactions, π–π stacking, and metal coordination.[39–41] Some of

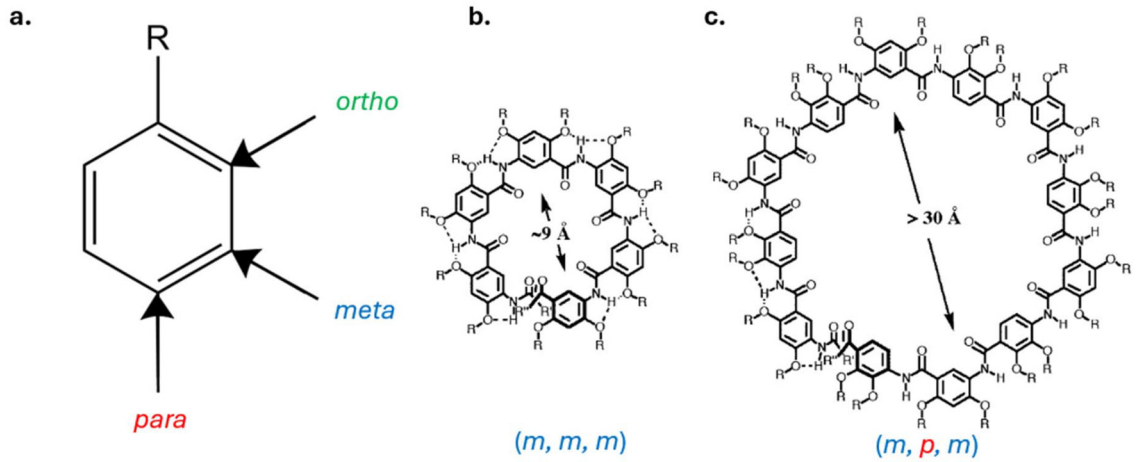


Fig. 3 a. Arene substitution patterns. b. Aromatic oligoamide helix from *meta*-disubstituted building blocks. c. Aromatic oligamide helix from alternating *meta* and *para* disubstituted building blocks, reproduced from ref. 38 with permission from Wiley, A. R. Sanford, K. Yamato, X. Yang, L. Yuan, Y. Han and B. Gong, Well-defined secondary structures: information-storing molecular duplexes and helical foldamers based on unnatural peptide backbones, copyright 2004.

the most commonly employed are amides,[42,43] triazoles,[44] ureas,[45,46] and hydrazines,[47] which will be discussed later.

An example of an intramolecular hydrogen-bond-driven foldamer is shown in Fig. 4a. Here, intramolecular hydrogen bonds stabilise the helical conformation of the oligoanthirilamide and creates a cavity of 0.85 nm.[48] Gong reported on interesting oligoamide polymers that consist of benzene rings linked with secondary amide groups. Depending on insertion of only *meta* or *meta*/*para* linked repeat units, and on the length of the foldamers, they could form crescents, helices or macrocyclesst-

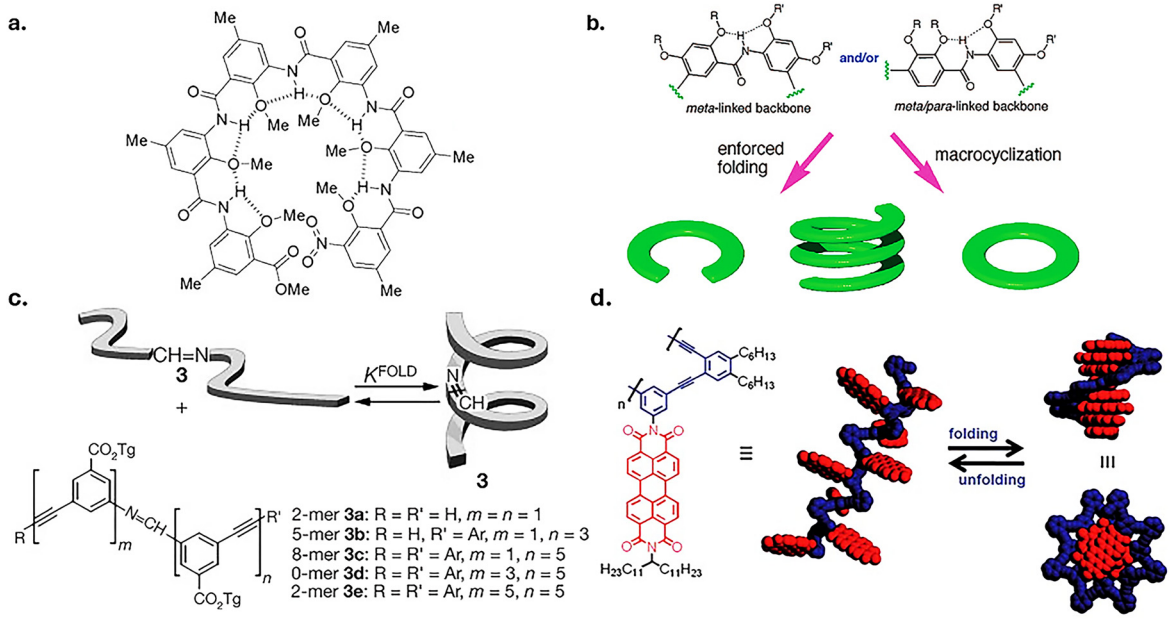


Fig. 4 a. Hydrogen-bond-driven helix formation in oligoanthirilamides, reproduced from ref. 48 with permission from Elsevier, H. P. Yi, C. Li, J. L. Hou, X. K. Jiang and Z. T. Li, Hydrogen-bonding-induced oligoanthranilamide foldamers. Synthesis, characterization, and complexation for aliphatic ammonium ions, copyright 2005. b. Cresents, helices, and macrocycles of oligomide foldamers, reproduced from ref. 49 with permission from the American Chemical Society, B. Gong, Hollow crescents, helices, and macrocycles from enforced folding and folding-assisted macrocyclization, copyright 2008. c. Oligo(*m*-phenylene ethylene) foldamers, reproduced from ref. 50 with permission from Springer Nature: O. Keunchan, K. Jeong and J. S. Moore, Folding-driven synthesis of pligomers, *Nature*, copyright 2001. d. PBI staircase helical structures, reproduced from ref. 51 with permission from the Royal Society of Chemistry, V. Dehm, M. Büchner, J. Seibt, V. Engel and F. Würthner, Foldamer with a spiral perylene bisimide staircase aggregate structure, copyright 2011.

abilised by intramolecular hydrogen bonding (Fig. 4b).[49] A typical example of solvophobically driven folding, where π–π stacking stabilises the helical structure is that of *meta*-connected phenylene ethynylene oligomers (*m*-PPE) (Fig. 4c).[50] Another interesting helical structure, where an oligophenylene ethynylene/perylene bisimide (PBI) forms a staircase aggregate helical structure due to π–π stacking has also been reported (Fig. 4d).[51]

2.3 Side-chain functionality and stereochemistry

Side-chain functionality also influences foldamer-folding behaviour by dictating intermolecular interactions and steric constraints. Functionalized pendant groups such as polar groups, hydrogen bond donors and acceptors, and aromatic residues can participate in specific interactions that stabilise the folded structure. Moreover, the spatial arrangement of side chains can dictate the overall shape and surface properties of the foldamer, thereby influencing its interactions with other molecules. The most commonly employed pendant groups are based on oligo(ethylene glycol) attached *via* ether, ester or amide linkages. Other common side groups are *tert*-butyl and isobutyl groups attached *via* ether linkages.

Stereochemistry, particularly in chiral foldamers, introduces additional complexity and diversity into foldamer design. By controlling the stereochemistry of the monomer units and their spatial arrangement within the foldamer backbone, researchers can create enantiomerically pure structures with unique folding properties and chiral recognition capabilities. This level of control over molecular chirality opens new avenues for designing bioactive compounds, catalysts, and materials with enhanced stereoselectivity and biological activity.

There are a few different ways that specific stereochemistry can be introduced into foldamers. The easiest way to explain these are by looking at helical foldamers. Helices are chiral structures, they have a twist sense, because they twist clockwise (*P*-helix) or anti-clockwise (*M*-helix) along a central axis. When achiral building blocks are used, there will be a racemic mixture of *P* and *M*-helices in solution (Fig. 5a).[52] To produce helices with a specific handedness, multiple routes are available. The building block itself can be chiral, which only allows the helix to twist in a certain direction (Fig. 5b).[52,53] Attaching chiral side chains to the foldamer backbone can also influence the chirality of the backbone, producing single-handed helices (Fig. 5c).[54–57] The foldamer can also be modified at one end with a chiral group, which by the sergeants and soldiers effect induces a certain chirality to the whole backbone (Fig. 5d).[58–61] Davis and co-workers recently reported that using different end groups provides a means to control the helical pitch of the foldamer helix.[62]

Ansari and Knipe recently wrote an interesting concept article exploring the use of atropisomeric bonds as design elements in foldamer formation. This opens up another dimension of control when designing foldamers and is an interesting, yet underexplored design tool which can advance the future of foldamers.[63]

2.4 Computational methods for predicting foldamer structures and dynamics

One of the key challenges in foldamer design is the prediction of folded structures and stability from the primary sequence of the monomer units. Computational methods offer valuable

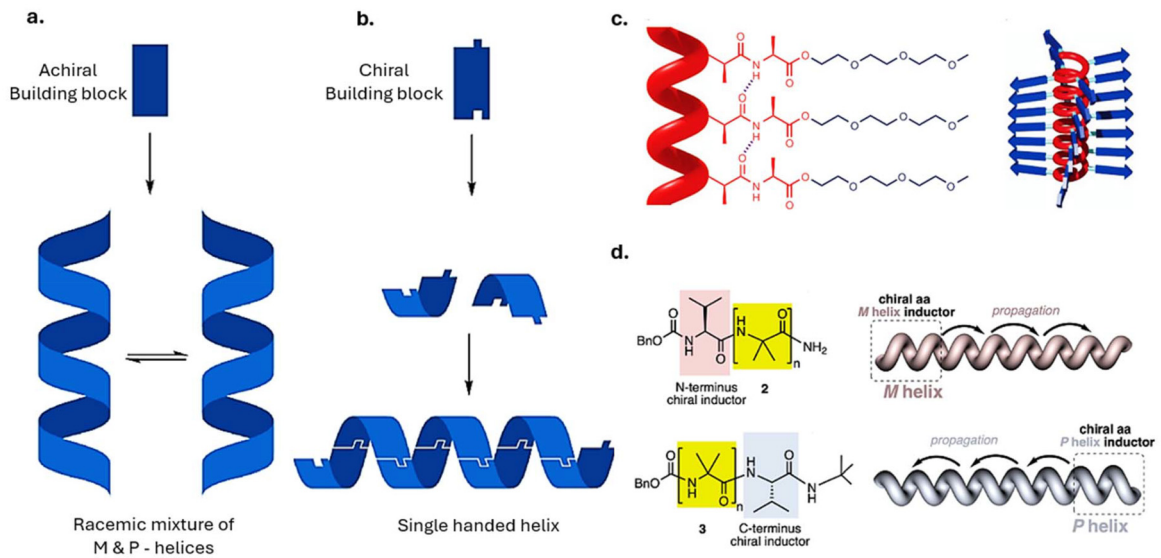


Fig. 5 a. Racemic mixture of *M* and *P*-helices from achiral building blocks. b. single-handed helix from chiral building blocks, reproduced from ref. 52 under the terms of the Creative Commons Attribution 3.0 International License. c.single-handed helix induced by attached chiral side chains, reproduced from ref. 56 with permission from Springer Nature: P. H. J. Kouwer, M. Koepf, V. A. A. Le Sage, M. Jaspers, A. M. Van Buul; Z. H. Eksteen-Akeroyd, T. Woltinge, E. Schwartz, H. J. Kitto, R. Hoogenboom, S. J. Picken, R. J. M. Nolte, E. Mendes and A. E. Rowan, Responsive biomimetic networks from polyisocyanopeptide hydrogels, *Nature*, copyright 2013. d. single-handed helix induced by chiral endgroups, reproduced from ref. 61 with permission from the Royal Society of Chemistry, M. Lago-Silva, M. Fernández-Míguez, R. Rodríguez, E. Quiñoá and F. Freire, Stimuli-responsive synthetic helical polymers, copyright 2023.

insights into the thermodynamics and kinetics of foldamer folding, allowing researchers to identify key interactions driving the folding process and optimize foldamer sequences for desired structural motifs and properties.

In the last three decades, computational methods have emerged as powerful tools for predicting the folding behaviour and structural dynamics of foldamers. As early as 1994, Gellman and co-workers performed model studies and screened a library of β-peptide foldamers to identify backbones that favoured helical conformations.[20,64] Simulations have been used to predict which functionalised *meta*-phenylene ethynylene polymers will adopt helical conformations in different solvents, based on structural and energetic considerations.[65,66] Molecular modelling techniques, such as molecular dynamics simulations,[67–70] Monte Carlo simulations,[71–74] and DFT quantum mechanical calculations,[75–77] enable researchers to explore the conformational space of foldamers and identify energetically favourable folding pathways.

Moreover, computational approaches facilitate the design of novel foldamer structures with tailored properties and functions by guiding rational design strategies and virtual screening of candidate sequences. By integrating experimental data with computational modelling, researchers can accelerate the discovery and optimization of foldamer-based materials, therapeutics and molecular devices,[78] thereby unlocking new opportunities for innovation in molecular engineering and nanotechnology.

3 Exploring the diversity of foldamer architectures and their building blocks

Foldamers, which are synthetic polymers capable of adopting defined three-dimensional conformations, exhibit remarkable structural diversity and versatility. By tuning their chemical composition and backbone architecture, foldamers can adopt a wide range of shapes and structures with unique properties and potential applications. Here, we delve into the different classes and shapes of foldamers, focusing on synthetic polymers, and provide examples of each.

3.1 A journey through shapes and structures

Pillar-like architectures are typically composed of aromatic rings linked by flexible chains that allow them to stack (Fig. 6a). Folding is typically driven by solvophobic effects stabilised by π–π stacking.[79–82] These types of stacked structures can be compared to important natural structures such as

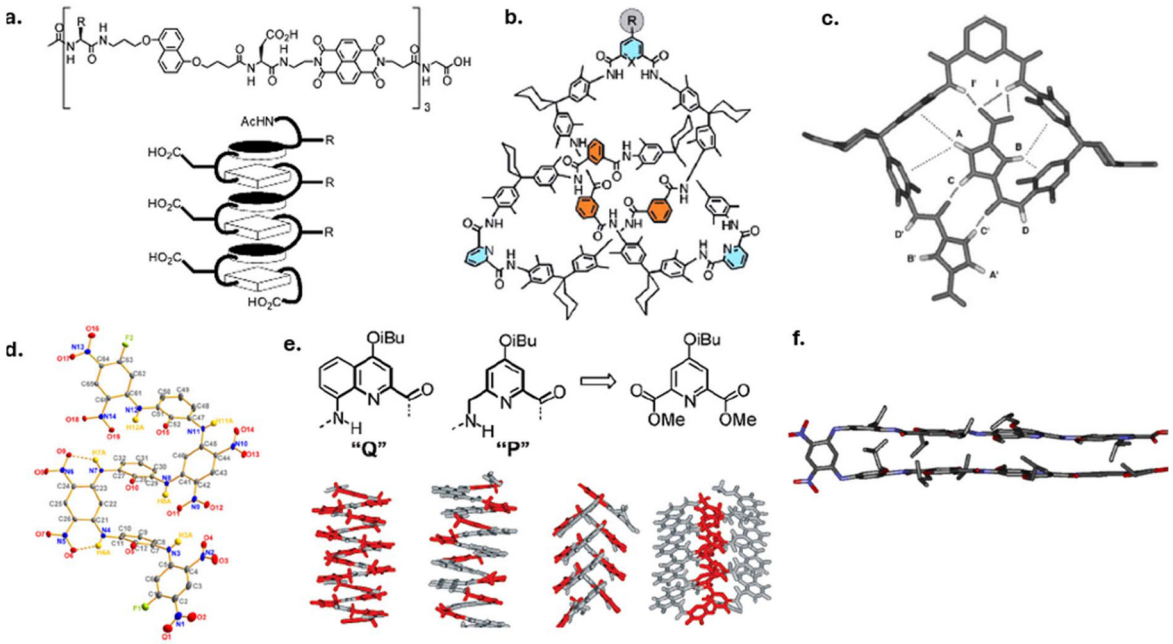


Fig. 6 a. Pillar-like architecture, adapted from ref. 82 with permission from the American Chemical Society, V. J. Bradford and B. L. Iverson, Amyloid-like behaviour in abiotic, amphiphilic foldamers, copyright 2008. b. Oligoamide knots, reproduced from ref. 84 with permission from Wiley, J. Brüggemann, S. Bitter, S. Müller, W. M. Müller, U. Müller, N. M. Maier, W. Lindner and F. Vögtle, Spontaneous knotting – from oligoamide threads to trefoil knots, copyright 2007. c. "Tail-biter"/pocket structure of an oligoamide, reproduced from ref. 86 with permission from the Royal Society of Chemistry, C. A. Hunter, A. Spitaleri and S. Tomas, Tailbiter: a new amide foldamer, copyright 2005. d. Zig-Zag structure of oligo *m*-aniline, reproduced from ref. 89 with permission from Elsevier, S. Li, D. X. Wang and M. X. Wang, Oligo-*m*-aniline foldamers, copyright 2012. e. Aromatic oligoamide folding into canonical and noncanonical herringbone helices with amide and quinoline units (grey) and 6-aminomethyl (red), adapted from ref. 90 with permission from the American Chemical Society, N. Delsuc, F. Godde, B. Kauffmann, J. M. Léger and I. Huc, The herringbone helix: a noncanonical folding in aromatic–aliphatic peptides, copyright 2007. f. Oligoamide-based β-sheet, adapted from ref. 93 with permission from the American Chemical Society, L. Sebaoun, B. Kauffmann, T. Delclos, V. Maurizot and I. Huc, Assessing stabilisation through π–π interactions in aromatic oligoamide β-sheet foldamers, copyright 2014.

G-quadruplexes which have interesting applications in DNA machines.[83] Oligoamide knots have also been reported where the extended threads are thought to knot in favourable solvents through pre-programmed favourable hydrogen-bond patterns (Fig. 6b).[84] The knot motif is of interest because in nature they are present in cyclotides which are macrocyclic peptides derived from plants which have applications in agriculture and as scaffolds in pharmaceutical designs.[85] Another interesting architecture was reported by Tomas and co-workers, of a so called "tail-biter". A synthetic oligoamide was programmed to fold in solution, driven by hydrogen bonding and aromatic interactions, leading to a pocket-like structures (Fig. 6c).[86] Multiple groups have also reported on zig/zag or snake-like architectures which are typically built from rigid aromatic units linked by amide or amine functionalities to enable hydrogen bonding directed folding, and to stabilise the folded structures (Fig. 6d).[87–89] Huc and co-workers reported a noncanonical herringbone helical architecture based on alternating 8-amino-2-quinoline carboxylic acid (Q) and dimethyl 2,6-pyridinedicarboxylate (P) monomer units. The methylene units of the "P" repeat units set the pyridine and amide units at a 90° angle, resulting in the formation of a herringbone helical structure (Fig. 6e).[90] More common architectures are, crescents, macrocycles, helices and β-sheets.[1,38,91,92]

Helical foldamers are characterized by the repetitive arrangement of monomer units along a helical axis, with specific backbone torsion angles driven by solvophobic interactions, intramolecular interactions such as hydrogen bonding and π–π stacking, to self-assemble into well-defined helical architectures. β-Sheets are foldamers with two oligomeric strands that are linked with a rigid turn which stack on top of each other and are typically stabilised by intramolecular π–π stacking (Fig. 6f).[93] Natural proteins have specific functions due to their folding patterns, and α-helix and β-sheet segments are common folding motifs present in proteins.[94] The β-sheet and its interactions in various biological processes have made it an important motif to study and understand, specifically in amyloid related diseases such as Alzheimer's,[95] and as protein recognition motifs.[96] Another emerging research field is development of higher order structures, however very few have been reported.[97–99] In the next section the plethora of foldamers based on the different building blocks they are made of is discussed.

3.2 Phenylene–ethynylene-based foldamers

3.2.1 *ortho*-Phenylene–ethynylene foldamers (*o*-PE). Jones and co-workers were the first to study the folding behaviour of *o*-PE tetramers. A library of *o*-PEs containing electron-rich and electron-poor phenylene rings were synthesized (Fig. 7a). The

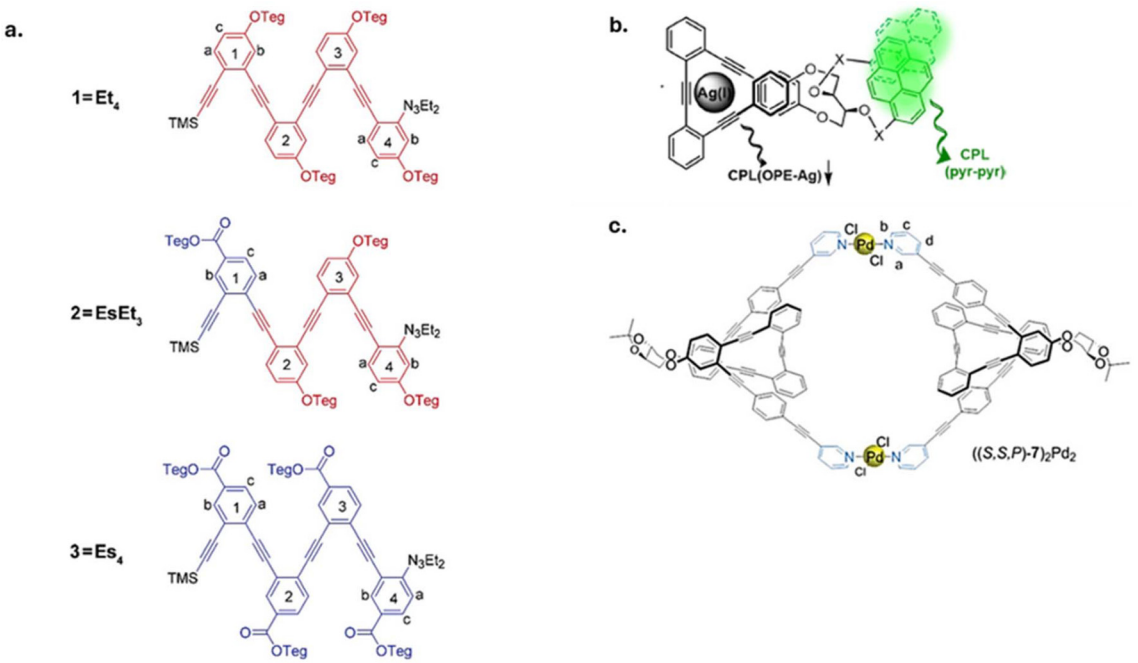


Fig. 7 a. *o*-PE tetramers with electron-rich (red) and electron-poor (blue) phenylene rings, adapted from ref. 100 with permission from the American Chemical Society, T. V. Jones, M. M. Slutsky, R. Laos, T. F. A., De Greef and G. N. Tew, Solution ^{1}H NMR confirmation of folding in short *O*-phenylene ethynylene oligomers, copyright 2005. b. *o*-PE, CPL-based ratiometric probe, adapted from ref. 102 with permission from the American Chemical Society, P. Reiné, J. Justicia, S. P. Morcillo, S. Abbate, B. Vaz, M. Ribagorda, Á. Orte, L. Álvarez De Cienfuegos, G. Longhi, A. G. Campaña, D. Miguel and J. M. Cuerva, Pyrene-containing *ortho*-oligo(phenylene)ethynylene foldamer as a ratiometric probe based on circularly polarized luminescence, copyright 2018. c. Stapled nucleus (*S*,*S*,*P*)-1, helical, systems (*S*,*S*,*P*)-2 (*S*,*S*,*P*)-6, ligand (*S*,*S*,*P*)-7 and metallosupramolecular complex ((*S*,*S*,*P*)-7)2Pd$_2$, reproduced from ref. 103 with permission from the Royal Society of Chemistry, A. M. Ortuño, P. Reiné, S. Resa, L. Álvarez De Cienfuegos, V. Blanco, J. M. Paredes, A. J. Mota, G. Mazzeo, S. Abbate, J. M. Ugalde, V. Mujica, G. Longhi, D. Miguel and J. M. Cuerva, Extended enantiopure *ortho*-phenylene ethylene (*o*-PE)-based helical systems as scaffolds for supramolecular architectures: a study of chiroptical response and its connection to the CISS effect, copyright 2021.

effect of π-rich and π-poor systems was studied, and it was concluded that slight temperature variations could also stabilise the folding structure, in addition to solvent effects.[100] Jones and co-workers were also the first to use ^{1}H NMR and NOESY spectroscopy to show evidence of helical folding behaviour in *o*-PEs. Subsequently, Slutsky and his colleagues developed a method using HMBC NMR spectroscopy experiments to assign the aromatic spin systems of these *o*-PEs.[101] More recent developments include the attachment of fluorescent pyrene to *o*-PEs, which function as circularly polarized luminescence (CPL)-based ratiometric probes,[102] (Fig. 7b) and metallo-supramolecular complexes formed from stapled *o*-PEs foldamer helices (Fig. 7c).[103]

3.2.2 *meta*-Phenylene–ethynylene foldamers (*m*-PPE). As early as 1997, Nelson and co-workers reported a nonbiological oligomer with an aromatic hydrocarbon backbone that has structural features that allow for a helical conformation with a large cavity (Fig. 8a and b). The *meta*-phenylene acetylene oligomers were appended with triethylene glycol monomethyl ether side chains, which allowed solubility in multiple organic solvents.[22] The folding behaviour was driven by solvophobic effects, and they showed that folding was sensitive to chain length, solvent quality and temperature. In 2002, Kübel and colleagues reported on the molecular packing and morphology of *m*-PPEs. When all monomer units were in the cisoid state, helices were formed, and when all monomer units were in the transoid state, ribbon-like structures were formed.[104] Moore's group extended their research on *m*-PPEs by incorporating chiral and rod-like guests into the helical cavity and showed that the system had potential in molecular recognition (Fig. 8c and d).[71,105] By 2004, Stone synthesized the first water soluble *m*-PPE, by appending hexa(ethylene glycol) side chains to the backbone.[106]

3.3 Aryltriazole-based foldamers

3.3.1 *meta*-Linked triazole-based foldamers. Since the introduction of 2,6-bis(1-aryl-1,2,3-tri-azol-4-yl)pyridines (BTPs) as building block for foldamers by Meudtner and co-workers in 2007, a lot of research has been done on BTPs as it provides a highly functional kinked building block with an extended ligand scaffold, which can be readily accessed *via* "click chemistry".[107] These foldamers switche to the *syn–syn* conformation upon protonation or metal coordination, which allows chelation of metals and formation of metal complexes using BTPs as ligands (Fig. 9a). The BTP building block was used to create higher oligomers, which prefer the *anti–anti* conformation, and the kinked building blocks are linked by *meta*-substituted phenylene hinges. The only allowable rotation occurs around the connecting bonds at the *m*-phenylene hinges, which leads to folding into a helical conformation that is enthalpically stabilised by the resulting π–π stacking interaction. By incorporation of side chains with chiral groups, helicity of the polymers in polar solvents could be controlled and helix inversion was achieved by incorporation of achiral halide ions (Fig. 9b).[108]

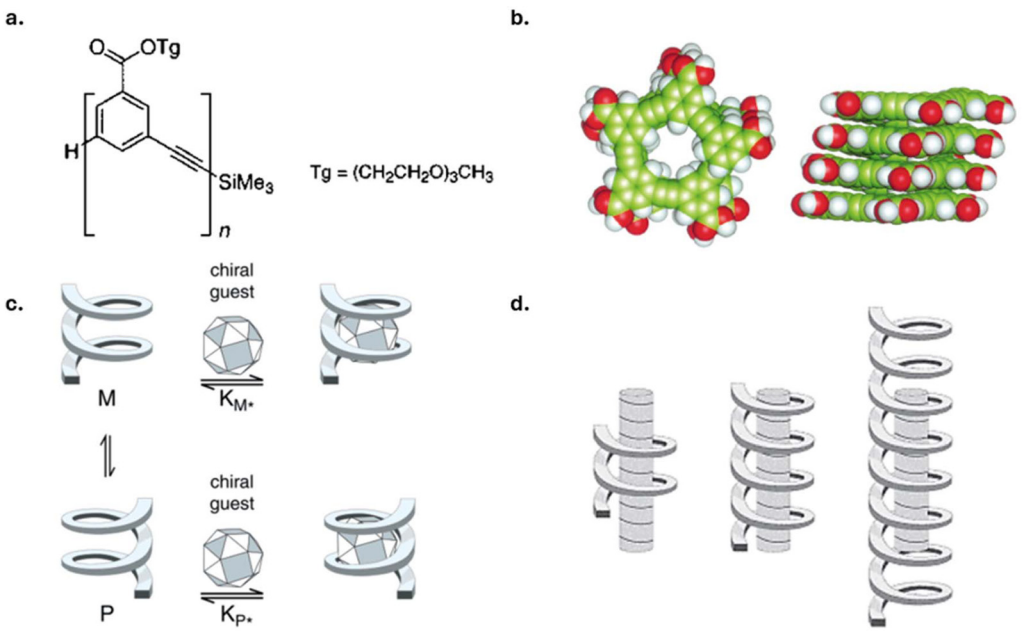


Fig. 8 a. *m*-PPE polymer structure appended with triethylene glycol side chains. b. Helical conformation of a *m*-PPE octadecamer, adapted from ref. 22 with permission from AAAS, J. C. Nelson, J. G. Saven, J. S. Moore and P. G. Wolynes, Solvophobically driven folding of nonbiological oligomers, copyright 1997. c. Incorporation of a chiral guest in *m*-PPE, adapted from ref. 71 with permission from the American Chemical Society, R. B. Prince, S. A. Barnes and J. S. Moore, Foldamer-based molecular recognition, copyright 2000. d. Incorporation of a rod-like guest in *m*-PPE, adapted from ref. 105 with permission from the American Chemical Society, A. Tanatani, M. J. Mio and J. S. Moore, Chain length-dependent affinity of helical foldamers for a rodlike guest, copyright 2001.

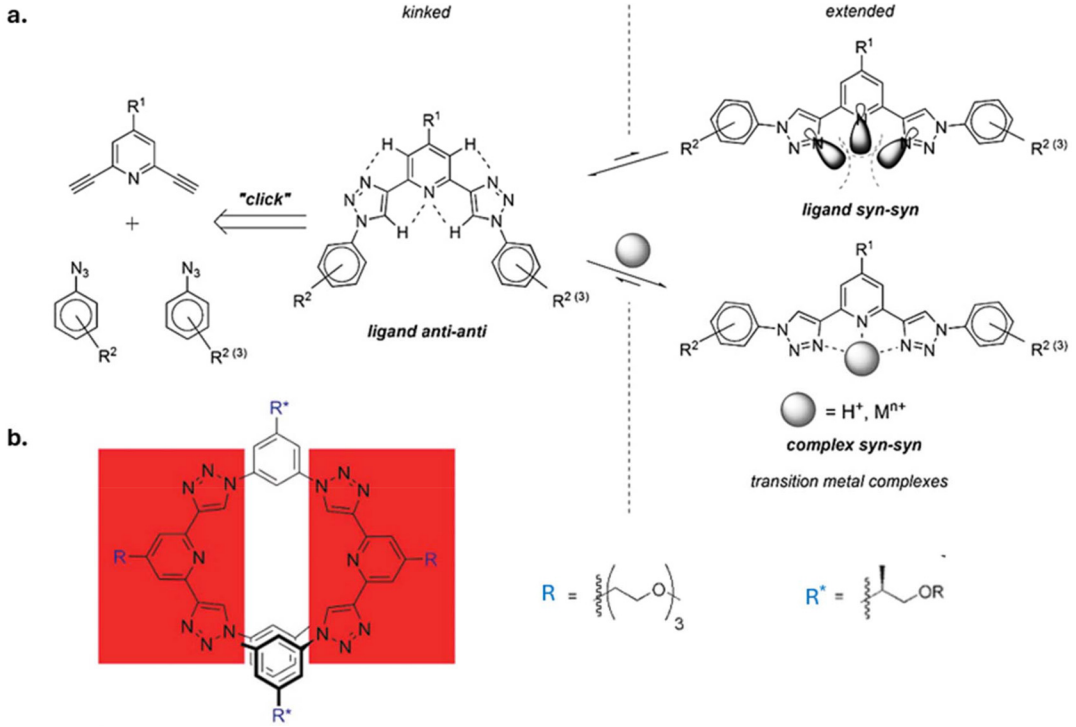


Fig. 9 a. BTPs as ligands for metal complexes with *syn–syn* conformations upon protonation or metal coordination, reproduced from ref. 107 with permission from Wiley, R. M. Meudtner, M. Ostermeier, R. Goddard, C. Limberg and S. Hecht, Multifunctional "clickates" as versatile extended heteroaromatic building blocks: efficient synthesis *via* click chemistry, conformational preferences, and metal coordination, copyright 2007. b. Higher BTP oligomers with chiral side chains form helical structures in polar solvents, reproduced from ref. 108 with permission from Wiley, R. M. Meudtner and S. Hecht, Helicity inversion in responsive foldamers induced by achiral halide ion guests, copyright 2008.

This work inspired the development of similar foldamers based on 1,2,3-triazoles. Using the same concept, research into aryl-triazole oligomers has become popular, and their ability to bind to anions is a topic of interest. Juwarker and co-workers were the first to explore the intermolecular interactions between the electropositive CH side of the aryl-triazole oligomers and electron-rich anions. It was shown that the 1,2,3-triazole CH···Cl^- interaction could guide folding in solution and in the solid state.[109] Juwarker and co-workers then studied the binding affinities of these oligomers with various anions by ^{1}H NMR spectroscopy titrations. The effective ionic radii of the anions were found to be the primary determinant of the binding interactions of the guest molecules. They concluded that the solvent effects are significant, and the strength of the binding interaction depends directly on the donor ability of the solvent (Fig. 10a).[110] Wang and co-workers designed a variety of cationic oligo(aryl-triazole)s able to fold into helical conformations in water and incorporated an amide N–H group as hydrogen-bond donor to construct anion-receptor oligo(phenyl-amide-triazole)s (Fig. 10b and c).[111,112] Similar work was reported by Shang and colleagues, where a pyridinium motif were incorporated for anion binding.[113] This anion binding mechanism led You and co-coworkers to design a triazole-based oligomer as a halogen bonding receptor for organohalogens (Fig. 10d).[114]

The 1,2,3-triazole moiety is an excellent hydrogen bond-donor due to its high dipole moment. Jiang and co-workers reported on the incorporation of halogen aryl-triazole units with oligomers based on isobutyl-4-fluorobenzoate or isobutyl-4-chlorobenzoate and their folded conformations (Fig. 10e & f).[44] The research into *meta*-linked aryl-triazole oligomers evolved and a lot of interesting foldamers were created in the last decade, some of which are discussed below.

Hua and co-workers designed a triazole-based oligomer capable of encapsulating chloride ions in aqueous acetonitrile solutions. The hydrophobic collapse of the foldamer capsules drives the solvent out and allows a microenvironment for hydrogen bonding (Fig. 11a).[115] Wang and co-workers developed ruthenium(III) complexes of aryl-triazole oligomers as anion receptors (Fig. 11b).[116] Zhao and co-workers then synthesized a triazole-based oligomer with ethynyl spacers to allow binding of various shaped anions including halides and oxyanions (Fig. 11c).[117] Yang and co-workers, modified an aryl-triazole foldamer with a naphthalimide fluorescent motif that enabled monitoring of enhanced anion-induced folding by fluorescence spectroscopy (Fig. 11d).[118] Borissov and co-workers designed interesting neutral iodotriazole foldamers as tetradentate halogen bonding anion receptors with enhanced anion affinities compared to their hydrogen bonding analogues, and with higher selectivity towards iodide ions over the lighter halides.[119] Thereafter, Borissov and co-workers proposed a novel approach for the recognition of anions in water by using a charge-neutral σ-hole halogen and a chalcogen

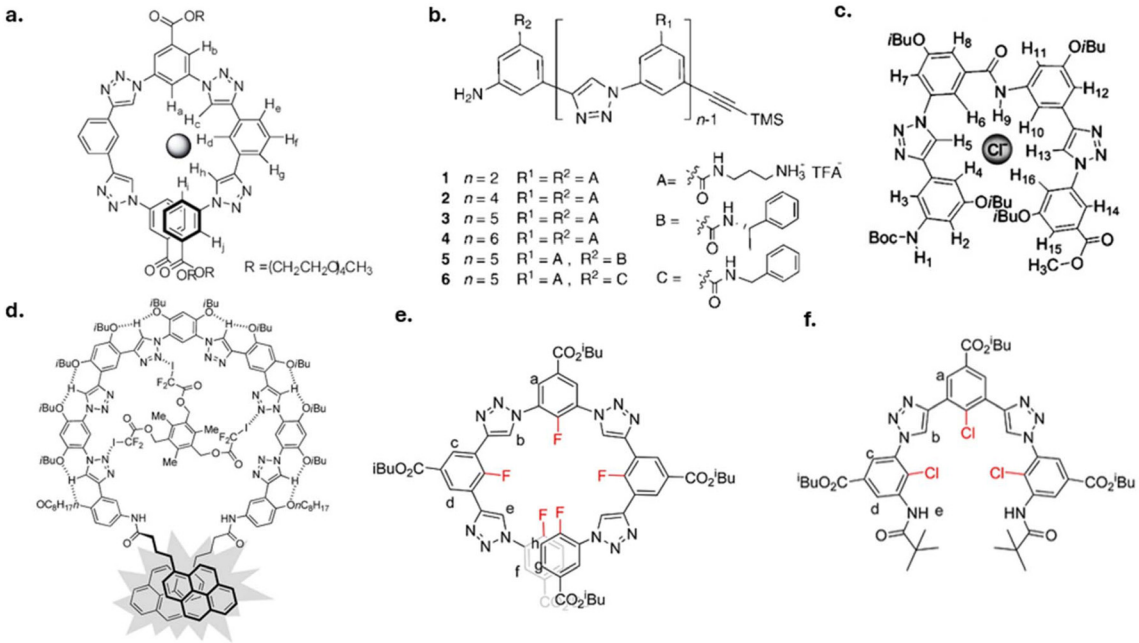


Fig. 10 a. 1,4-Diaryl-1,2,3-triazole oligomer capable of binding anions, adapted from ref. 110 with permission from the American Chemical Society, H. Juwarker, J. M. Lenhardt, J. C. Castillo, E. Zhao, S. Krishnamurthy, R. M. Jamiolkowski, K. H. Kim and S. L. Craig, Anion binding of short, flexible aryl triazole oligomers, copyright 2009. b. Cationic oligo(aryl-triazole) oligomers, reproduced from ref. 112 with permission from Wiley, Y. Wang, F. Li, Y. Han, F. Wang and H. Jiang, Folding and aggregation of cationic oligo(aryl-triazole)s in aqueous solution, copyright 2009. c. Representation of folding of oligo(phenyl-amide-triazole) with chloride binding, reproduced from ref. 111 with permission from Wiley, Y. Wang, J. Xiang and H. Jiang, Halide-guided oligo(aryl-triazole-amide)s foldamers: receptors for multiple halide ions, copyright 2011. d. Triazole-based oligomers bind organohalides through multiple N···I halogen bonds, reproduced from ref. 114 with permission from Wiley, L. Y. You, S. G. Chen, X. Zhao, Y. Liu, W. X. Lan, Y. Zhang, H. J. Lu, C. Y. Cao and Z. T. Li, C–H···O hydrogen bonding induced triazole foldamers: efficient halogen bonding receptors for organohalogens, copyright 2012. e. Structure of isobutyl-4-fluorobenzoate triazole based oligomer, adapted from ref. 44 with permission from the American Chemical Society, J. Shang, N. M. Gallagher, F. Bie, Q. Li, Y. Che, Y. Wang and H. Jiang, Aromatic triazole foldamers induced by C–H···X (X = F, Cl) intramolecular hydrogen bonding, copyright 2014. f. Structure of isobutyl-4-chlorobenzoate triazole based oligomer, adapted from ref. 44 with permission from the American Chemical Society, J. Shang, N. M. Gallagher, F. Bie, Q. Li, Y. Che, Y. Wang and H. Jiang, Aromatic triazole foldamers induced by C–H···X (X = F, Cl) intramolecular hydrogen bonding, copyright 2014.

bonding acyclic host. The integration of halogen and chalcogen bond-donor atoms into a foldamer structure containing hydrophilic functionalities exploits the intrinsic hydrophobicity of the polymer. A 2 : 1 host–guest stoichiometric complex assembly was formed in water, with the anion encapsulated, stabilised by multidentate, convergent σ-hole donors (Fig. 11e).[120]

Bunchuay and co-workers' more recent work includes synthesis of a charge-neutral halogen bonding tetradentate iodotriazole macrocycle for anion recognition. The macrocycle consists of a tri-ester group for solubilization, a bidentate iodotriazole as the anion binding site, and an aromatic xylyl/naphthyl spacer unit.[121] Liu and co-workers also proposed a foldamer capable of encapsulating anions, inspired by the solvent exclusion principle. They designed sequence-defined aryl-triazole foldamers, which in their helical folded states are pre-organised for 1 : 1 anion complexation.[122]

3.3.2 *para*-Linked aryl-triazole foldamers. Pfukwa was the first to postulate that the use of *para*-aryl-disubstitution in poly (aryl-triazoles) (P(*p*-AT)s) could lead to helical conformations, given that the 1,4-disubtitution of the triazole moiety would induce enough curvature in the polymer (Fig. 12a). This substitution pattern would lead to a helical structure with a much larger cavity than the *meta*-linked systems studied before and had the potential of encapsulating much larger molecules. Molecular modelling of the all cisoid P(*p*-AT) predicted a helix with a cavity of 30.6 Å (Fig. 12b). The P(*p*-AT)s were appended with tri(ethylene glycol) monomethyl ether side chains to impart solubility, stability and chirality to the helix (Fig. 12c).[123] The folding was solvophobically driven by adding water (a bad solvent) to DMF (a good solvent). Folding was tracked by UV-Vis spectroscopy and circular dichromism (CD) spectroscopy. As the water content increased from 0 to 13%, the polymer started to fold, forming loose spring helices, while at higher water contents the helices started tightening and form stable helices. When the water content exceeds 28% the helices started to stack and form nanotubes that eventually aggregated into bundles (Fig. 12d). Pfukwa and co-workers also showed that the foldamer was capable of encapsulating poly(γ-benzyl-L-glutamate) (PBLG), which was chosen to mimic a single RNA strand (Fig. 12e).[124] Recently, Carter and co-workers also showed how linear dichromism (LD) could be used as a tool to track the higher-order assembly of these P(*p*-AT)s in solution.[125]

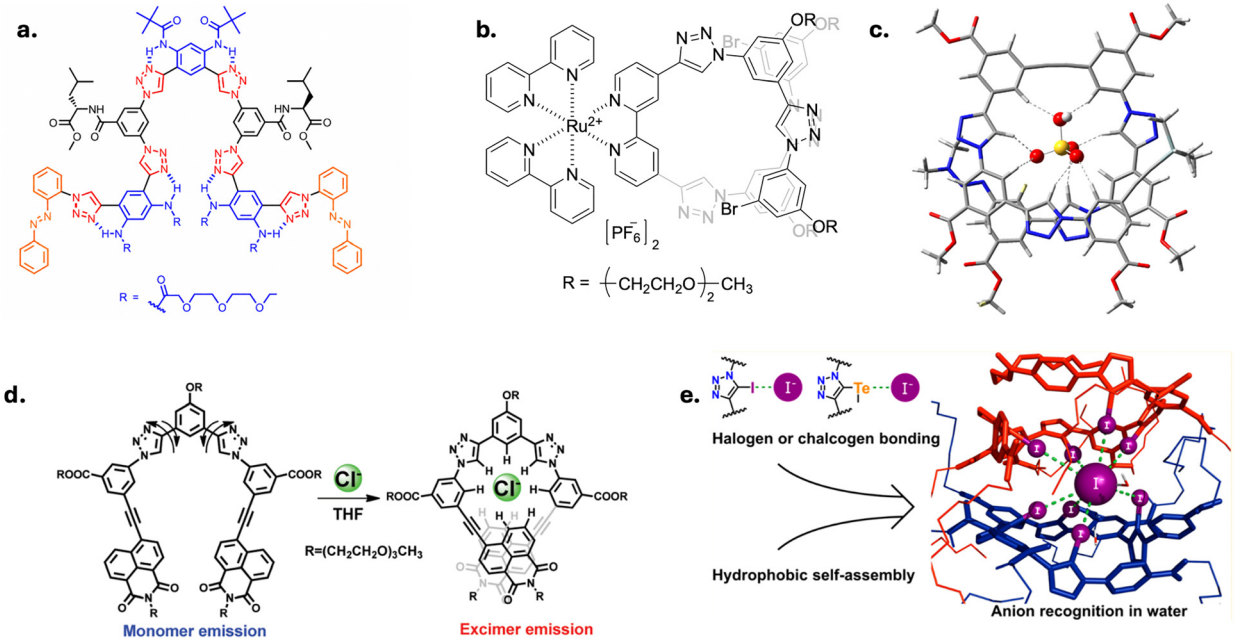


Fig. 11 a. Triazole-based oligomer for encapsulation of anions, adapted from ref. 115 with permission from the American Chemical Society, Y. Hua, Y. Liu, C. H. Chen and A. H. Flood, Hydrophobic collapse of foldamer capsules drives picomolar-level chloride binding in aqueous acetonitrile solutions, copyright 2013. b. Ruthenium(III) complexes of aryl-triazole oligomers, reproduced from ref. 116 with permission from Wiley, Y. Wang, W. Zhao, F. Bie, L. Wu, X. Li and H. Jiang, Ruthenium(II) complexes of aryl triazole foldamers as receptors for anions, copyright 2016. c. Triazole-based oligomer with ethynyl spacers binding HSO_4^- ions, reproduced from ref. 117 with permission from Elsevier, W. Zhao, F. Huang, Y. Wang, Q. Li, J. Shang, Y. Che and H. Jiang, Aryl-triazole foldamers with ethynyl spacers as effective receptors for halides and oxyanions, copyright 2016. d. Neutral iodotriazole foldamers as tetradentate halogen bonding anion receptors, reproduced from ref. 118 with permission from the Royal Society of Chemistry, L. Yang, Y. Wang, Y. Che and H. Jiang, An aryl-triazole foldamer containing a 1,8-naphthalimide fluorescent motif for monitoring and enhancing the anion-induced folding, copyright 2017. e. Charge-neutral σ-hole halogen and chalcogen bonding acyclic host, reproduced from ref. 120 with permission from the American Chemical Society, A. Borissov, I. Marques, J. Y. C. Lim, V. Félix, M. D. Smith and P. D. Beer, Anion recognition in water by charge-neutral halogen and chalcogen bonding foldamer receptors, copyright 2019.

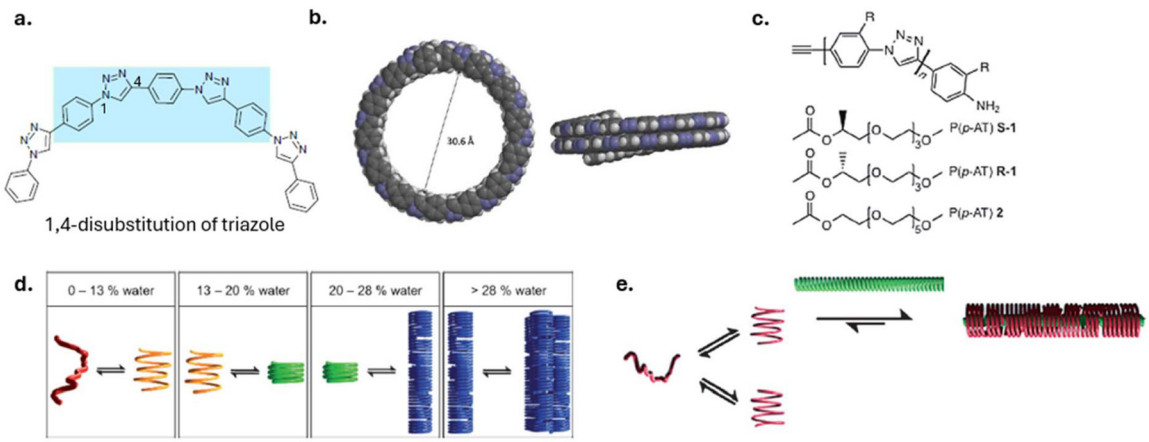


Fig. 12 a. *para*-Linked aryl-triazole backbone with 1,4-disubstituted triazole units. b. Molecular model of P(*p*-AT) helix. c. P(*p*-AT)s appended with chiral and nonchiral tri(ethylene glycol) monomethyl ether side chains, reproduced with permission of the author, copyright 2012.[123] d. Hierarchial self-assembly of P(*p*-AT)s with increasing water content. e. Encapsulation of PBLG in P(*p*-AT)s, reproduced from ref. 124 with permission from Wiley, R. Pfukwa, P. H. J. Kouwer, A. E. Rowan and B. Klumperman, Templated hierarchical self-assembly of poly(*p*-aryltriazole) foldamers, copyright 2013.

3.4 Oligoamide-based foldamers

3.4.1 Aromatic oligoamide foldamers. Aromatic oligoamide-based foldamers, exhibit helical secondary structures stabilised by intramolecular hydrogen bonding. These foldamers can adopt helical conformations with varying pitches and handedness, offering a versatile platform for designing biomimetic materials and molecular recognition elements.

Zhang and co-workers developed an aromatic oligoamide where they replaced the amide hydrogen bonds with the acid-labile 2,4-dimethoxybenzyl (DMB) group. Upon removal of the DMB groups, the polymer folded into multiturn helices (Fig. 13a).[126] Bao and co-workers reported an interesting supramolecular capsule with a cavity in which 1,10-decanediol could be bound. This carefully designed aromatic amide foldamer allows encoding of three levels of information including, cavity size, recognition of guests, and the ability to adopt a single or double helical structure (Fig. 13b).[127] Singleton and co-workers developed a method for increasing the size of the cavity by strand intercalation (Fig. 13c).[128] Tsiamantas and colleagues designed an aromatic oligoamide-based macrocycle, where two helices were intermolecularly connected with disulfide bridging. They showed that helix–helix handedness was communicated remotely by the disulfide bridged side chains and was specific for a given side chain-length (Fig. 13d).[129] Zhao and co-workers studied the folding and self-association mechanisms of a range of aromatic oligoamide foldamers by computational methods. The results revealed that the formation of single helices was driven by π–π interactions and that aggregation of two single-helical motifs was energetically favourable. The spontaneous self-assembly was thought to proceed by an "unwinding–threading–rewinding" mechanism (Fig. 13e).[130] Zhao and his colleagues also studied aromatic oligoamides, and the effect of oligomer length, solvent, and temperature on the self-association of these oligomers. They reported that the π–π stacking interaction strength increased nonlinearly with oligomer length. Opposite to typical aromatic stacking, it was found that stacking of these oligomers was enhanced in low polarity solvents, weakened in polar solvents, and was sensitive to temperature changes (Fig. 13f).[131] More recently Yu and co-workers showed that when the aromatic oligoamides are linked through a disulfide bond it could form a helix-turn-helix trimer and after reduction of that bond it would form a anti-parallel double helix. It is also possible to form different host : guest complexes with diacids in both helical forms.[132] These aromatic oligoamide foldamers were typically synthesized through a condensation step-growth type polymerisations which made molecular weight control challenging.

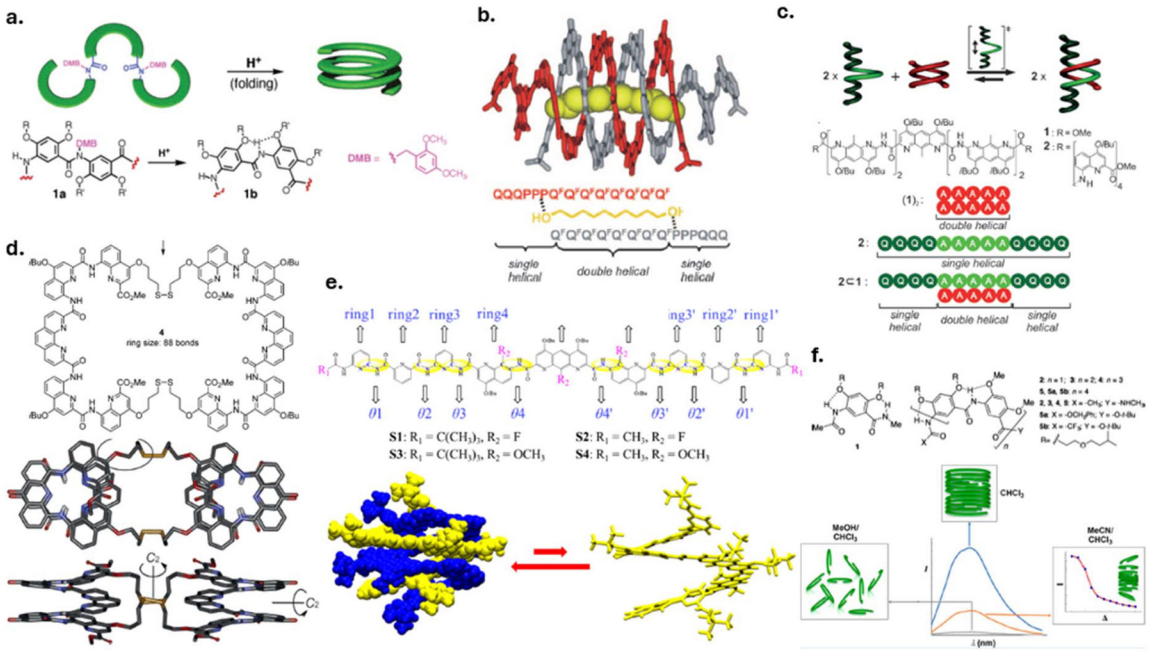


Fig. 13 a. Oligoamide polymer with DMB groups that fold into helices upon removal of the DMB group, reproduced from ref. 126 with permission from the American Chemical Society, A. Zhang, J. S. Ferguson, K. Yamato, C. Zheng and B. Gong, Improving foldamer synthesis through protecting group induced unfolding of aromatic oligoamides, copyright 2006. b. Double helix oligoamide capsule encapsulating 1,10-decanediol, reproduced from ref. 127 with permission from Wiley, C. Bao, Q. Gan, B. Kauffmann, H. Jiang and I. Huc, A self-assembled foldamer capsule: combining single and double helical segments in one aromatic amide sequence, copyright 2009. c. Intercalation of a helical segment with a wide diameter and a propensity to self-hybridize into duplexes (in red) into a longer sequence that exists as a single helix (in green) to form a heteroduplex, reproduced from ref. 128 with permission from Wiley, M. L. Singleton, G. Pirotte, B. Kauffmann, Y. Ferrand and I. Huc, Increasing the size of an aromatic helical foldamer cavity by strand intercalation, copyright 2014. d. Oligoamide *C*2-symmetrical, two-helix bundle-like macrocyclic structure, reproduced from ref. 129 with permission from Wiley, C. Tsiamantas, X. de Hatten, C. Douat, B. Kauffmann, V. Maurizot, H. Ihara, Takafuji, N. Metzler-Nolte and I. Huc, Selective dynamic assembly of disulfide macrocyclic helical foldamers with remote communication of handedness, copyright 2016. e. Double-stranded helical aromatic oligoamide foldamer, reproduced from ref. 130 with permission from the American Chemical Society, D. Zhao, L. Yang, Y. Yuan, H. Wang, H. Dong and S. Li, Molecular mechanism of self-assembly of aromatic oligoamides into interlocked double-helix foldamers, copyright 2017. f. Self-assembly and stacking of aromatic oligoamides, reproduced from ref. 131 with permission from the American Chemical Society, Y. Zhao, A. L. Connor, T. A. Sobiech and B. Gong, Effects of oligomer length, solvents, and temperature on the self-association of aromatic pligoamide foldamers, copyright 2018.

Recently, Pal and co-workers developed a living polymerisation method using phosphorus based reagents which allow high molecular weights and narrow molar mass dispersities, opening up more opportunities for these foldamers to be used in industry.[133]

3.4.2 Quinoline-derived oligoamide foldamers. Another heavily investigated group of oligoamide foldamers is based on quinoline. Dolain and co-workers did a comprehensive study on the helical handedness of quinoline-derived oligoamide foldamers and the role of steric effects in solution and in the solid state. The foldamers had specific chiral groups attached to the end of quinoline-derived oligoamides to induce chirality (Fig. 14a). After assigning *R* or *S* chirality of the stereogenic centre, it was observed that *R* chirality usually led to right-handed helices and *S* chirality to left-handed helices. The conformation of the stereocenter typically preferred its bulkiest group pointing away from the helix, its second bulkiest group in line with the helix and the smallest group pointing towards the helix.[58] Wolffs was part of a group that investigated photoinduced processes in electron donor–acceptor pairs and how it was affected by helical bridge length and chromophore position. Quinoline-derived foldamers functionalized with oligo(*p*-phenylene vinylene) on one end and a perylene bisimide-chromophore on the other end were studied (Fig. 14b).[134] They concluded that the foldamer bridge mediated the charge transfer from donor to acceptor through a super-exchange mechanism, and that there exists a linear trend between the logarithm of the charge separation rate constant and the distance between the chromophores.[134] Dawson and co-workers designed a series of water-soluble quinoline-derived foldamers capable of retaining their chiral handedness in water. They were able to separate *P* and *M* helices with HPLC for foldamers that contained chiral moieties with no handedness induction, and identified foldamers that had single-handedness by incorporation of a chiral moiety onto the 8-position of the quinoline monomer (Fig. 14d).[135]

Zheng and co-workers published an investigation of induced helicity on quinoline-derived foldamers appended with pyridyl moieties either at the N- or C-terminus. The work concluded that absolute chiral induction was obtained when the chiral pyridyl acid was appended at the N-terminus, and incomplete chiral induction was obtained when appended on the C-terminus (Fig. 14c).[136] Zheng an co-workers also observed single-handed foldamers when *S*- or *R*-enantiomers

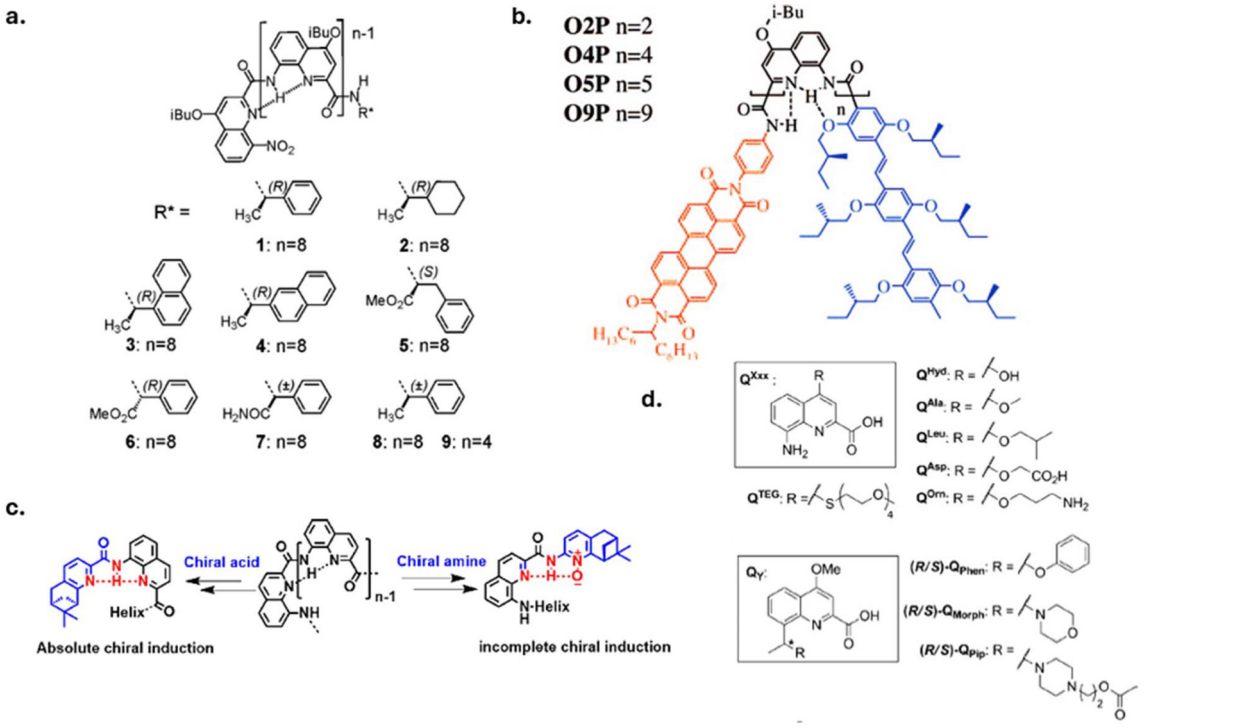


Fig. 14 a. Quinoline-derived oligoamides and chiral substituents, reproduced from ref. 58 with permission from the American Chemical Society, C. Dolain, H. Jiang, J. M. Léger, P. Guionneau and I. Huc, Chiral induction in quinoline-derived oligoamide foldamers: assignment of helical handedness and role of steric effects oligomers, copyright 2005. b. Quinoline-derived oligoamide functionalised with oligo(*p*-phenylene vinylene) and a perylene bisimide chromophore, reproduced from ref. 134 with permission from the American Chemical Society, M. Wolffs, N. Delsuc, D. Veldman, N. V. Anh, R. M. Williams, S. C. J. Meskers, R. A. J. Janssen, I. Huc and A. P. H. J. Schenning, Helical aromatic oligoamide foldamers as organizational scaffolds for photoinduced charge transfer, copyright 2009. c. Quinoline-derived oligoamide functionalised with enantiomers of oxazolylaniline, reproduced from ref. 136 with permission from the American Chemical Society, copyright 2017. d. Water-soluble quinoline-derived foldamers, reproduced from ref. 135 with permission from Wiley, S. J. Dawson, Á. Mészáros, L. Peth, C. Colombo, M. Csékei, A. Kotschy and I. Huc, Controlling helix handedness in water-soluble quinoline oligoamide foldamers, copyright 2014.

of oxazolylaniline were attached to the ends of the quinoline-derived foldamers.[137] These quinoline derived foldamers have potential in many medical applications, however up until now, their general use has been largely prevented by a limited access to required monomers and the difficulty of synthesizing the oligomers. Recently, Zwillinger and co-workers have developed an automated solid-phase synthesis method, which can produce 20-unit oligomers with diverse sidechain modifications possible on the 4, 5, and 6 position of the quinoline rings.[138] Xu and colleagues also developed an easy condensation synthesis strategy for alternating pyridine and quinoline helical foldamers with polymers up to 128 units long.[139]

3.5 Oligourea-based foldamers

Hamilton and Rodriguez developed benzoylurea oligomers inspired by the α-helix. They were the first to show that the benzoylurea derivatives are water compatible and can function as α-helix mimics (Fig. 15a).[140] After this, the interest in oligomeric aromatic/aliphatic *N*,*N*-linked urea oligomers exploded, given that the urea linkage has desirable features for folding, including its rigidity, planarity, polarity and its hydrogen bonding capacity.[46] These peptidomimetic oligoureas have the propensity to fold into helical conformations in solution and can interact with biological targets.[141] The 2,5-helix is stabilised by intramolecular three-centred H-bonds closing 12- and 14-membered H-bonded pseudorings (Fig. 15c).[142]

Gan and co-workers designed oligourea-based helical molecular tapes that can slowly wind around rod-like guests, with promising capabilities in molecular machinery (Fig. 15b).[143] Shortly thereafter, Wu and co-workers developed an oligourea foldamer capable of coordination with chloride.[145] Wechsel and co-workers reported the first oligoureas of *meso* cyclohexane-1,2-diamines. A preferred screw sense could be induced by selective protection of the enantiotopic end groups or by coordination with a chiral carboxylate anion.[146] Wechsel then showed that these *meso*-helices and the intermolecular association with achiral anionic guests could lead to inversion of their preferred conformation. The inversion is caused by strong intermolecular hydrogen bonding, which leads to reorganization of the intramolecular H-bonding network.[147] Gupta and co-workers investigated the folding behaviour after *N*-methylation of the N-terminus in oligourea foldamers and concluded that the methylated oligoureas have similar helical structures as unmethylated ones.[148] More recently, Pendem and co-workers designed well-defined parallel helical hairpin-motifs by bridging aliphatic oligourea helices with 4,4′-methylene diphenyl diisocyanate (Fig. 15d).[144]

3.6 Indolocarbazole-based foldamers

Chang and co-workers were the first to report on an oligoindole-based foldamer that adopts a helical conformation by interactions with chloride ions to form a helix that is stabilised

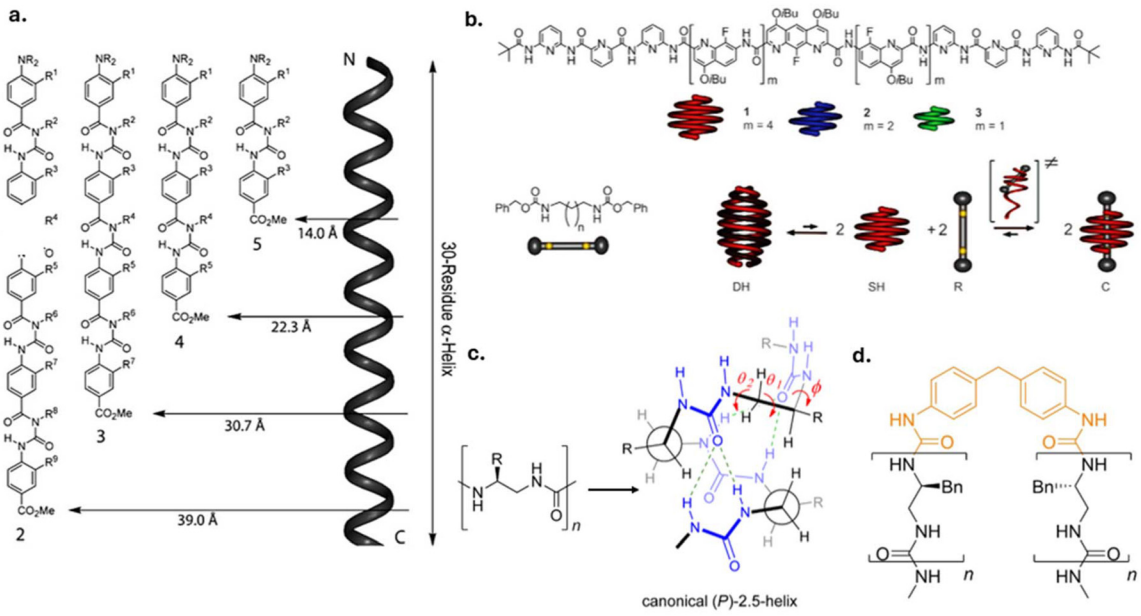


Fig. 15 a. Benzoylurea oligomers as an α-helix mimic, reproduced from ref. 140 with permission from Wiley, J. M. Rodriguez and A. D. Hamilton, Benzoylurea oligomers: synthetic foldamers that mimic extended α helices, copyright 2007. b. Oligourea-based helical molecular tapes, reproduced from ref. 143 with permission from AAAS, Q. Gan, Y. Ferrand, C. Bao, B. Kauffmann, A. Grélard, H. Jiang and I. Huc, Helix-rod host–guest complexes with shuttling rates much faster than disassembly, copyright 2011. c. *N*,*N*-Linked urea oligomers and the 2,5-helix stabilised by intramolecular three-centred H-bonds, reproduced from ref. 142 with permission, N. Pendem, C. Douat, P. Claudon, M. Laguerre, S. Castano, B. Desbat, D. Cavagnat, E. Ennifar, B. Kauffmann and G. Guichard, Helix-forming propensity of aliphatic urea oligomers incorporating noncanonical residue substitution patterns, copyright 2013. d. Helical hairpin-based on aliphatic oligoureas, reproduced from ref. 144 with permission from Wiley, N. Pendem, Y. R. Nelli, L. Cussol, C. Didierjean, B. Kauffmann, C. Dolain and G. Guichard, Synthesis and crystallographic characterization of helical hairpin oligourea foldamers, copyright 2023.

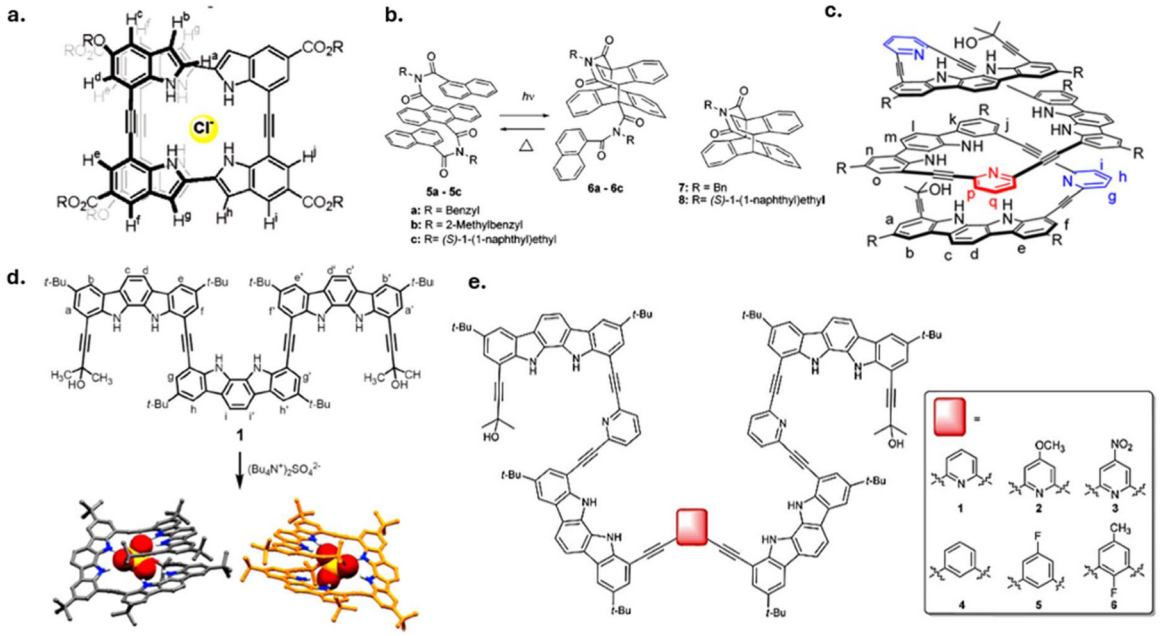


Fig. 16 a. Oligoindole and its helical conformation induced by hydrogen bonding with Cl^-, reproduced from ref. 149 with permission from the American Chemical Society, K. J. Chang, B. N. Kang, M. H. Lee and K. S. Jeong, Oligoindole-based foldamers with a helical conformation induced by chloride, copyright 2005. b. Reversible [4 + 4] cycloaddition of S-shaped foldamers 5a–5c, reproduced from ref. 151 with permission from the American Chemical Society, H. Masu, I. Mizutani, T. Kato, I. Azumaya, K. Yamaguchi, K. Kishikawa and S. Kohmoto, Naphthalene- and anthracene-based aromatic foldamers with iminodicarbonyl linkers: their stabilities and application to a chiral photochromic system using retro [4 + 4] cycloaddition, copyright 2006. c. Indolocarbazole–pyridine that fold into helices, reproduced from ref. 152 with permission from the American Chemical Society, H. G. Jeon, J. Y. Jung, P. Kang, M. G. Choi and K. S. Jeong, Folding-generated molecular tubes containing one-dimensional water chains, copyright 2016. d. Molecular structure of indolocarbozole trimer and its crystal structures when complexed with $(Bu_4N^+)_2SO_4^{2-}$, reproduced from ref. 153 with permission from the American Chemical Society, J. M. Suk, D. A. Kim and K. S. Jeong, Helicity control of an indolocarbazole foldamer by chiral organic anions, copyright 2012. e. Molecular structures of indolocarbozole foldamers 1–6 with varying central aromatic linkers, reproduced from ref. 154 with permission from the Royal Society of Chemistry, J. S. Kim, H. G. Jeon and K. S. Jeong, Modulation of helix stability of indolocarbazole–pyridine hybrid foldamers, copyright 2016.

by hydrogen bonding (Fig. 16a).[149] Suk and Jeong then reported a water-soluble indolocarbazole-based foldamer and described its capability of binding halides in water in order $Cl^- > F^- > Br^-$, which differs to the order in organic solvents due to competing solvation.[150]

Masu and co-workers prepared a foldamer using iminodicarbonyl linkers to position an anthracene moiety sandwiched between two naphthalene moieties. The S-shaped folding structure was confirmed with X-ray analysis and it was concluded that foldamers 5a and 5b formed achiral single crystals, while 5 formed chiral crystals and that facile intramolecular [4 + 4] photocycloaddition could be attained (Fig. 16b).[151] Jeong's group later reported that the helicity of indolocarbazole foldamers can be controlled by interaction with chiral organic anions (Fig. 16d).[153] Jeon and co-workers also created a series of indolocarbazole–pyridine (IP) foldamers. The helical folding is induced by dipolar interactions and stabilised by π–π stacking of the repeat units (Fig. 16c).[152] Modulation of helix stability by varying the central pyridine with other aromatic monomers in different solvents was further studied by Kim and co-workers (Fig. 16e).[154] Lee and co-workers then showed that the IP foldamers were capable of hosting up to 4 iodide ions in the cavities.[155]

3.7 Oligomeric cholates

Between 2005 and 2009, Zhong, Zhao and co-workers studied amphiphilic foldamers made of cholic acid monomer units connected in a head-to-tail fashion. Cholic acid has a hydrophobic β-face and a hydrophilic α-face (Fig. 17a). In nonpolar solvents the oligomeric cholates form helical structures with a nanosized cavity. The nonpolar solvent preferentially solvates the hydrophobic β-face and buries the hydrophilic α-face, forcing the oligomer into its helical conformation (Fig. 17b).[156] Zhong and Zhao also constructed a hybrid foldamer with six cholate units and two methionines labelled with a dansyl group. Surfactants were added to solubilize the foldamer in micelles and it was used as a fluorescent sensor for mercury ions (Fig. 17c).[157] Zong's group also studied the folding behaviour of cholate oligomers in nonpolar solvents with a small amount of polar solvent. Folding created a hydrophilic nanocavity where the polar solvent was entrapped. They concluded that folding was favoured for larger sized polar solvent molecules and smaller/acyclic nonpolar solvent molecules (Fig. 17d).[158] Zhong and co-workers also did a study on controlling the conformation of oligocholate foldamers by surfactant micelles and how addition of NaCl affects the folding behaviour in solution. When solubilized in sodium

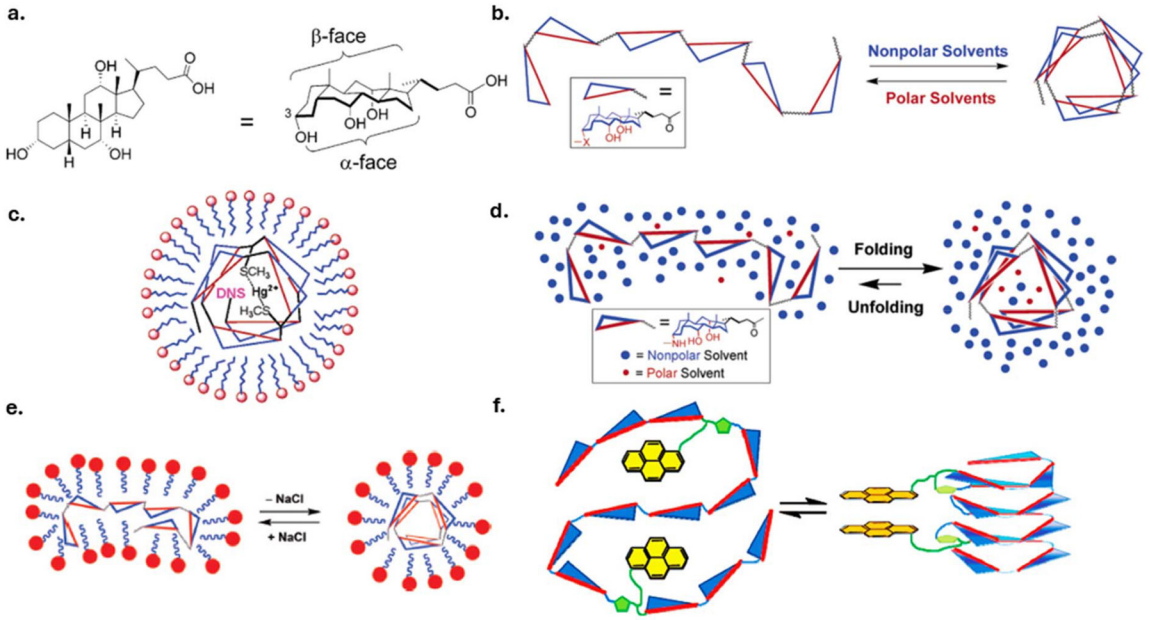


Fig. 17 a. Cholic acid monomer with its α-face and β-face. b. Oligocholates by linking cholates in a head-to tail manner and their helical conformation in nonpolar solvents, reproduced from ref. 156 with permission from the American Chemical Society, Y. Zhao and Z. Zhong, Oligomeric cholates: amphiphilic foldamers with nanometer-sized hydrophilic cavities, copyright 2005. c. Cholate foldamer-based fluorescence sensor modulated by surfactant micelles for Hg^{2+} detection, reproduced from ref. 157 with permission from the American Chemical Society, Y. Zhao and Z. Zhong, Detection of Hg^{2+} in aqueous solutions with a foldamer-based fluorescent sensor modulated by surfactant micelles, copyright 2006. d. Oligocholates with hydrophilic nanocavity where a polar solvent is entrapped, reproduced from ref. 158 with permission from the American Chemical Society, Y. Zhao, Z. Zhong and E. H. Ryu, Preferential solvation within hydrophilic nanocavities and its effect on the folding of cholate foldamers, copyright 2007. e. Effect of NaCl on oligocholate folding in SDS micelles, reproduced from ref. 159 with permission from the American Chemical Society, Z. Zhong and Y. Zhao, Controlling the conformation of oligocholate foldamers by surfactant micelles, copyright 2008. f. Higher oligocholates by click chemistry, reproduced from ref. 160 with permission from the American Chemical Society, X. Pan and Y. Zhao, Efficient construction of oligocholate foldamers *via* "click" chemistry and their tolerance of structural heterogeneity, copyright 2009.

dodecyl sulfate, the foldamers were stable in their helical conformation, and upon addition of NaCl they unfolded (Fig. 17e).[159] Their research was extended to oligocholates which include nonamer and dodecamer derivatives by utilizing 1,3-dipolar cycloaddition between an alkynyl-terminated cholate trimer and an azido-functionalized cholate hexamer. These longer "clicked" oligomers folded in a similar manner to their parent foldamers because of the solvophobically driven folding mechanism (Fig. 17f).[160]

3.8 β-Sheet foldamers

Apart from α-helices, β-sheets are another common secondary structure easily obtainable when designing foldamers. Only a couple of examples will be briefly discussed. Maurizot and co-workers designed foldamers that fold into cylindrical β-sheets based on alternating 1,5-diamino-2,4-dinitrobenzene units and 1,5-diamino-2,4-dialkoxybenzene units. The six-membered hydrogen bond ring between the NH and the NO, as well as the five-membered hydrogen bond ring between the same NH and the OR group, allows the trimer to from a crescent shape which is further stabilised by π–π stacking when the oligomer is long enough (Fig. 18a).[161] Sebaoun and co-workers developed β-sheets based on π–π aromatic stacking, using 4,6-dinitro-1,3-phenylenediamine unit. They used rigid hairpin turns that lead to face-to-face interactions between the linear aromatic segments and studied the influence of substituents of the adjacent rings on the folding of the β-hairpins (Fig. 18b).[162] Shortly thereafter, Sebaoun and co-workers also studied the stability of these structures using two-stranded β-sheets with variable linear aromatic segment lengths. They concluded that conformational stability of these β-sheets can be reached using less rigid turn units with longer linear strands which have more extensive π–π interactions (Fig. 18c).[93] Lamouroux and co-workers also developed a basket-type structure by incorporating bent β-sheets into helical conformations. The basket cavity size is controlled by the curvature of the β-sheet segment and can bind and release a guest with minimal disturbance to its structure (Fig. 18d).[163]

3.9 Other interesting foldamers

Hou and co-workers reported on the first oligohydrazine-based foldamers that adopt helical conformations driven by intramolecular hydrogen bonding used for recognition of alkyl saccharides in chloroform (Fig. 19a).[164] Cai and colleagues extended the research of oligohydrazine foldamers and found that they formed stable vesicles in methanol and gels in nonpolar aliphatic hydrocarbons (Fig. 19b).[165] Liu and co-workers reported that triazene-arylene oligomers could fold and unfold

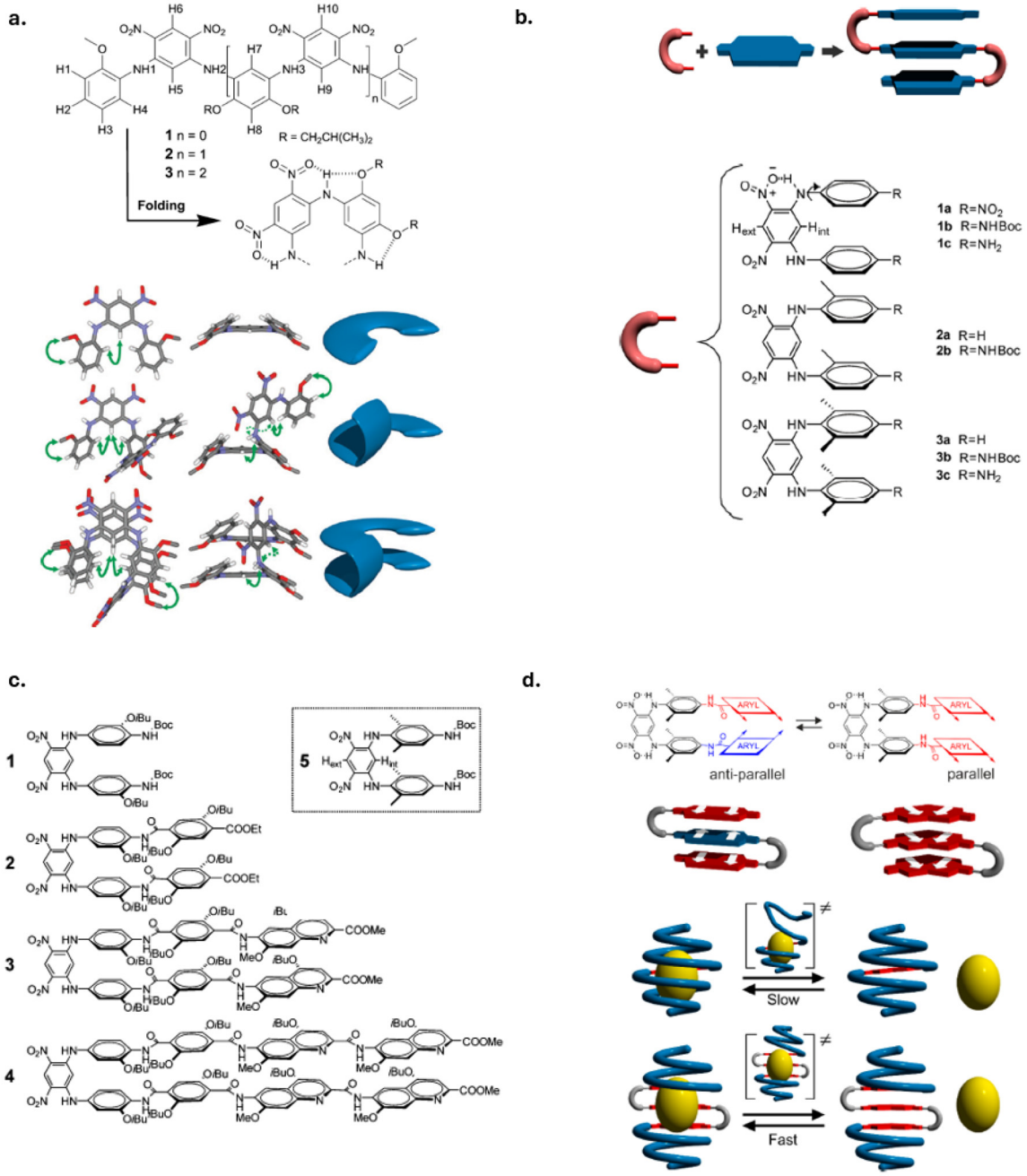


Fig. 18 a. Folding of oligomers through intramolecular hydrogen bonds and crystal structures, reproduced from ref. 161 with permission from the Royal Society of Chemistry, V. Maurizot, S. Massip, J. M. Léger and G. Déléris, Cylindrical sheet formation of oligo-*meta*-aniline foldamers, copyright 2009. b. Design elements for building aromatic oligoamide β-sheet foldamers and influence of substituents on folding of hairpins, reproduced from ref. 162 with permission from the American Chemical Society, L. Sebaoun, V. Maurizot, T. Granier, B. Kauffmann and I. Huc, Aromatic oligoamide β-sheet foldamers, copyright 2014. c. Two-stranded aromatic oligoamide β-sheets possessing linear segments of increasing length, reproduced from ref. 93 with permission from the American Chemical Society, L. Sebaoun, B. Kauffmann, T. Delclos, V. Maurizot and I. Huc, Assessing stabilisation through π–π interactions in aromatic oligoamide β-sheet foldamers, copyright 2014. d. Design of basket with helix-sheet-helix architecture that can bind and release a guest with minimal perturbation of its structure, adapted from ref. 163 with permission from the American Chemical Society, A. Lamouroux, L. Sebaoun, B. Wicher, B. Kauffmann, Y. Ferrand, V. Maurizot and I. Huc, Controlling dipole orientation through curvature: aromatic foldamer bent β-sheets and helix-sheet-helix architectures, copyright 2017.

upon application of chemical stimuli in aqueous solution (Fig. 19c).[166] Linear oligomers containing two (lin2) or four (lin4) perylene tetracarboxylic diimide units, monocyclic complement (cyc2), and concatenated foldable rings (cat4) were prepared and studied by single molecule fluorescence spectroscopy by Han and co-workers (Fig. 19d).[167]

Bie and co-workers reported the capability of oligohydrazines to recognise saccharides as well as halide anions.[170]

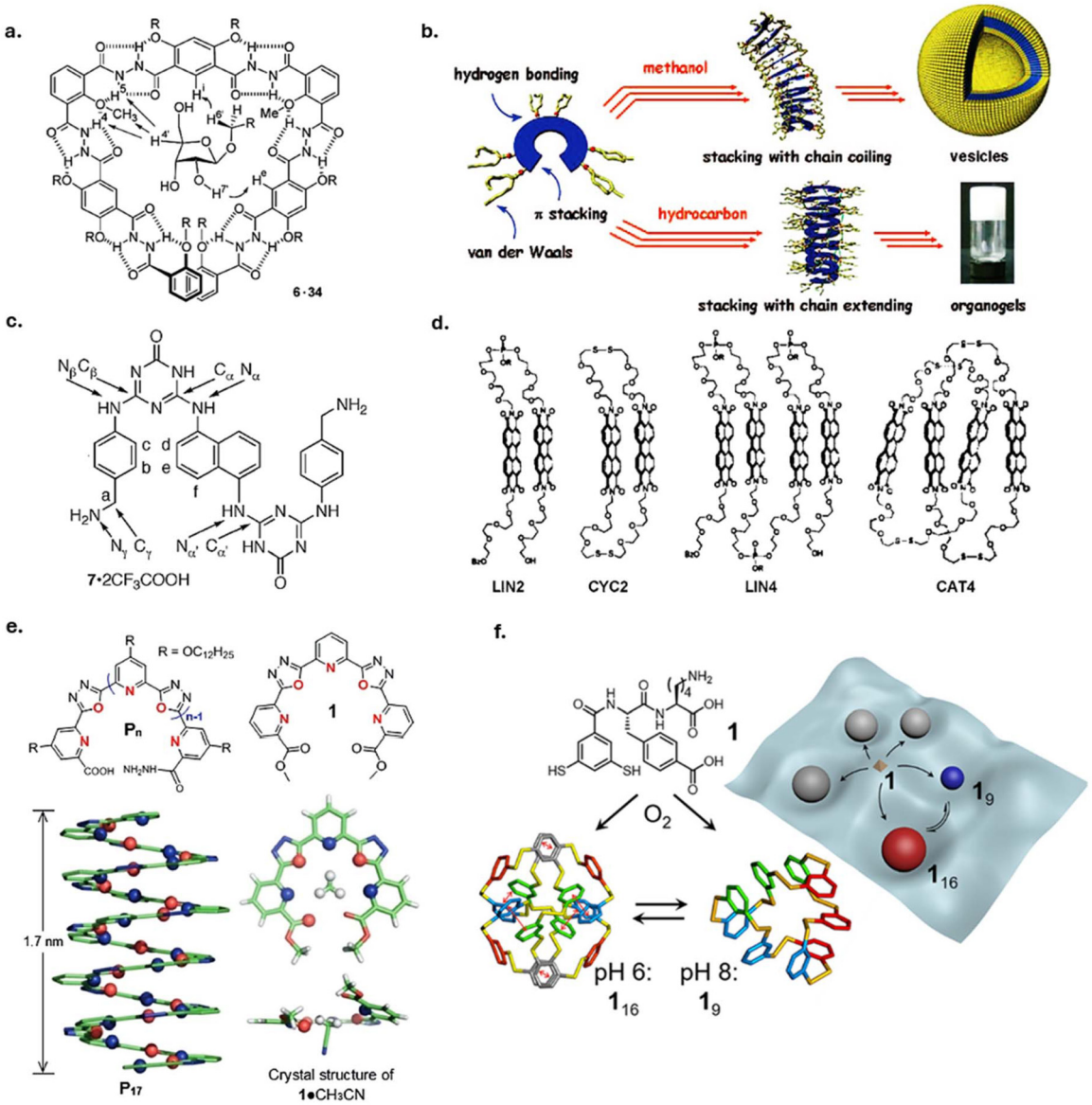


Fig. 19 a. Oligohydrazine-based foldamer, reproduced from ref. 164 with permission from the American Chemical Society, J. L. Hou, X. B. Shao, G. J. Chen, Y. X. Zhou, X. K. Jiang and Z. T. Li, Hydrogen bonded oligohydrazide foldamers and their recognition for saccharides, copyright 2004. b. Oligohydrazine and the proposed mechanism of vesicle formation and organogel formation, reproduced from ref. 165 with permission from the American Chemical Society, W. Cai, G. T. Wang, Y. X. Xu, X. K. Jiang and Z. T. Li, Vesicles and organogels from foldamers: a solvent-modulated self-assembling process, copyright 2008. c. Triazene-arylene oligomer, reproduced from ref. 166 with permission from the American Chemical Society, S. Liu, P. Y. Zavalij, Y. F. Lam and L. Isaacs, Refolding foldamers: triazene-arylene oligomers that change shape with chemical stimuli, copyright 2007. d. Linear, monocyclic and concatenated foldable rings with perylene tetracarboxylic diimide units, reproduced from ref. 167 with permission from the American Chemical Society, J. J. Han, A. D. Shaller, W. Wang and A. D. Q. Li, Architecturally diverse nanostructured foldamers reveal insightful photoinduced single-molecule dynamics, copyright 2008. e. Pyridine/oxadiazole-based helical foldamer ion channel, reproduced from ref. 168 with permission from Wiley, F. Chen, J. Shen, N. Li, A. Roy, R. Ye, C. Ren and H. Zeng, Pyridine/oxadiazole-based helical foldamer ion channels with exceptionally high K^+/Na^+ selectivity, copyright 2020. f. Size and shape shifting foldamer based on disulfide peptides, reproduced from ref. 169 under the terms of the Creative Commons Attribution 4.0 International License.

Zhao and co-workers designed a well-folded pyridone foldamer capable of binding with potassium that serves as an organocatalyst for transition-metal-free arylations of unactivated arenes.[171] Ahn and Grate reported that triazene-based foldamers are biomimetic and robust. Molecular dynamic simulations showed that linear nanorod foldamers stabilised by hydrogen bonding and π–π interactions could form. These nanorods resemble those of DNA, α-helices, and β-sheets.[172] More recently, Chen and co-workers reported on pyridine/oxadiazole-based helical foldamer ion channels with high selectivity for potassium and sodium ions (Fig. 19e).[168] Another interesting building block based on an aromatic di-thiols has

been developed by Pappas and co-workers. They showed that different sized cyclic structures form depending on the attached side groups.[173] The reversable covalent nature of the disulfide bond also makes it possible to form dynamic foldamer structures. Following this, Jin and colleagues reported the first size and shape shifting foldamer based on disulfide peptides. They reported that the macrocycle ring size as well as its folded shape could be changed through varying the pH of the solution (Fig. 19f).[169] Recently Lee and colleagues have reviewed foldamers based on *N*-arylene and ethynylene, giving a good summary of their structure, function and applications.[174]

The diverse building blocks and shapes of foldamers offer a rich landscape of structural motifs and functional properties, providing a versatile platform for molecular design and engineering. By harnessing the unique characteristics of each foldamer class, researchers can tailor their properties for specific applications paving the way for innovative solutions to complex challenges in healthcare, energy, and environmental sustainability.

4 Applications of foldamers

4.1 Foldamer-based anion receptors/transporters

As seen from the discussion of different foldamers, anion recognition chemistry is a highly explored research field in supramolecular chemistry. Most anions are generally good hydrogen bond acceptors, and the foldamers are typically constructed with the required hydrogen bond donor groups in the backbone of the oligomers.[175] The hydrogen bond donors typically include the polarized CH protons of 1,2,3-triazoles[110,111] (Fig. 11a and b), and the NH protons of indoles[149,176] (Fig. 16a), ureas[177,178] (Fig. 20a and b) and amides (Fig. 20c).[179] These foldamers can be designed with specific hydrogen bond directionality leading to specific conformations with specific sizes, which allows differentiation among anions. In designing foldamers with effective host : guest interactions, the organisation energy of the foldamer to encapsulate the guest ion is of great importance.[180] In the last decade, focus has progressed from developing foldamers as anion receptors to their application as anion transmembrane transporters.[181] Anions fulfil important roles in multiple biological processes.[182,183] Multiple diseases

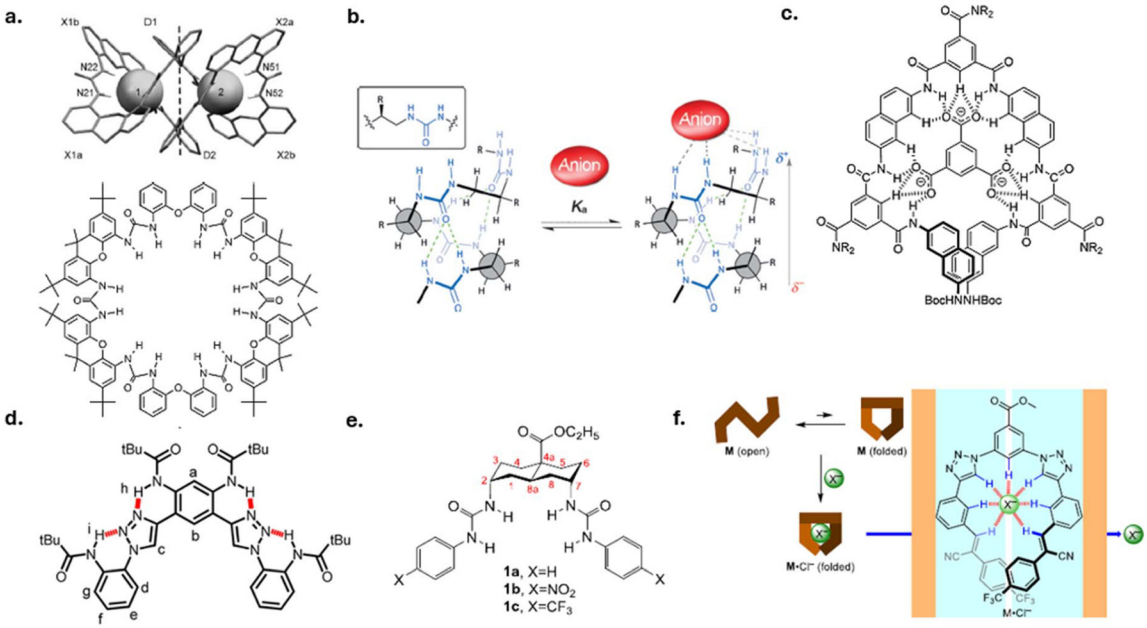


Fig. 20 a. A macrocyclic hexaurea that wraps around two Cl^- ions in a figure eight shape, reproduced from ref. 177 with permission from Wiley, D. Meshcheryakov, V. Böhmer, M. Bolte, V. Hubscher-Bruder, F. Arnaud-Neu, H. Herschbach, A. Van Dorsselaer, I. Thondorf and W. Mögelin, Two chloride ions as a template in the formation of a cyclic hexaurea, copyright 2006. b. Aliphatic helical oligourea for anion recognition, reproduced from ref. 178 with permission from Wiley, V. Diemer, L. Fischer, B. Kauffmann and G. Guichard, Anion recognition by aliphatic helical oligoureas, copyright 2016. c. Aromatic amide-based oligomer with folding induced by benzene-1,2,3-tricarboxylate anion, reproduced from ref. 179 with permission from the American Chemical Society, Y. X. Xu, G. T. Wang, X. Zhao, X. K. Jiang and Z. T. Li, Folding of aromatic amide-based oligomers induced by benzene-1,3,5-tricarboxylate anion in DMSO, copyright 2009. d. Preorganised aryl-triazole foldamer effective in transmembrane transport of Cl^-, reproduced from ref. 185 with permission from the American Chemical Society, J. Shang, W. Si, W. Zhao, Y. Che, J. L. Hou and H. Jiang, Preorganized aryltriazole foldamers as effective transmembrane transporters for chloride anion, copyright 2014. e. Decalin tetra urea foldamers for transmembrane anion transport, reproduced from ref. 186 with permission from Elsevier, H. Valkenier, C. M. Dias, C. P. Butts and A. P. Davis, A folding decalin tetra-urea for transmembrane anion transport, copyright 2017. f. Triazole-cyanostilbene foldamer capable on transmembrane transport of anions through a lipid bilayer membrane, reproduced from ref. 187 with permission from the American Chemical Society, D. Mondal, M. Ahmad, P. Panwaria, A. Upadhyay and P. Talukdar, Anion recognition through multivalent C–H hydrogen bonds: anion-induced foldamer formation and transport across phospholipid membranes, copyright 2022.

such as cystic fibrosis, Batter syndrome and Dent's disease are thought to be caused by the dysfunction of Cl^- ion channels.[184] Understanding the Cl^- ion transmembrane transport mechanism and possible replacement of these ion channels with biocompatible foldamers are therefore of interest. Shang and co-workers were the first to report that a preorganized aryl-triazole foldamer could be used as an effective transmembrane transporter for Cl^- ions across a lipid bilayer (Fig. 20d).[185] Valkenier and co-workers identified another foldamer capable of anion transmembrane transport. They synthesised a decalin-bis isocyanate coupled with *o*-aminophenyl urea side arms that could bind and transport anions (Fig. 20e).[186] Mondal and co-workers designed a triazole-cyanostilbene foldamer that could effectively transport SO_4^{2-} and Cl^- ions through a lipid bilayer membrane (Fig. 20f).[187] Other similar work has been reported for quinoline-derived helical unimolecular transmembrane proton channels,[188] and pyridine-oxadiazole-derived transmembrane potassium channels.[189] In contrast, oligourea based foldamers have been shown to have excellent water permeability across lipid membranes with low to no ion transport. This allows oligourea foldamers to have potential applications in water purification.[190]

4.2 Foldamer-based sensors/transporters for alkaline ions and metal cations

Binding of cations in helical cavities has also been a widely explored research field in foldamer applications. Lehn and co-workers developed a naphthyridine-pyrimidine oligomer that possesses electrical dipoles pointing into the helical cavity suitable for binding to alkaline ions such as K^+ and Cs^+ through ion–dipole interactions (Fig. 21a).[191] Tian and co-workers have recently showed that artificial ion channels could be constructed using *o*-phenanthroline-oxadiazole-based foldamers with H^+, Na^+ and K^+ transport capabilities similar to natural gramicidin A.[192] Lin and co-workers also used *o*-phenanthroline-oxadiazole-based foldamers functionalised with carboxylic acid terminal end groups, which allowed high Ca^{2+}/Mg^{2+} selectivity ratios. The deprotonation of the carboxylic end groups in aqueous media allowed effective electrostatic interaction with the Ca^{2+} ions, and the size of the cavity made it more selective towards Ca^{2+} than Mg^{2+} ions (Fig. 21c).[193] Xu and colleagues synthesized aromatic foldamer channels with tunable pore sizes, those with larger pore sizes were able to transport larger molecules such as glucose and those with narrow pore sizes had selectivity towards Na^+/K^+ ions.[194] Shen and his colleagues developed a Li^+ selective channel using pyridine and thiopyridone units. The helical structure is stabilised through hydrogen bonding between the amide H-atom and the O- and S-atoms within the cavity and the electron rich nature and the cavity size made it highly selective for transporting Li^+ ions over Na^+ and K^+ ions.[195] Zubair and colleagues wrote a short review classifying all the different building blocks used in foldamers channels and highlighted their

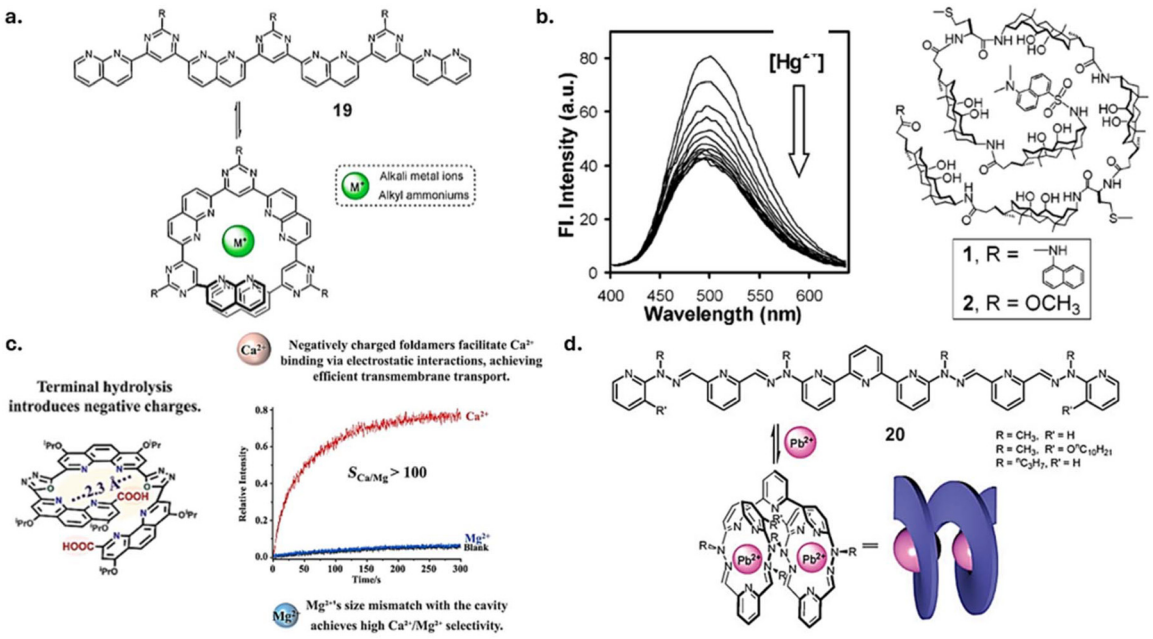


Fig. 21 a. Naphthyridine–pyrimidine oligomer binding to alkali metal cations within a helical cavity, reproduced from ref. 202 with permission from the Royal Society of Chemistry, H. Juwarker, J. M. Suk and K. S. Jeong, Foldamers with helical cavities for binding complementary guests, copyright 2009. b. Fluorescence spectra of mercury solution titration experiment with oligocholate foldamers, reproduced from ref. 198 with permission from the American Chemical Society, Y. Zhao and Z. Zhong, Tuning the sensitivity of a foldamer-based mercury sensor by its folding energy, copyright 2006. c. *o*-Phenanthroline-oxadiazole-based foldamer Ca^{2+} ion channel, reproduced from ref. 193 with permission from Wiley, Z. Lin, S. Yu, J. Chen, J. Tian, Z. Xu, C. Yao and Z. Dong, Artificial foldamer-based calcium ion carriers with high Ca^{2+}/Mg^{2+} selectivity ratio, copyright 2025. d. Pyridine-hydrazone oligomer demonstrating 1 : 2 binding to Pb^{2+}, reproduced from ref. 202 with permission from the Royal Society of Chemistry, H. Juwarker, J. M. Suk and K. S. Jeong, Foldamers with helical cavities for binding complementary guests, copyright 2009.

potential to be used in remedial applications for dysfunctional natural channels.[196] Yao and colleagues showed that pyridine-oxadiazole based foldamers were suitable for use as catalysts for alkali-cation-selective arylation reactions.[197] Zhao and Zhong focused some of their research on metal cation sensors based on cholates. Although oligocholates do not have any intramolecular forces that drive folding, they are very sensitive to solvophobic interactions. They reported on an oligocholate as a mercury sensor. The foldamer end groups were modified with naphthyl and danzyl allowing them to study the folding behaviour using FRET (Fig. 21b).[198] Zhao and Zhong also designed an oligocholate capable of detecting zinc ions, by formation of a pyrene excimer when binding occurs through helical folding.[199] Ramírez and co-workers developed a pyridine-hydrazone oligomer capable of binding lead ions in a 1 : 2 stoichiometry (Fig. 21d).[200] For more examples of the role of metal ions in foldamers and their interaction, see the recent review by Algar and co-workers.[201]

4.3 Foldamer-based capsules for biomolecular recognition

Foldamers offer a versatile platform for designing sensors capable of selectively recognising and detecting biomolecules with high sensitivity and specificity. By engineering foldamers with tailored binding pockets and recognition motifs, researchers can develop sensors for a wide range of targets, including proteins, nucleic acids, and small molecules. Molecular capsules have been used in catalysis,[203] drug delivery,[204] and protection of ligands from degradation,[205] which inspired the design of foldamer capsules that can do the same.

Wang and co-worker designed a hybrid polymer for selective DNA fluorescence probes. The polymer consisted of an alternating sequence of a biological single strand deoxyribonucleic acid and an organic fluorescent sequence, which enabled self-assembly into folded nanostructures. The biological sequences helped with molecular recognition and the synthetic sequence offered fluorescence detection. They showed that configurational changes occur when binding with polynucleotides by using fluorescence measurements.[206] Li and co-workers developed chiral aromatic hydrazide foldamers capable of encapsulating alkylated glucose derivatives with good diastereomeric selectivity. Selectivity was probed by incorporating *R*- or *S*-proline units at the ends of the backbone (Fig. 22a).[207]

In 2014, Zhang and colleagues wrote a thorough review an aromatic amide and hydrazide-based foldamers and their host-guest capabilities. The focus of the review was on larger guests such as mono- and disaccharides, chiral aromatic amines and acids and on how to potentially tune the dynamics of the host–guest interactions.[211] Huc's group has also focused on designing sequence-defined aromatic oligoamides for selective encapsulation of fructose,[212] citric acid,[209] (Fig. 22c) tarta-

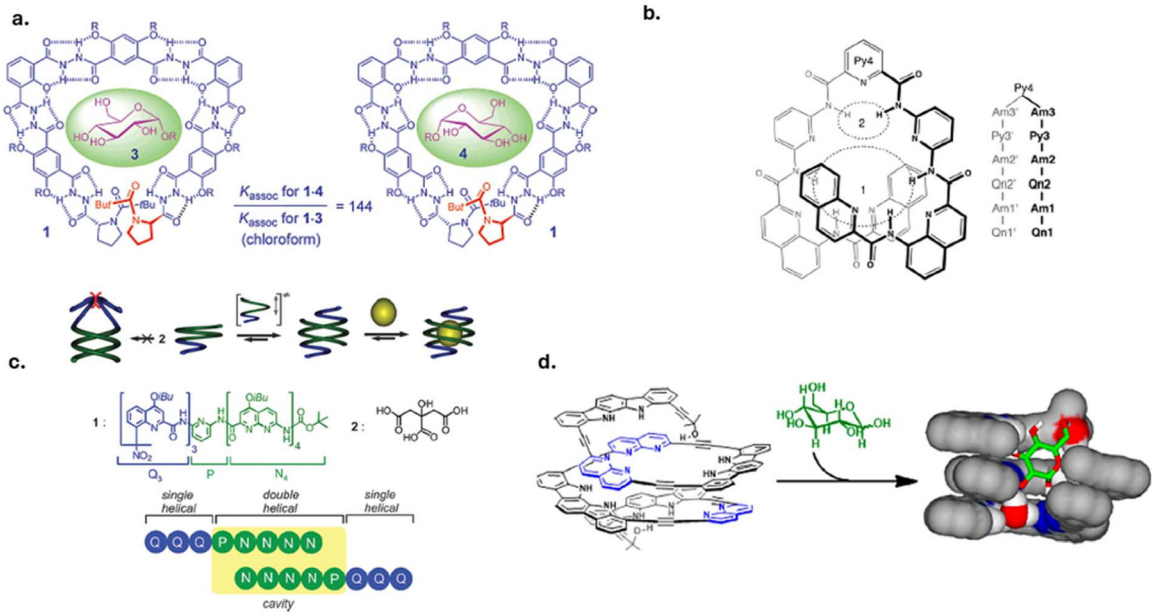


Fig. 22 a. Chiral aromatic hydrazide foldamers complexing with alkylated glucose derivatives in chloroform, reproduced from ref. 207 with permission from the American Chemical Society, C. Li, G. T. Wang, H. P. Yi, X. K. Jiang, Z. T. Li and R. X. Wang, Diastereomeric recognition of chiral foldamer receptors for chiral glucoses, copyright 2007. b. Hybrid pyridine–quinoline arylamide foldamers and their two binding sites in the capsule, reproduced from ref. 208 with permission from the Royal Society of Chemistry, A. M. Abramyan, Z. Liu and V. Pophristic, mechanistic and dynamic insights into ligand encapsulation by helical arylamide foldamers, copyright 2014. c. Double helix equilibrium of aromatic oligoamide and its encapsulation of citric acid, reproduced from ref. 209 with permission from the Royal Society of Chemistry, N. Chandramouli, Y. Ferrand, B. Kauffmann and I. Huc, Citric acid encapsulation by a double helical foldamer in competitive solvents, copyright 2016. d. Indolocarbazole–naphthyridine encapsulating glucose, reproduced from ref. 210 with permission from the American Chemical Society, J. Y. Hwang, H. G. Jeon, Y. R. Choi, J. Kim, P. Kang, S. Lee and K. S. Jeong, Aromatic hybrid foldamer with a hydrophilic helical cavity capable of encapsulating glucose, copyright 2017.

ric acid,[213] xylobiose and homomeric or heteromeric pairs of pentoses.[214] Abramyan and co-workers did an intensive study on arylamide foldamers based on hybrid pyridine–quinoline sequences and its 'apple peel' shaped capsule capable of encapsulating ligands such as water, hydrogen peroxide, hydrazine, formic acid and methanol (Fig. 22b).[208] Hwang and coworkers reported on a foldamer based on indolocarbazole–naphthyridine capable of encapsulating monosaccharides (Fig. 22d).[210] Ge and co-workers recently reported that positively charged helical foldamers could also be used for transmembrane delivery of nucleic acids, and hence could be used in therapeutic applications.[215]

4.4 Foldamers in protein complexes and protein surface recognition

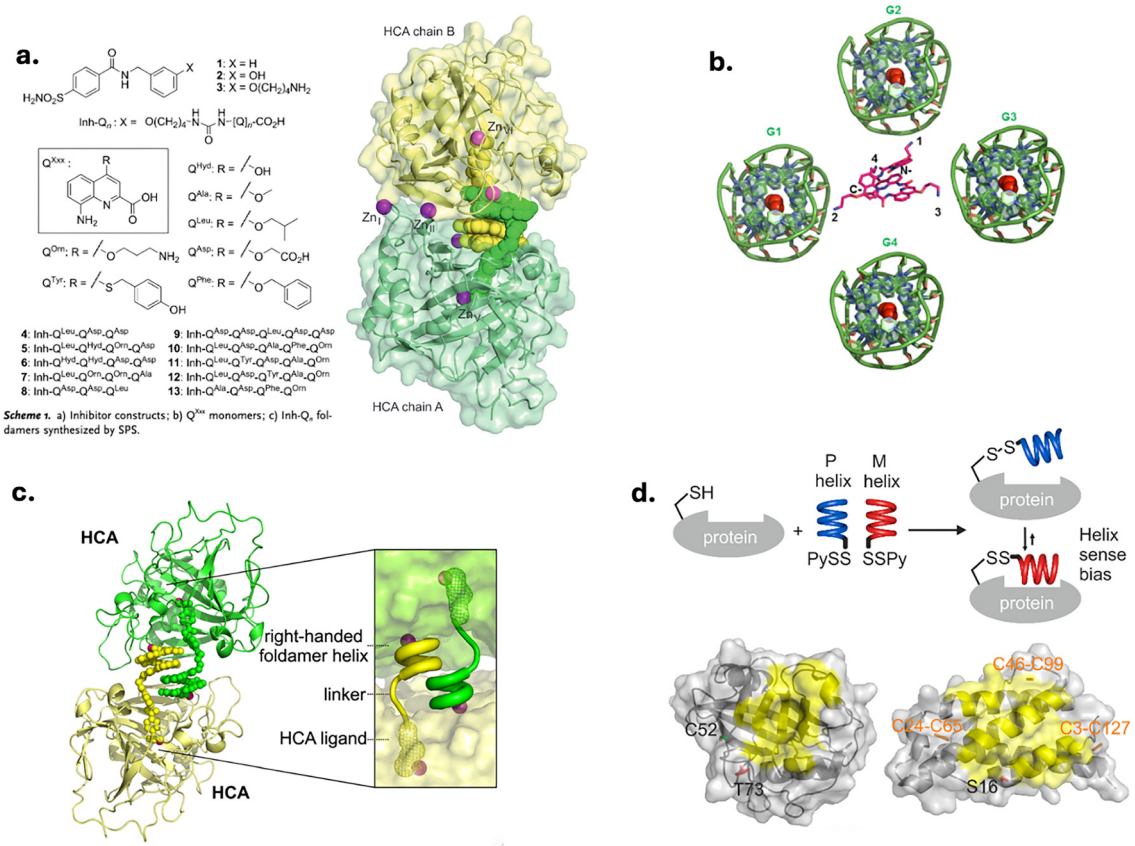
Proteins typically function as complexes or within networks by interactions with other proteins.[216] The study of foldamers in protein complexes and recognition of protein surfaces has been a topic of research in the last decade. Inhibition of protein–protein interaction (PPI) has high therapeutic potential;[217] however, PPI inhibitors based on traditional small molecules are still a challenge because they often struggle to disrupt these interactions due to the large and dynamic binding interfaces in PPIs.[218] The use of α-helix mimetics as PPI inhibitors has increasingly been studied, as they exhibit more complex binding modes that utilize more than one recognition point or can bind with longer surface contacts.[219] Developments in this area using foldamers can lead to the development of new PPI inhibitors, pharmacological tools and therapeutics.[220]

Buratto and co-workers developed 10 helical aromatic oligoamide foldamers based on 8-amino-2-quinolinecarboxylic acid (Q), where the repeat units were equipped with proteinogenic side chains. The crystal structure of the complex between one foldamer and human carbonic anhydrase II (HCA) could be resolved and revealed several foldamer–protein, foldamer–foldamer, and protein–protein interactions (Fig. 23a).[221] Mandal and colleagues was the first to identify that quinoline-based oligoamide foldamers are a powerful class of ligands for G-quadruplex DNA (Fig. 23b).[222] Jewginski and co-workers also showed that protein dimerization can be promoted using the aggregation properties of a protein ligand. Crystal structures showed that the hydrophobicity of the oligoamide and its side chain interaction formed a HCA_2–$foldamer_3$ complex in which you can find three stacked helices with two of them linked to an HCA molecule (Fig. 23c).[223] Vallade and colleagues extended their research to other proteins such as cyclophilin A (CypA) and interleukin4 (IL4), which are relevant therapeutic targets in PPIs. They developed a tethering approach for detection of the protein–foldamer interactions. The CypA/IL4 were linked by a disulfide bridge of varying lengths and the foldamers were equipped with different proteinogenic side chains. CD spectroscopy revealed diastereoselective surface interactions between foldamer and protein, which induced preferred handedness of the foldamer helix (Fig. 23d).[224]

4.5 Foldamer-based stimuli-responsive materials

Foldamers can also be designed to respond to external stimuli, such as UV light, temperature changes, pH changes or solvent polarity, leading to the development of stimuli-responsive materials. By incorporating responsive elements into the foldamer backbone, researchers can engineer materials with tuneable properties and dynamic functionalities.[61] Incorporating foldamers into mechanoresponsive materials has also been a topic of many research teams due to the fact that it allows for reversibility that can typically not be achieved by small molecules due to irreversible bond breaking.[225]

A good example of a photo-responsive foldamer was reported when Hecht and Khan incorporated a photochromic azo-benzene unit into an *m*-PPE. They designed it with *cis*- and *trans* azobenzene moieties, which selectively turn the helical conformation on and off with UV radiation (Fig. 24a).[226,227] Yu an co-workers did a comprehensive study on these photoswitchable polymers focussing on the role of the number of switching units and their specific location and orientation in the helical backbone.[228] Steinwand and colleagues studied the ultrafast dynamics of the photoisomerization of the azobenzene moieties in the foldamer backbone by time resolved femtosecond/picosecond pump–probe spectroscopy.[229] Meudtner and co-workers introduced an alternating triazole-pyridine/benzene copolymer that forms helical structures and with addition of transition metal ions, these polymers turn into gels. The metal ions cause coordinative crosslinks to form between polymers, which leads to gelation of the polymer solutions. These polymers show potential applications as sensors and magnetic materials (Fig. 24b).[230] In 2010, Flood and Hua developed an achiral aryl-triazole-based foldamer able to regulate chloride concentrations in solution by photoisomerization. The polymer was modified with two azobenzene end groups which creates a folded binding pocket for the chloride ions. Upon irradiation with UV light, the chloride ions are released, because the *trans*-dominated structure becomes unstable (Fig. 24c).[231] Similar work was also reported by Wang and Lee.[232,233] Another photo-active group that can be used is tetraphenylethylene (TPE). Hardoin and coworkers showed that the photo-induced protonation of TPE end groups causes the difunctionalised oligopyridine dicarboxamide helical foldamers to unfold (Fig. 24d).[234] Kouwer and co-workers presented a synthetic gel that can mimic gels prepared from peptidic materials. These foldamers are polyisocyanopeptides grafted with oligo(ethylene glycol) side chains. These thermally responsive polymers possess a stiff helical structure, have strong intramolecular hydrogen bonds and show a thermal transition upon heating where the chains start bundling together and then generate a transparent gel.[56] A pH-responsive foldamer was designed by Chen and co-workers, based on phenanthroline-derived oligoamides bearing a chiral (*R*)-phenethylamino end group. In solution, these foldamers formed helices with a single-handedness, and addition of triflic acid led to protonation of the phenanthroline, which caused random coil formation. This "off" switch could be reversed by



Scheme 1. a) Inhibitor constructs; b) Q^{Xxx} monomers; c) Inh-Q_n foldamers synthesized by SPS.

Fig. 23 a. Library of oligoamide foldamers, and crystal structure of the HCA–foldamer complex, reproduced from ref. 221 with permission from Wiley, J. Buratto, C. Colombo, M. Stupfel, S. J. Dawson, C. Dolain, B. Langlois D'Estaintot, L. Fischer, T. Granier, M. Laguerre, B. Gallois and I. Huc, Structure of a complex formed by a protein and a helical aromatic oligoamide foldamer at 2.1 Å resolution, copyright 2014. b. Aromatic amide foldamers and G-quadruplex DNA, reproduced from ref. 222 with permission from Wiley, P. K. Mandal, B. Benoît, B. Anglois D'estaintot, B. Kauffmann and I. Huc, Multivalent interactions between an aromatic helical foldamer and a DNA G-quadruplex in the solid state, copyright 2016. c. HCA_2–$foldamer_3$ complex, reproduced from ref. 223 with permission from the American Chemical Society, M. Jewginski, T. Granier, B. Langlois D'Estaintot, L. Fischer, C. D. Mackereth and I. Huc, Self-assembled protein-aromatic foldamer complexes with 2 : 3 and 2 : 2 : 1 stoichiometries, copyright 2017. d. Tethering of a racemic mixture of *P*- and *M*-helical foldamers to a protein *via* a disulfide bridge and preferred helix handedness through diastereoselective foldamer/protein surface interactions, reproduced from ref. 224 with permission from the American Chemical Society, M. Vallade, M. Jewginski, L. Fischer, J. Buratto, K. Bathany, J. M. Schmitter, M. Stupfel, F. Godde, C. D. Mackereth and I. Huc, Assessing interactions between helical aromatic oligoamide foldamers and protein surfaces: a tethering approach, copyright 2019.

deprotonation with triethylamine (Fig. 24e).[235] Sun and co-workers reported interesting amine-responsive phenol-based oligoamides. These foldamers contained deprotonateable OH groups that were sensitive to the basicity of the solutions and undergo amine-induced folding, which results in fluorescence quenching (Fig. 24f).[236] Brioche and co-workers developed a library of 2-aminoisobutyric acid-based achiral helical foldamers capable of functioning as a "proton-counting" molecular device by pH-dependent conformational changes. The foldamer had a basic binding site, which interacted with the most acidic chiral ligands in the ligand mixture and induced an absolute helical screw sense that could be relayed by the conformational reporter (enantiotropic methyl end groups) attached to the C-terminus. When a base or acid was added, the binding site modulated its interaction with the mixture of ligands, which resulted in a change in the helical sense (Fig. 24g).[237] Another acid switchable group that can be used for foldamer transitions is the *N*-alkylated imidazole amide, which prefers the *trans*-configuration after protonation.[238] Liu and co-workers also developed sequence-defined aryl-triazole-based foldamers that form chloride templated helices. They could interconvert between a 1 : 1 single helix and a 2 : 2 double helix through the interplay of the unit sequences, solvent quality, temperature and concentration. The double helix was highly preferred when the chain end had stabilising $CH\cdots Cl^-$ hydrogen bonding units such as the bisamide phenylenes. Solvophobic effects could also help to stabilise the 2 : 2 double helix (Fig. 24h).[239]

4.6 Foldamers as charge-transfer materials

Bridge-mediated electron transport is subject of research in fields such as physics, chemistry, and biology.[240] Some proteins are known to act as electron-transfer agents, which is key in multiple cellular processes including, photosynthesis,[241–243]

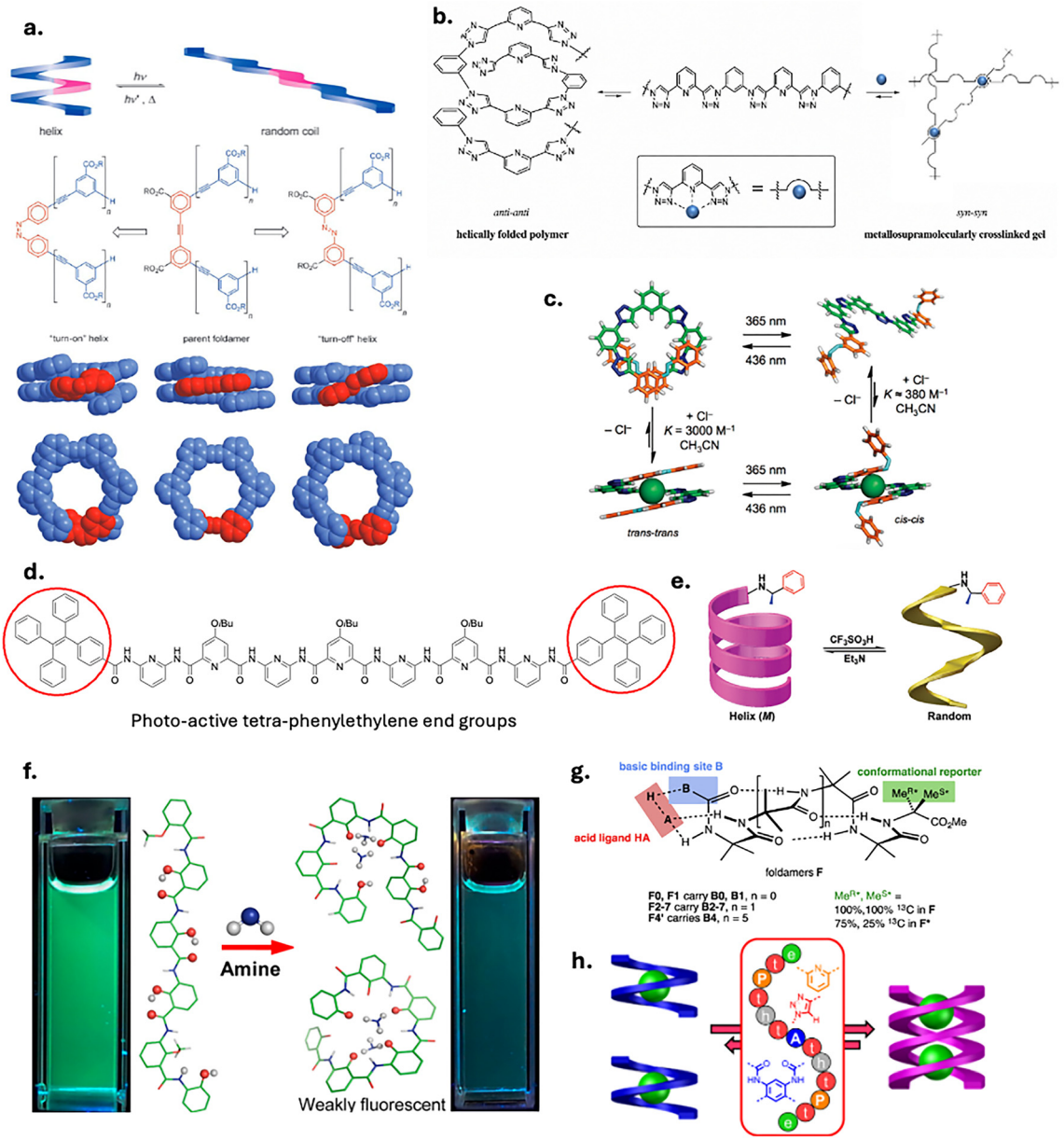


Fig. 24 a. Photo-responsive *m*-PPE with incorporated azobenzene, reproduced from ref. 226 and 227 with permission from Wiley, A. Khan and S. Hecht, Towards photocontrol over the helix-coil transition in foldamers: synthesis and photoresponsive behaviour of azobenzene-core amphiphilic oligo(*meta*-phenylene ethynylene)s. and A. Khan, C. Kaiser and S. Hecht, Prototype of a photoswitchable foldamer, copyright 2006. b. BTP-containing linear main chain polymers, their solution conformation, and formation of metallo-supramolecular gels, reproduced from ref. 230 with permission from Wiley, R. M. Meudtner and S. Hecht, Responsive backbones based on alternating triazole-pyridine/benzene copolymers: from helically folding polymers to metallosupramolecularly crosslinked gels, copyright 2008. c. Achiral aryl-triazole and cycle of photo-driven binding and release of chloride ions, reproduced from ref. 231 with permission from the American Chemical Society, Y. Hua and A. H. Flood, Flipping the switch on chloride concentrations with a light-active foldamer, copyright 2010. d. Photo-active tetra-phenylene end groups, reproduced from ref. 234 with permission from Wiley, L. Hardoin, R. Kdouh, Y. Aidibi, S. Azar, B. Siegler, M. Siegler, S. Goeb, E. Levillain, P. A. Bouit, O. Galangau, M. Sallé and D. Canevet, Photoresponsive helical foldamers: conformational control through double helix formation and light-induced protonation, copyright 2025. e. Phenanthroline-derived oligoamides with acid- and base-controllable switches, reproduced from ref. 235 with permission from the American Chemical Society, H. Y. Hu, J. F. Xiang, Y. Yang and C. F. Chen, Chiral induction in phenanthroline-derived oligoamide foldamers: an acid- and base-controllable switch in helical molecular strands, copyright 2008. f. Phenol-based oligoamides and their amine-induced folding and fluorescence quenching behaviour, reproduced from ref. 236 with permission from the American Chemical Society, C. Sun, Y. Liu, J. Liu, Y. J. Lu, L. Yu, K. Zhang and H. Zeng, Computational insights into processes underlying the amine-induced fluorescence quenching of a stimuli-responsive phenol-based hexameric foldamer host, copyright 2014. g. 2-Aminoisobutyric acid-based helical foldamer with basic binding site (blue), ligand interaction (red) and conformational reporter (green), reproduced from ref. 237 under the terms of the Creative Commons Attribution 4.0 International License. h. Sequence-defined aryl-triazole chloride-templated helixes, 1 : 1 single helix and 2 : 2 double helix, reproduced from ref. 239 with permission from the American Chemical Society, Y. Liu, F. C. Parks, W. Zhao and A. H. Flood, Sequence-controlled stimuli-responsive single-double helix conversion between 1 : 1 and 2 : 2 chloride-foldamer complexes, copyright 2018.

enzyme catalysis[244,245] and DNA repair. This inspired the design of artificial molecular electronic devices, as an application of foldamers in recent years. In 2016, Li and co-workers synthesized photoactive triads. An electron donor oligo(paraphenylenevinylene) was bridged with varying lengths of helical oligoamides appended with an electron acceptor (perylene bismide) on the other end. They showed that after photoexcitation, electron transfer through the bridge to the acceptor occurs on a picosecond time scale. The electron donor is oxidized and the hole migrates through the bridge to the acceptor, with the charge-separated state being in the micro second scale (Fig. 25a).[246] In the following year, Méndez-Ardoy investigated long-range vertical and horizontal charge transport in helical oligo-quinolinecarboxamide foldamers, organized as a single monolayer on a gold surface. Conductive AFM revealed that vertical conductivity occurred efficiently and horizontal conductivity was negligible (Fig. 25b).[247] Pulka-Ziach and co-workers introduced α-helicomimetic oligoureas capable of directional electron transport with length-dependant conductivity properties (Fig. 25c).[248]

4.7 Other interesting foldamer applications

Most of the intensely investigated applications of foldamers have been discussed thus far; however, other interesting applications of foldamers have been reported. For example, an oligopyridine foldamer has been reported that can interact with crystal surfaces and modify the growth of calcite crystals.[249] In 2011, Moore and Gosh studied an *m*-PE foldamer with macromolecules appended to its chain ends, and showed that the foldamers collapsed into helical conformations when the macromolecules exceeded a certain size limit (Fig. 26a).[250] They compared this to the ability of unstructured proteins, which induce folding of globular proteins. In 2016, a fluorescent probe for anions such as sulfate and fluoride were developed based on indolocarbazole–pyridine hybrid foldamers. Fluorescence of this foldamer was completely quenched in its helical conformation, but with disruption by anion interactions it became highly fluorescent (Fig. 26b).[251] In 2020, Bueno and co-workers discussed the principles of capacitive ion-sensing interfaces. They developed an aryl-triazole foldamer-based electrochemical anion sensor capable of recruiting ions from an electrolyte solution (Fig. 26c).[252] Foldamers can even be used in catalysis of chemical reactions, and the chirality of these polymers can lead to enantioselectivity with respect to the formed products. This is exemplified by the asymmetric hydrogenation of dehydroamino acid esters with a chiral Rh(I) catalyst, synthesized by complexation of Rh $(cod)_2BF_4$ with single-handed helical quinoline oligoamide foldamers (Fig. 26d).[253] Another foldamer-based chiral catalyst was based on naphthalenediamine oligomers, which could be used in the chemoselective addition reaction of malonate half-thioesters with enolate acceptors.[254] Hou and co-workers reported an interesting urea-based foldamer quaternary cocrystal. The foldamer co-crystalized with a halide anion, tetraalkylammonium cation and haloalkyne through hydrogen and halogen bonding (Fig. 26e).[255] Recently Laffilé and colleagues showed that water soluble quinoline based foldamers were able to emit circularly polarised luminescence, with potential

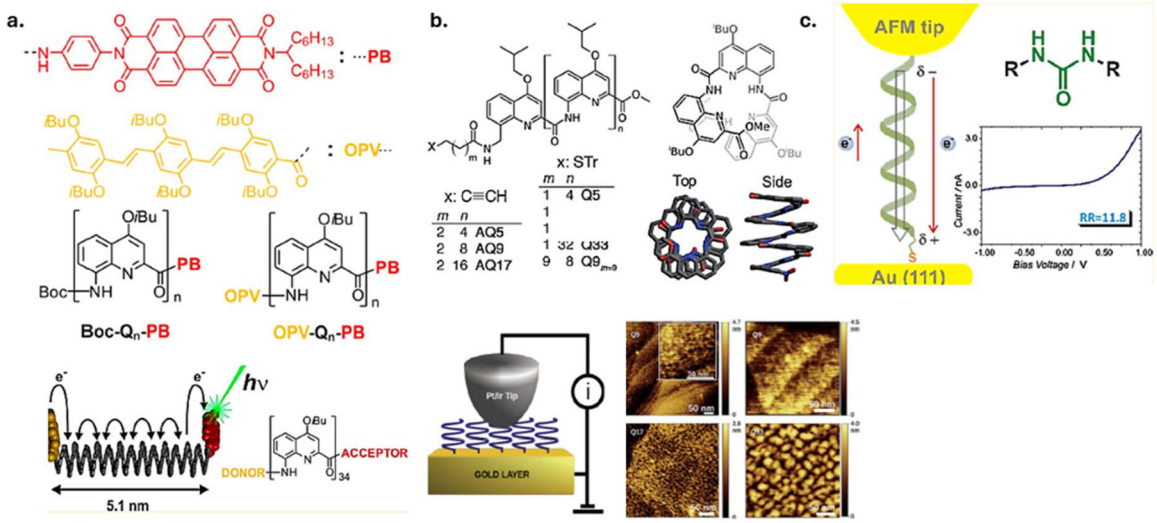


Fig. 25 a. Photoactive triad bridged with 9, 14, 18, 19, or 34 8-amino-2-quinolinecarboxylic acid repeat units, N-terminal electron-donor oligo (paraphenylenevinylene) (yellow) and a C-terminal electron acceptor perylene bisimide (red), reproduced from ref. 246 with permission from the American Chemical Society, X. Li, N. Markandeya, G. Jonusauskas, N. D. McClenaghan, V. Maurizot, S. A. Denisov and I. Huc, Photoinduced electron transfer and hole migration in nanosized helical aromatic oligoamide foldamers, copyright 2016. b. Oligo-quinolinecarboxamide monolayer on a gold surface and conductive AFM analysis, reproduced from ref. 247 with permission from the Royal Society of Chemistry, A. Méndez-Ardoy, N. Markandeya, X. Li, Y. T. Tsai, G. Pecastaings, T. Buffeteau, V. Maurizot, L. Muccioli, F. Castet, I. Huc and D. M. Huc, Multi-dimensional charge transport in supramolecular helical foldamer assemblies, copyright 2017. c. α-Helicomimetic oligoureas with 8–12 repeat units as candidate for nanoelectronics, reproduced from ref. 248 with permission from the American Chemical Society, K. Pulka-Ziach, A. K. Puszko, J. Juhaniewicz-Debinska and S. Sek, Electron transport and a rectifying effect of oligourea foldamer films entrapped within nanoscale junctions, copyright 2009.

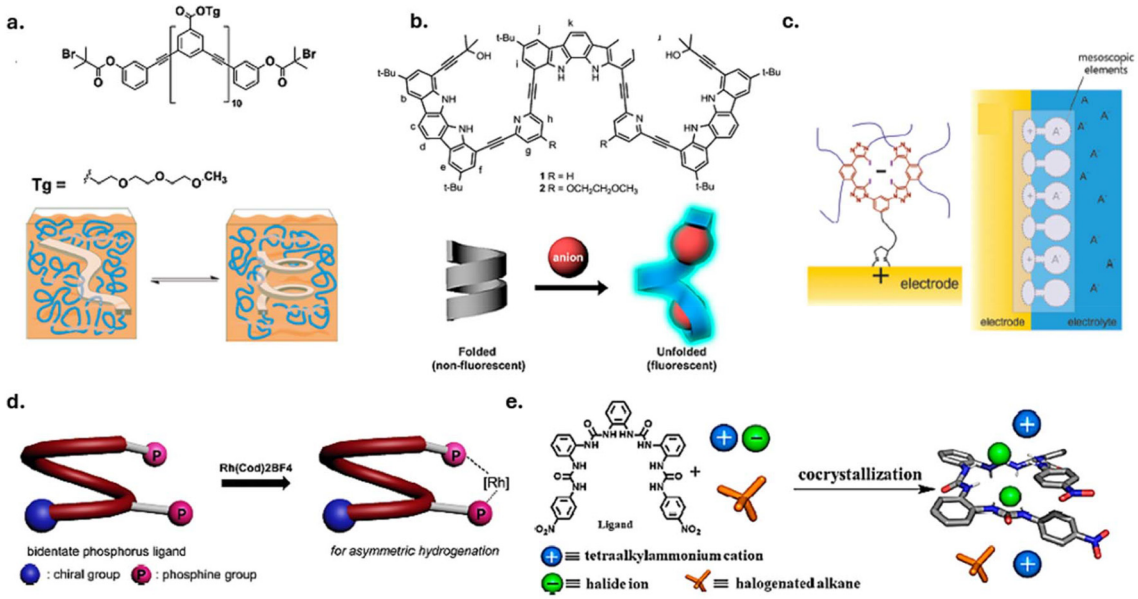


Fig. 26 a. *m*-PE appended with macromolecules equilibrate between unstructured and helical conformations, reproduced from ref. 250 with permission from the American Chemical Society, K. Ghosh and J. S. Moore, Foldamer structuring by covalently bound macromolecules, copyright 2011. b. Indolocarbazole–pyridine hybrid fluorescent probe for anions, reproduced from ref. 251 with permission from the American Chemical Society, copyright 2016. c. Depiction of an occupied mesoscopic receptor–electrode based on aryl-triazole foldamers, reproduced from ref. 252 with permission from the Royal Society of Chemistry, P. R. Bueno, R. Hein, A. Santos, and J. J. Davis, The nanoscopic principles of capacitive ion sensing interfaces, copyright 2020. d. Single-handed quinoline oligoamide foldamer complex resulting in a chiral Rh(I) catalyst, reproduced from ref. 253 with permission from the Royal Society of Chemistry, L. Zheng, D. Zheng, Y. Wang, C. Yu, K. Zhang, and H. Jiang, Chiral bisphosphine ligands based on quinoline oligoamide foldamers: application in asymmetric hydrogenation, copyright 2019. e. Illustration of quaternary cocrystal formation of urea foldamer, anion, cation and halogenated alkene, reproduced from ref. 255 with permission from the American Chemical Society, L. Hou, L. Gao, W. Zhang, X. J. Yang and B. Wu, Quaternary cocrystals based on halide-binding foldamers through both hydrogen and halogen bonding, copyright 2021.

applications in chiroptical bioimaging.[256] As discussed previously foldamers have potential as PPI inhibitors. Mauran and co-workers have also shown that attaching a short oligourea helix to the termini of peptides aided the formation of α-helix structures in water, a structure which is typically compromised in water due to competitive H-bonding with the solvent.[257]

5 Conclusions and future outlook

This review summarizes the current state-of-the-art in abiotic foldamer research and highlights the transformative potential of this rapidly evolving field. Aromatic rings and cyclics are the most commonly used backbone building blocks given that they impose constraints in the folded conformation and aid in stabilisation of foldamers through π–π interactions. Amides, triazoles, ureas and hydrazines are typically introduced into a backbone to stabilise the foldamer through hydrogen bonding. Side-chain functionalities are just as important for the foldamer-folding behaviour because they dictate intermolecular interactions, the shape and surface characteristics in solution. Stereochemistry, introduces additional complexity and diversity into foldamer design and by controlling spatial arrangement within a foldamer backbone, researchers can create enantiomerically pure structures with selective folding properties, chiral recognition capabilities and enhanced biological activity. Using computational approaches can accelerate the discovery and design of new foldamer structures with tailored properties and functions. A relatively unexplored area in foldamer design is the use of atropisomeric bonds which restrict rotation around specific single bonds. Researchers can potentially open up another dimension of control when designing foldamers with atropisomeric bonds. By harnessing these principles of foldamer design and leveraging innovative synthesis and characterization techniques, researchers can unlock new opportunities for advancing molecular engineering and addressing complex biomedical and materials science challenges. The diversity of foldamer architectures and their building blocks, is potentially limitless, and understanding how different building blocks can be used to create different shapes and structures, can help researchers develop new foldamers. While challenges remain in foldamer design, synthesis, and characterization, interdisciplinary collaborations and technology integration offer exciting opportunities for advancing foldamer research and realizing their full potential in nanotechnology and beyond. An understudied topic in foldamer research concerns tertiary and higher-order structures. To maximize understanding of foldamers and their potential applications, the design and study of more complex architec-

tures is still needed. By exploring the emerging applications, it is clear that abiotic foldamers are closing the gap between small molecules and natural proteins. Foldamers can be designed to have specific functions, which include, anion, alkaline and metal ion receptors/transporters and biomolecular and protein recognition. Foldamers can be designed to react to external stimuli such as (UV) light, temperature changes and pH changes, which give access to specific functionality on demand. Foldamers with charge-transfer capabilities can be used to design artificial molecular electronic devices. In conclusion, foldamers are poised to make significant contributions to molecular engineering, materials science, and therapeutics, potentially shaping the future of healthcare, energy and environmental sustainability.

Author contributions

A. C.: data curation, investigation, writing (original draft), writing (review & editing). R. P.: conceptualization, supervision, writing (review & editing). B. K.: conceptualization, funding acquisition, supervision, writing (review & editing).

Conflicts of interest

The authors have no conflicts of interest to declare.

Data availability

As a review, this manuscript doesn't contain original data. Hence, a data statement is not applicable.

Acknowledgements

The authors acknowledge financial support through the South African Research Chair Initiative (SARChI) of the National Research Foundation (NRF) and the Department of Science and Technology (DST) (grant no: 46855).

References

1 D. J. Hill, M. J. Mio, R. B. Prince, T. S. Hughes and J. S. Moore, A Field Guide to Foldamers, *Chem. Rev.*, 2001, **12**, 3893–4011, DOI: 10.1021/cr990120t.
2 C. S. Hanes, The Action of Amylases in Relation to the Structure of Starch and Its Metabolism in the Plant. Parts IV-VII, *New Phytol.*, 1937, **36**(3), 189–239, DOI: 10.1111/j.1469-8137.1937.tb06913.x.
3 H. R. Branson, R. B. Corey and L. Pauling, The Structure of Proteins; Two Hydrogen-Bonded Helical Configurations of the Polypeptide Chain, *Proc. Natl. Acad. Sci. U. S. A.*, 1951, **375**, 205–211, DOI: 10.1073/pnas.37.4.205.
4 J. D. Watson and F. H. C. Crick, Molecular Structure of Nucleic Acids A Structure for Deoxyribose Nucleic Acid, *Nature*, 1953, **171**, 737–738, DOI: 10.1038/171737a0.
5 D. Lundberg and B. R. Doty, P. Polypeptides. XVII. A Study of the Kinetics of the Primary Amine-Initiated of N-Carboxy-Anhydrides with Special Reference to Configurational and Stereochemical Effects, *J. Am. Chem. Soc.*, 1957, **79**, 3961–3972, DOI: 10.1021/ja01572a004.
6 D. Cambridge, P. D. Lundberg and R. Massachusetts, Polypeptides. Xa. Additional Comments of the Amine-Initiated Polymerization, *J. Am. Chem. Soc.*, 1957, **79**(9), 2338–2339, DOI: 10.1021/ja01566a087.
7 F. Chen, G. Lepore and M. Goodman, Conformational Studies of Poly[(S)-/3-Aminobutyric Acid], *Macromolecules*, 1974, **7**(6), 779–783, DOI: 10.1021/ma60042a016.
8 J. M. Fernández-Santín, J. Aymamí, A. Rodríguez-Galán, S. Muñoz-Guerra and J. A. Subirana, A Pseudo α-Helix from Poly(α-Isobutyl-*L*-Aspartate), a Nylon-3 Derivative, *Nature*, 1984, **311**, 53–54, DOI: 10.1038/311053a0.
9 G. Natta, P. Pino, P. Corradini, F. Danusso, E. Mantica, G. Nazzanti and G. Moraglio, Crystalline High polymers of α-Olifins, *J. Am. Chem. Soc.*, 1955, **77**, 1708, DOI: 10.1021/ja01611a109.
10 P. Pino and G. P. Lorenzi, Optically active vinyl polymers. II. The Optical Activity of Isotactic and Block Polymers of Optically active α- olefins in Dilute Hydrocarbon Solution, *J. Am. Chem. Soc.*, 1960, **82**, 4745–4747, DOI: 10.1021/ja01502a077.
11 P. Pino, G. P. Chiradelli and G. P. Lorenzi, Optically Active Vinyl Polymers. VI. Chromatographic resolution of Linear Polymers of (*R*)(*S*)-4-methyl-1-hexene, *J. Am. Chem. Soc.*, 1962, **84**, 1487, DOI: 10.1021/ja00867a027.
12 P. Pino, G. P. Chiradelli and G. P. Lorenzi, Optically Active Vinyl Polymers. X. Synthesis of Optically Active Poly-α-Olefins from Racemic Monomers by Asymmetric Catalysts, *J. Am. Chem. Soc.*, 1963, **85**, 3888–3889, DOI: 10.1021/ja00906a036.
13 P. Pino, Optically Active Addition Polymers, *Adv. Polym. Sci.*, 1965, **4**, 393–459, DOI: 10.1007/BFb0051609.
14 P. Pino, P. Salvadori, E. Chiellini and P. Luisi, Optical Activity and Optical Rotatory Dispersion in Synthetic Polymers, *Pure Appl. Chem.*, 1968, **16**, 469–490, DOI: 10.1351/pac196816020469.
15 R. C. Schultz and E. Kaiser, Synthese Und Eigenschaften von Optisch Aktiven Polymeren, *Adv. Polym. Sci.*, 1965, **4**, 236–315, DOI: 10.1007/BFb0050992.
16 R. J. M. Nolte, A. J. M. van Beijnen and W. Drenth, Chirality in Polyisocyanides, *J. Am. Chem. Soc.*, 1974, **96**(18), 5932–5933, DOI: 10.1021/ja00825a038.
17 K. Ute, K. Hirose, H. Kashimoto and K. Hatada, Helix-Sense Reversal of Isotactic Chloral Oligomers in Solution, *J. Am. Chem. Soc.*, 1991, **133**, 6305–6306, DOI: 10.1021/ja00016a076.
18 K. Matyjaszewski, Preparation of Inorganic and Organometallic Polymers with Controlled Structures, *J. Inorg. Organomet. Polym. Mater.*, 1991, 5–27, DOI: 10.1007/BF00696533.

19 V. Percec, J. Heck, M. Lee, G. Ungar and A. Alvarez-Castillo, Poly(2-Vinyloxyethyl 3,4,5-Tris[4-(*n*-Dodecanyloxy) Benzyloxy]Benzoate}: A Self-Assembled Supramolecular Polymer Similar to Tobacco Mosaic Virus, *J. Mater. Chem.*, 1992, **2**, 1033–1039, DOI: 10.1039/JM9920201033.

20 D. H. Appella, L. A. Christianson, I. L. Karle, D. R. Powell and S. H. Gellman, β-Peptide Foldamers: Robust Helix Formation in a New Family of Amino Acid Oligomers, *J. Am. Chem. Soc.*, 1996, **118**, 13071–13072, DOI: 10.1021/ja963290l.

21 G. S. Hanan, J.-M. Lehn, N. Kyritsakas and J. Fischer, Molecular Helicity: A General Approach for Helicity Induction in a Polyheterocyclic Molecular Strand, *J. Chem. Soc., Chem. Commun.*, 1995, 765–766, DOI: 10.1039/C39950000765.

22 J. C. Nelson, J. G. Saven, J. S. Moore and P. G. Wolynes, Solvophobically Driven Folding of Nonbiological Oligomers, *Science*, 1997, **277**, 1793–1796, DOI: 10.1126/science.277.5333.1793.

23 F. Bouillère, S. Thétiot-Laurent, C. Kouklovsky and V. Alezra, Foldamers Containing γ-Amino Acid Residues or Their Analogues: Structural Features and Applications, *Amino Acids*, 2011, **41**, 687–707, DOI: 10.1007/s00726-011-0893-3.

24 T. A. Martinek and F. Fülöp, Peptidic Foldamers: Ramping up Diversity, *Chem. Soc. Rev.*, 2012, **41**(2), 687–702, DOI: 10.1039/c1cs15097a.

25 R. N. Zuckermann, J. M. Kerr, S. B. H. Kent and W. H. Moos, Efficient Method for the Preperation of Peptoids[Oligo(*N*-Substituted Glycines)] by Submonomer Solid-Phase Synthesis, *J. Am. Chem. Soc.*, 1992, **114**, 10647–10649, DOI: 10.1021/ja00052a076.

26 G. Maayan, M. D. Ward, K. Kirshenbaum and K. A. Dill, Folded Biomimetic Oligomers for Enantioselective Catalysis, *Proc. Natl. Acad. Sci. U. S. A.*, 2009, **106**(33), 13679–13684, DOI: 10.1073/pnas.0903187106.

27 P. Ghosh, G. Ruan, N. Fridman and G. Maayan, Amide Bond Hydrolysis of Peptoids, *Chem. Commun.*, 2022, **58**(71), 9922–9925, DOI: 10.1039/d2cc02717h.

28 M. T. Dohm, R. Kapoor and A. E. Barron, Peptoids: Bio-Inspired Polymers as Potential Pharmaceuticals, *Curr. Pharm. Des.*, 2011, **17**, 2732–2747, DOI: 10.2174/138161211797416066.

29 K. L. Bicker and S. L. Cobb, Recent Advances in the Development of Anti-Infective Peptoids, *Chem. Commun.*, 2020, **56**(76), 11158–11168, DOI: 10.1039/d0cc04704j.

30 R. Gopalakrishnan, A. I. Frolov, L. Knerr, W. J. Drury and E. Valeur, Therapeutic Potential of Foldamers: From Chemical Biology Tools to Drug Candidates, *J. Med. Chem.*, 2016, **59**, 9599–9621, DOI: 10.1021/6b00376.

31 G. Guichard and I. Huc, Synthetic Foldamers, *Chem. Commun.*, 2011, **47**(21), 5933–5941, DOI: 10.1039/c1cc11137j.

32 Z. T. Li, J. L. Hou and C. Li, Peptide Mimics by Linear Arylamides: A Structural and Functional Diversity Test, *Acc. Chem. Res.*, 2008, **41**(10), 1343–1353, DOI: 10.1021/ar700219m.

33 Y. Ferrand and I. Huc, Designing Helical Molecular Capsules Based on Folded Aromatic Amide Oligomers, *Acc. Chem. Res.*, 2018, **51**(4), 970–977, DOI: 10.1021/acs.accounts.8b00075.

34 P. Prabhakaran, G. Priya and G. J. Sanjayan, Foldamers: They're Not Just for Biomedical Applications Anymore, *Angew. Chem., Int. Ed.*, 2012, **51**(17), 4006–4008, DOI: 10.1002/anie.201107521.

35 I. Saraogi and A. D. Hamilton, Recent Advances in the Development of Aryl-Based Foldamers, *Chem. Soc. Rev.*, 2009, **38**, 1726–1743, DOI: 10.1039/b819597h.

36 M. A. B. Block, C. Kaiser, A. Khan and S. Hecht, Discrete Organic Nanotubes Based on a Combination of Covalent and Non-Covalent Approaches, *Top. Curr. Chem.*, 2005, **245**, 89–150, DOI: 10.1007/b98167.

37 A. Roy, P. Prabhakaran, P. K. Baruah and G. J. Sanjayan, Diversifying the Structural Architecture of Synthetic Oligomers: The Hetero Foldamer Approach, *Chem. Commun.*, 2011, **47**(42), 11593–11611, DOI: 10.1039/c1cc13313f.

38 A. R. Sanford, K. Yamato, X. Yang, L. Yuan, Y. Han and B. Gong, Well-Defined Secondary Structures: Information-Storing Molecular Duplexes and Helical Foldamers Based on Unnatural Peptide Backbones, *Eur. J. Biochem.*, 2004, 1416–1425, DOI: 10.1111/j.1432-1033.2004.04062.x.

39 E. Yashima, K. Maeda, H. Lida, Y. Furusho and K. Nagai, Helical Polymers: Synthesis, Structures, and Functions, *Chem. Rev.*, 2009, **109**(11), 6102–6211, DOI: 10.1021/cr900162q.

40 H. Miyake and H. Tsukube, Coordination Chemistry Strategies for Dynamic Helicates: Time-Programmable Chirality Switching with Labile and Inert Metal Helicates, *Chem. Soc. Rev.*, 2012, **41**(21), 6977–6991, DOI: 10.1039/c2cs35192g.

41 I. Huc and H. Jiang, Organic Foldamers and Helices, *Supramol. Chem.*, 2012, 1–23, DOI: 10.1002/9780470661345.smc082.

42 D. W. Zhang, X. Zhao, J. L. Hou and Z. T. Li, Aromatic Amide Foldamers: Structures, Properties, and Functions, *Chem. Rev.*, 2012, **112**, 5271–5316, DOI: 10.1021/cr300116k.

43 I. Huc, Aromatic Oligoamide Foldamers, *Eur. J. Org. Chem.*, 2004, 17–29, DOI: 10.1002/ejoc.200300495.

44 J. Shang, N. M. Gallagher, F. Bie, Q. Li, Y. Che, Y. Wang and H. Jiang, Aromatic Triazole Foldamers Induced by C-H···X (X = F, Cl) Intramolecular Hydrogen Bonding, *J. Org. Chem.*, 2014, **79**(11), 5134–5144, DOI: 10.1021/jo500582c.

45 S. H. Yoo, B. Li, C. Dolain, M. Pasco and G. Guichard, Urea Based Foldamers, in *Methods in Enzymology*, Academic Press Inc., Elsevier, 2021, vol. 656, pp. 59–92. DOI: 10.1016/bs.mie.2021.04.019.

46 L. Fischer and G. Guichard, Folding and Self-Assembly of Aromatic and Aliphatic Urea Oligomers: Towards Connecting Structure and Function, *Org. Biomol. Chem.*, 2010, 3102–3117, DOI: 10.1039/c001090a.

47 X. Zhao and Z. T. Li, Hydrogen Bonded Aryl Amide and Hydrazide Oligomers: A New Generation of Preorganized Soft Frameworks, *Chem. Commun.*, 2010, 1601–1616, DOI: 10.1039/b924552a.
48 H. P. Yi, C. Li, J. L. Hou, X. K. Jiang and Z. T. Li, Hydrogen-Bonding-Induced Oligoanthranilamide Foldamers. Synthesis, Characterization, and Complexation for Aliphatic Ammonium Ions, *Tetrahedron*, 2005, **61**(33), 7974–7980, DOI: 10.1016/j.tet.2005.06.042.
49 B. Gong, Hollow Crescents, Helices, and Macrocycles from Enforced Folding and Folding-Assisted Macrocyclization, *Acc. Chem. Res.*, 2008, **41**(10), 1376–1386, DOI: 10.1021/ar700266f.
50 O. Keunchan, K. Jeong and J. S. Moore, Folding-Driven Synthesis of Oligomers, *Nature*, 2001, **414**, 889–893, DOI: 10.1038/414889a.
51 V. Dehm, M. Büchner, J. Seibt, V. Engel and F. Würthner, Foldamer with a Spiral Perylene Bisimide Staircase Aggregate Structure, *Chem. Sci.*, 2011, **2**(11), 2094–2100, DOI: 10.1039/c1sc00435b.
52 D. T. J. Morris and J. Clayden, Screw Sense and Screw Sensibility: Communicating Information by Conformational Switching in Helical Oligomers, *Chem. Soc. Rev.*, 2023, 2480–2496, DOI: 10.1039/d2cs00982j.
53 E. Yashima, N. Ousaka, D. Taura, K. Shimomura, T. Ikai and K. Maeda, Supramolecular Helical Systems: Helical Assemblies of Small Molecules, Foldamers, and Polymers with Chiral Amplification and Their Functions, *Chem. Rev.*, 2016, 13752–13990, DOI: 10.1021/acs.chemrev.6b00354.
54 H. B. Jang, Y. R. Choi and K. S. Jeong, Matched and Mismatched Phenomena in the Helix Orientation Bias Induced by Chiral Appendages at Multiple Positions of Indolocarbazole-Pyridine Hybrid Foldamers, *J. Org. Chem.*, 2018, **83**(9), 5123–5131, DOI: 10.1021/acs.joc.8b00482.
55 R. B. Prince, L. Brunsveld, E. W. Meijer and J. S. Moore, Twist Sense Bias Induced by Chiral Side Chains in Helically Folded Oligomers, *Angew. Chem., Int. Ed.*, 2000, **39**(1), 228–230, DOI: 10.1002/(SICI)1521-3773(20000103)39:1<228::AID-ANIE228>3.0.CO;2-B.
56 P. H. J. Kouwer, M. Koepf, V. A. A. Le Sage, M. Jaspers, A. M. Van Buul, Z. H. Eksteen-Akeroyd, T. Woltinge, E. Schwartz, H. J. Kitto, R. Hoogenboom, S. J. Picken, R. J. M. Nolte, E. Mendes and A. E. Rowan, Responsive Biomimetic Networks from Polyisocyanopeptide Hydrogels, *Nature*, 2013, **493**(7434), 651–655, DOI: 10.1038/nature11839.
57 A. Tanatani, A. Yokoyama, I. Azumaya, Y. Takakura, C. Mitsui, M. Shiro, M. Uchiyama, A. Muranaka, N. Kobayashi and T. Yokozawa, Helical Structures of N-Alkylated Poly(p-Benzarnide)s. Oligomers, *J. Am. Chem. Soc.*, 2005, **127**(23), 8553–8561, DOI: 10.1021/ja0455291.
58 C. Dolain, H. Jiang, J. M. Léger, P. Guionneau and I. Huc, Chiral Induction in Quinoline-Derived Oligoamide Foldamers: Assignment of Helical Handedness and Role of Steric Effects Oligomers, *J. Am. Chem. Soc.*, 2005, **127**(37), 12943–12951, DOI: 10.1021/ja0527828.
59 G. N. Vemuri, R. R. Pandian, B. J. Spinello, E. B. Stopler, Z. J. Kinney and C. S. Hartley, Twist Sense Control in Terminally Functionalized: *Ortho* -Phenylenes, *Chem. Sci.*, 2018, **9**(43), 8260–8270, DOI: 10.1039/c8sc02821d.
60 D. Zheng, C. Yu, L. Zheng, Y. Zhan and H. Jiang, Absolute Control of Helicity at the C-Termini in Quinoline Oligoamide Foldamers by Chiral Oxazolylaniline Moieties, *Chin. Chem. Lett.*, 2020, **31**(3), 673–676, DOI: 10.1016/j.cclet.2019.07.061.
61 M. Lago-Silva, M. Fernández-Míguez, R. Rodríguez, E. Quiñoá and F. Freire, Stimuli-Responsive Synthetic Helical Polymers, *Chem. Soc. Rev.*, 2023, 793–852, DOI: 10.1039/d3cs00952a.
62 A. R. Davis, S. Ozturk, C. C. Seaton, L. Male and S. J. Pike, Controlling the Helical Pitch of Foldamers through Terminal Functionality: A Solid State Study, *Chem. – Eur. J.*, 2024, **30**(68), e202402892, DOI: 10.1002/chem.202402892.
63 S. Ansari and P. C. Knipe, Atropisomeric Foldamers, *ChemPlusChem*, 2024, **89**(8), e202400218, DOI: 10.1002/cplu.202400218.
64 S. H. Gellman and G. P. Dado, Intramolecular Hydrogen Bonding in Derivatives of 5-Alanine and -Amino Butyric Acid: Model Studies for the Folding of Unnatural Polypeptide Backbones, *J. Am. Chem. Soc.*, 1994, **116**(1), 1054–1062, DOI: 10.1021/ja00082a029.
65 H. H. Nguyen, J. H. McAliley, W. R. Batson and D. A. Bruce, Molecular Design of Functionalized *M*-Poly(Phenylene Ethynylene) Foldamers: From Simulation to Synthesis, *Macromolecules*, 2010, **43**(14), 5932–5942, DOI: 10.1021/ma100746x.
66 O. S. Lee and J. G. Saven, Simulation Studies of a Helical *M*-Phenylene Ethynylene Foldamer, *J. Phys. Chem. B*, 2004, **108**(32), 11988–11994, DOI: 10.1021/jp048642m.
67 B. Zhang, T. Yuan, H. Jiang and M. Lei, Molecular Dynamics Simulations on the Stability and Assembly Mechanisms of Quadruple and Double Helical Aromatic Amide, Foldamers, *J. Phys. Chem. B*, 2009, **113**(31), 10934–10941, DOI: 10.1021/jp9033358.
68 Z. Liu, A. M. Abramyan and V. Pophristic, Helical Arylamide Foldamers: Structure Prediction by Molecular Dynamics Simulations, *New J. Chem.*, 2015, **39**(5), 3229–3240, DOI: 10.1039/c4nj01925c.
69 S. H. Ahn and J. W. Grate, Foldamer Architectures of Triazine-Based Sequence-Defined Polymers Investigated with Molecular Dynamics Simulations and Enhanced Sampling Methods, *J. Phys. Chem. B*, 2019, **123**(44), 9364–9377, DOI: 10.1021/acs.jpcb.9b06067.
70 S. Debnath, A. H. Flood and K. Raghavachari, Solvent-Dependent Folding Behavior of a Helix-Forming Aryl-Triazole Foldamer, *J. Phys. Chem. B*, 2024, **128**(7), 1586–1594, DOI: 10.1021/acs.jpcb.3c04907.
71 R. B. Prince, S. A. Barnes and J. S. Moore, Foldamer-Based Molecular Recognition, *J. Am. Chem. Soc.*, 2000, **122**(12), 2758–2762, DOI: 10.1021/ja993830p.

72 S. J. Shandler, M. V. Shapovalov, R. L. Dunbrack and W. F. Degrado, Development of a Rotamer Library for Use in β-Peptide Foldamer Computational Design, *J. Am. Chem. Soc.*, 2010, **132**, 7312–7320, DOI: 10.1021/ja906700x.

73 P. D. Renfrew, T. W. Craven, G. L. Butterfoss, K. Kirshenbaum and R. Bonneau, A Rotamer Library to Enable Modeling and Design of Peptoid Foldamers, *J. Am. Chem. Soc.*, 2014, **136**, 8772–8782, DOI: 10.1021/ja503776z.

74 A. Méndez-Ardoy, N. Markandeya, X. Li, Y. T. Tsai, G. Pecastaings, T. Buffeteau, V. Maurizot, L. Muccioli, F. Castet, I. Huc and D. M. Bassani, Multi-Dimensional Charge Transport in Supramolecular Helical Foldamer Assemblies, *Chem. Sci.*, 2017, **8**(10), 7251–7257, DOI: 10.1039/c7sc03341a.

75 L. Ducasse, F. Castet, A. Fritsch, I. Huc and T. Buffeteau, Density Functional Theory Calculations and Vibrational Circular Dichroism of Aromatic Foldamers, *J. Phys. Chem. A*, 2007, **111**(23), 5092–5098, DOI: 10.1021/jp071645p.

76 S. Debnath, A. Sengupta, K. V. J. Jose and K. Raghavachari, Fragment-Based Approaches for Supramolecular Interaction Energies: Applications to Foldamers and Their Complexes with Anions, *J. Chem. Theory Comput.*, 2018, **14**(12), 6226–6239, DOI: 10.1021/acs.jctc.8b00525.

77 W. Li, H. Ma, S. Li and J. Ma, Computational and Data Driven Molecular Material Design Assisted by Low Scaling Quantum Mechanics Calculations and Machine Learning, *Chem. Sci.*, 2021, **12**, 14987–15006, DOI: 10.1039/d1sc02574k.

78 L. Wang, C. Douat, J. Sigl, P. Sai Reddy, L. Fischer, B. L. d'Estaintot, Z. Liu, V. Pophristic, Y. Yang, Y. Zhang and I. Huc, Structure-Based Design of an Aromatic Helical Foldamer-Protein Interface, *Chem. Sci.*, 2025, **16**(27), 12385–12396, DOI: 10.1039/d5sc01826a.

79 A. Tanatani, H. Kagechika, I. Azumaya, R. Fukutomi, Y. Ito, K. Yamaguchi and K. Shudo, Helical Aromatic Urea and Guanidine, *Tetrahedron Lett.*, 1997, **38**, 4425–4428, DOI: 10.1016/S0040-4039(97)00922-2.

80 A. J. Zych and B. L. Iverson, Synthesis and Conformational Characterization of Tethered, Self-Complexing 1,5-Dialkoxynaphthalene/1,4,5,8-Naphthalenetetracarboxylic Diimide Systems, *J. Am. Chem. Soc.*, 2000, **122**(37), 8898–8909, DOI: 10.1021/ja0019225.

81 F. C. Krebs and M. Jørgensen, Synthesis and Structural Characterization of New Stiff Rod Oligomeric Domains by X-Ray Crystallography and NMR, *J. Org. Chem.*, 2002, **67**(21), 7511–7518, DOI: 10.1021/jo025980f.

82 V. J. Bradford and B. L. Iverson, Amyloid-like Behavior in Abiotic, Amphiphilic Foldamers, *J. Am. Chem. Soc.*, 2008, **130**(4), 1517–1524, DOI: 10.1021/ja0780840.

83 J. Dong, M. P. O'Hagan and I. Willner, Switchable and Dynamic G-Quadruplexes and Their Applications, *Chem. Soc. Rev.*, 2022, **51**, 7631–7661, DOI: 10.1039/d2cs00317a.

84 J. Brüggemann, S. Bitter, S. Müller, W. M. Müller, U. Müller, N. M. Maier, W. Lindner and F. Vögtle, Spontaneous Knotting - From Oligoamide Threads to Trefoil Knots, *Angew. Chem., Int. Ed.*, 2007, **46**(1–2), 254–259, DOI: 10.1002/anie.200601938.

85 S. J. De Veer, M. W. Kan and D. J. Craik, Cyclotides: From Structure to Function, *Chem. Rev.*, 2019, **119**, 12375–12421, DOI: 10.1021/acs.chemrev.9b00402.

86 C. A. Hunter, A. Spitaleri and S. Tomas, Tailbiter: A New Amide Foldamer, *Chem. Commun.*, 2005, **29**, 3691–3693, DOI: 10.1039/b506093a.

87 A. M. Kendhale, R. Gonnade, P. R. Rajamohanan, H. J. Hofmann and G. J. Sanjayan, Foldamers with Unusual Structural Architecture from Spirobi(Indane) Building Blocks, *Chem. Commun.*, 2008, **22**, 2541–2543, DOI: 10.1039/b800825f.

88 P. Prabhakaran, S. S. Kale, V. G. Puranik, P. R. Rajamohanan, O. Chetina, J. A. K. Howard, H. J. Hofmann and G. J. Sanjayan, Sequence-Specific Unusual (1→2)-Type Helical Turns in α/β-Hybrid Peptides, *J. Am. Chem. Soc.*, 2008, **130**, 17743–17754, DOI: 10.1021/ja804297f.

89 S. Li, D. X. Wang and M. X. Wang, Oligo-*m*-Aniline Foldamers, *Tetrahedron Lett.*, 2012, **53**(47), 6426–6429, DOI: 10.1016/j.tetlet.2012.09.050.

90 N. Delsuc, F. Godde, B. Kauffmann, J. M. Léger and I. Huc, The Herringbone Helix: A Noncanonical Folding in Aromatic-Aliphatic Peptides, *J. Am. Chem. Soc.*, 2007, **129**(37), 11348–11349, DOI: 10.1021/ja074285s.

91 K. Yamato, M. Kline and B. Gong, Cavity-Containing, Backbone-Rigidified Foldamers and Macrocycles, *Chem. Commun.*, 2012, **48**(100), 12142–12158, DOI: 10.1039/c2cc36391g.

92 T. Nakano and Y. Okamoto, Synthetic Helical Polymers: Conformation and Function, *Chem. Rev.*, 2001, **101**, 4013–4038, DOI: 10.1021/cr0000978.

93 L. Sebaoun, B. Kauffmann, T. Delclos, V. Maurizot and I. Huc, Assessing Stabilization through π-π Interactions in Aromatic Oligoamide β-Sheet Foldamers, *Org. Lett.*, 2014, **16**(9), 2326–2329, DOI: 10.1021/ol500512f.

94 J. S. Nowick, Chemical Models of Protein β-Sheets, *Acc. Chem. Res.*, 1999, **32**(4), 287–296, DOI: 10.1021/ar970204t.

95 P. N. Cheng, J. D. Pham and J. S. Nowick, The Supramolecular Chemistry of β-Sheets, *J. Am. Chem. Soc.*, 2013, **135**(15), 5477–5492, DOI: 10.1021/ja3088407.

96 J. S. Nowick, Exploring β-Sheet Structure and Interactions with Chemical Model Systems, *Acc. Chem. Res.*, 2008, **41**(10), 1319–1330, DOI: 10.1021/ar800064f.

97 S. Wang, J. Sigl, L. Allmendinger, V. Maurizot and I. Huc, A Focus on a Complex Abiotic Tertiary Structure, *Chem. Sci.*, 2025, **16**, 2958–2960, DOI: 10.1039/d4sc07336c.

98 F. S. Menke, B. Wicher, V. Maurizot and I. Huc, Homochiral versus Heterochiral Dimeric Helical Foldamer Bundles: Chlorinated-Solvent-Dependent Self-Sorting, *Angew. Chem., Int. Ed.*, 2023, **62**(12), e202217325, DOI: 10.1002/anie.202217325.

99 S. Wang, L. Allmendinger and I. Huc, Abiotic Foldamer Quaternary Structures, *Angew. Chem., Int. Ed.*, 2024, **63**(48), e202413252, DOI: 10.1002/anie.202413252.

100 T. V. Jones, M. M. Slutsky, R. Laos, T. F. A. De Greef and G. N. Tew, Solution ^{1}H NMR Confirmation of Folding in Short O-Phenylene Ethynylene Oligomers, *J. Am. Chem. Soc.*, 2005, **127**, 17235–17240, DOI: 10.1021/ja053530.

101 M. M. Slutsky, T. V. Jones and G. N. Tew, Spin System Assignment of Homo-*o*-Phenylene Ethynylene Oligomers, *J. Org. Chem.*, 2007, **72**(2), 342–347, DOI: 10.1021/jo061175f.

102 P. Reiné, J. Justicia, S. P. Morcillo, S. Abbate, B. Vaz, M. Ribagorda, Á. Orte, L. Álvarez de Cienfuegos, G. Longhi, A. G. Campaña, D. Miguel and J. M. Cuerva, Pyrene-Containing *Ortho* -Oligo(Phenylene)Ethynylene Foldamer as a Ratiometric Probe Based on Circularly Polarized Luminescence, *J. Org. Chem.*, 2018, **83**(8), 4455–4463, DOI: 10.1021/acs.joc.8b00162.

103 A. M. Ortuño, P. Reiné, S. Resa, L. Álvarez de Cienfuegos, V. Blanco, J. M. Paredes, A. J. Mota, G. Mazzeo, S. Abbate, J. M. Ugalde, V. Mujica, G. Longhi, D. Miguel and J. M. Cuerva, Extended Enantiopure *Ortho*-Phenylene Ethylene (*o*-PE)-Based Helical Systems as Scaffolds for Supramolecular Architectures: A Study of Chiroptical Response and Its Connection to the CISS Effect, *Org. Chem. Front.*, 2021, **8**(18), 5071–5086, DOI: 10.1039/d1qo00822f.

104 C. Kübel, M. J. Mio, J. S. Moore and D. C. Martin, Molecular Packing and Morphology of Oligo(*m*-Phenylene Ethynylene) Foldamers, *J. Am. Chem. Soc.*, 2002, **124**(29), 8605–8610, DOI: 10.1021/ja0204022.

105 A. Tanatani, M. J. Mio and J. S. Moore, Chain Length-Dependent Affinity of Helical Foldamers for a Rodlike Guest, *J. Am. Chem. Soc.*, 2001, 1792–1793, DOI: 10.1021/ja003678n.

106 M. T. Stone and J. S. Moore, A Water-Soluble *m*-Phenylene Ethynylene Foldamer, *Org. Lett.*, 2004, **6**, 469–472, DOI: 10.1021/ol036238k.

107 R. M. Meudtner, M. Ostermeier, R. Goddard, C. Limberg and S. Hecht, Multifunctional "Clickates" as Versatile Extended Heteroaromatic Building Blocks: Efficient Synthesis via Click Chemistry, Conformational Preferences, and Metal Coordination, *Chem. – Eur. J.*, 2007, **13**(35), 9834–9840, DOI: 10.1002/chem.200701240.

108 R. M. Meudtner and S. Hecht, Helicity Inversion in Responsive Foldamers Induced by Achiral Halide Ion Guests, *Angew. Chem., Int. Ed.*, 2008, **47**(26), 4926–4930, DOI: 10.1002/anie.200800796.

109 H. Juwarker, J. M. Lenhardt, D. M. Pham and S. L. Craig, 1,2,3-Triazole CH···Cl- Contacts Guide Anion Binding and Concomitant Folding in 1,4-Diaryl Triazole Oligomers, *Angew. Chem., Int. Ed.*, 2008, **47**(20), 3740–3743, DOI: 10.1002/anie.200800548.

110 H. Juwarker, J. M. Lenhardt, J. C. Castillo, E. Zhao, S. Krishnamurthy, R. M. Jamiolkowski, K. H. Kim and S. L. Craig, Anion Binding of Short, Flexible Aryl Triazole Oligomers, *J. Org. Chem.*, 2009, **74**(23), 8924–8934, DOI: 10.1021/jo901966f.

111 Y. Wang, J. Xiang and H. Jiang, Halide-Guided Oligo(Aryl-Triazole-Amide)s Foldamers: Receptors for Multiple Halide Ions, *Chem. – Eur. J.*, 2011, **17**(2), 613–619, DOI: 10.1002/chem.201001560.

112 Y. Wang, F. Li, Y. Han, F. Wang and H. Jiang, Folding and Aggregation of Cationic Oligo(Aryl-Triazole)s in Aqueous Solution, *Chem. – Eur. J.*, 2009, **15**(37), 9424–9433, DOI: 10.1002/chem.200900546.

113 J. Shang, W. Zhao, X. Li, Y. Wang and H. Jiang, Aryl-Triazole Foldamers Incorporating a Pyridinium Motif for Halide Anion Binding in Aqueous Media, *Chem. Commun.*, 2016, **52**(24), 4505–4508, DOI: 10.1039/c5cc10422j.

114 L. Y. You, S. G. Chen, X. Zhao, Y. Liu, W. X. Lan, Y. Zhang, H. J. Lu, C. Y. Cao and Z. T. Li, C-H···O Hydrogen Bonding Induced Triazole Foldamers: Efficient Halogen Bonding Receptors for Organohalogens, *Angew. Chem., Int. Ed.*, 2012, **51**(7), 1657–1661, DOI: 10.1002/anie.201106996.

115 Y. Hua, Y. Liu, C. H. Chen and A. H. Flood, Hydrophobic Collapse of Foldamer Capsules Drives Picomolar-Level Chloride Binding in Aqueous Acetonitrile Solutions, *J. Am. Chem. Soc.*, 2013, **135**(38), 14401–14412, DOI: 10.1021/ja4074744.

116 Y. Wang, W. Zhao, F. Bie, L. Wu, X. Li and H. Jiang, Ruthenium(II) Complexes of Aryl Triazole Foldamers as Receptors for Anions, *Chem. – Eur. J.*, 2016, **22**(15), 5233–5242, DOI: 10.1002/chem.201504910.

117 W. Zhao, F. Huang, Y. Wang, Q. Li, J. Shang, Y. Che and H. Jiang, Aryl-Triazole Foldamers with Ethynyl Spacers as Effective Receptors for Halides and Oxyanions, *Tetrahedron Lett.*, 2016, **57**(15), 1691–1694, DOI: 10.1016/j.tetlet.2016.03.008.

118 L. Yang, Y. Wang, Y. Che and H. Jiang, An Aryl-Triazole Foldamer Containing a 1,8-Naphthalimide Fluorescent Motif for Monitoring and Enhancing the Anion-Induced Folding, *Org. Biomol. Chem.*, 2017, **15**(37), 7747–7752, DOI: 10.1039/c7ob01736g.

119 A. Borissov, J. Y. C. Lim, A. Brown, K. E. Christensen, A. L. Thompson, M. D. Smith and P. D. Beer, Neutral Iodotriazole Foldamers as Tetradentate Halogen Bonding Anion Receptors, *Chem. Commun.*, 2017, **53**(16), 2483–2486, DOI: 10.1039/c7cc00727b.

120 A. Borissov, I. Marques, J. Y. C. Lim, V. Félix, M. D. Smith and P. D. Beer, Anion Recognition in Water by Charge-Neutral Halogen and Chalcogen Bonding Foldamer Receptors, *J. Am. Chem. Soc.*, 2019, **141**(9), 4119–4129, DOI: 10.1021/jacs.9b00148.

121 T. Bunchuay, K. Boonpalit, A. Docker, A. Ruengsuk, J. Tantirungrotechai, M. Sukwattanasinitt, P. Surawatanawong and P. D. Beer, Charge Neutral Halogen Bonding Tetradentate-Iodotriazole Macrocycles Capable of Anion Recognition and Sensing in Highly Competitive Aqueous Media, *Chem. Commun.*, 2021, **57**(90), 11976–11979, DOI: 10.1039/d1cc05037k.

122 Y. Liu, F. C. Parks, E. G. Sheetz, C. H. Chen and A. H. Flood, Polarity-Tolerant Chloride Binding in Foldamer Capsules by Programmed Solvent-Exclusion, *J. Am. Chem. Soc.*, 2021, **143**(8), 3191–3204, DOI: 10.1021/jacs.0c12562.

123 R. Pfukwa, Hierarchical Self-Assembly of Novel Para-Aryltriazole Helical Foldamers, *PhD Dissertation*, Stellenbosch University, 2012.
124 R. Pfukwa, P. H. J. Kouwer, A. E. Rowan and B. Klumperman, Templated Hierarchical Self-Assembly of Poly(*p*-Aryltriazole) Foldamers, *Angew. Chem., Int. Ed.*, 2013, **52**(42), 11040–11044, DOI: 10.1002/anie.201303135.
125 J. G. Carter, R. Pfukwa, L. Riley, J. H. R. Tucker, A. Rodger, T. R. Dafforn and B. Klumperman, Linear Dichroism Activity of Chiral Poly(*p*-Aryltriazole) Foldamers, *ACS Omega*, 2021, **6**(48), 33231–33237, DOI: 10.1021/acsomega.1c06139.
126 A. Zhang, J. S. Ferguson, K. Yamato, C. Zheng and B. Gong, Improving Foldamer Synthesis through Protecting Group Induced Unfolding of Aromatic Oligoamides, *Org. Lett.*, 2006, **8**(22), 5117–5120, DOI: 10.1021/ol062103d.
127 C. Bao, Q. Gan, B. Kauffmann, H. Jiang and I. Huc, A Self-Assembled Foldamer Capsule: Combining Single and Double Helical Segments in One Aromatic Amide Sequence, *Chem. – Eur. J.*, 2009, **15**(43), 11530–11536, DOI: 10.1002/chem.200900877.
128 M. L. Singleton, G. Pirotte, B. Kauffmann, Y. Ferrand and I. Huc, Increasing the Size of an Aromatic Helical Foldamer Cavity by Strand Intercalation, *Angew. Chem., Int. Ed.*, 2014, **53**(48), 13140–13144, DOI: 10.1002/anie.201407752.
129 C. Tsiamantas, X. de Hatten, C. Douat, B. Kauffmann, V. Maurizot, H. Ihara, M. Takafuji, N. Metzler-Nolte and I. Huc, Selective Dynamic Assembly of Disulfide Macrocyclic Helical Foldamers with Remote Communication of Handedness, *Angew. Chem.*, 2016, **128**(4), 6962–6966, DOI: 10.1002/ange.201601156.
130 D. Zhao, L. Yang, Y. Yuan, H. Wang, H. Dong and S. Li, Molecular Mechanism of Self-Assembly of Aromatic Oligoamides into Interlocked Double-Helix Foldamers, *J. Phys. Chem. B*, 2017, **121**(43), 10064–10072, DOI: 10.1021/acs.jpcb.7b09067.
131 Y. Zhao, A. L. Connor, T. A. Sobiech and B. Gong, Effects of Oligomer Length, Solvents, and Temperature on the Self-Association of Aromatic Oligoamide Foldamers, *Org. Lett.*, 2018, **20**(17), 5486–5489, DOI: 10.1021/acs.orglett.8b02438.
132 L. Yu, D. Li, C. Ma, B. Kauffmann, S. Liao and Q. Gan, Redox-Regulated and Guest-Driven Transformations of Aromatic Oligoamide Foldamers in Advanced Structures, *J. Am. Chem. Soc.*, 2024, **146**(19), 12907–12912, DOI: 10.1021/jacs.4c03275.
133 S. Pal, L. Hong, R. V. M. Freire, S. Farooq, S. Salentinig and A. F. M. Kilbinger, High-Molecular-Weight Poly(aromatic amide) Foldamers via Living Polymerization, *Macromolecules*, 2023, **56**, 7984–7992, DOI: 10.1021/acs.macromol.3c01539.
134 M. Wolffs, N. Delsuc, D. Veldman, N. V. Anh, R. M. Williams, S. C. J. Meskers, R. A. J. Janssen, I. Huc and A. P. H. J. Schenning, Helical Aromatic Oligoamide Foldamers as Organizational Scaffolds for Photoinduced Charge Transfer, *J. Am. Chem. Soc.*, 2009, **131**(13), 4819–4829, DOI: 10.1021/ja809367u.
135 S. J. Dawson, Á. Mészáros, L. Peth, C. Colombo, M. Csékei, A. Kotschy and I. Huc, Controlling Helix Handedness in Water-Soluble Quinoline Oligoamide Foldamers, *Eur. J. Org. Chem.*, 2014, 4265–4275, DOI: 10.1002/ejoc.201402247.
136 L. Zheng, Y. Zhan, C. Yu, F. Huang, Y. Wang and H. Jiang, Controlling Helix Sense at N- and C-Termini in Quinoline Oligoamide Foldamers by β-Pinene-Derived Pyridyl Moieties, *Org. Lett.*, 2017, **19**(6), 1482–1485, DOI: 10.1021/acs.orglett.7b00510.
137 D. Zheng, L. Zheng, C. Yu, Y. Zhan, Y. Wang and H. Jiang, Significant Enhancement of Circularly Polarized Luminescence Dissymmetry Factors in Quinoline Oligoamide Foldamers with Absolute Helicity, *Org. Lett.*, 2019, **21**(8), 2555–2559, DOI: 10.1021/acs.orglett.9b00450.
138 M. Zwillinger, P. Sőregi, F. Sanchez, C. Douat, M. Csékei, I. Huc and A. Kotschy, Development of Aromatic Foldamer Building Blocks Bearing Multiple Biogenic Side Chains, *J. Org. Chem.*, 2025, **90**(8), 3043–3052, DOI: 10.1021/acs.joc.4c02900.
139 Z. Xu, J. Tian, W. Wang, M. Lu, C. Zhang, H. Yu, M. Wang and Z. Dong, Synthesis of 128-Meric Helical Amide Foldamer with a 16 Nm Length, *ACS Macro Lett.*, 2025, **14**(6), 853–857, DOI: 10.1021/acsmacrolett.5c00183.
140 J. M. Rodriguez and A. D. Hamilton, Benzoylurea Oligomers: Synthetic Foldamers That Mimic Extended α Helices, *Angew. Chem., Int. Ed.*, 2007, **46**(45), 8614–8617, DOI: 10.1002/anie.200701869.
141 L. Fischer, P. Claudon, N. Pendem, E. Miclet, C. Didierjean, E. Ennifar and G. Guichard, The Canonical Helix of Urea Oligomers at Atomic Resolution: Insights into Folding-Induced Axial Organization, *Angew. Chem., Int. Ed.*, 2010, **49**(6), 1067–1070, DOI: 10.1002/anie.200905592.
142 N. Pendem, C. Douat, P. Claudon, M. Laguerre, S. Castano, B. Desbat, D. Cavagnat, E. Ennifar, B. Kauffmann and G. Guichard, Helix-Forming Propensity of Aliphatic Urea Oligomers Incorporating Noncanonical Residue Substitution Patterns, *J. Am. Chem. Soc.*, 2013, **135**(12), 4884–4892, DOI: 10.1021/ja401151v.
143 Q. Gan, Y. Ferrand, C. Bao, B. Kauffmann, A. Grélard, H. Jiang and I. Huc, Helix-Rod Host-Guest Complexes with Shuttling Rates Much Faster than Disassembly, *Science*, 2011, **311**, 1172–1175, DOI: 10.1126/science.1171245.
144 N. Pendem, Y. R. Nelli, L. Cussol, C. Didierjean, B. Kauffmann, C. Dolain and G. Guichard, Synthesis and Crystallographic Characterization of Helical Hairpin Oligourea Foldamers, *Chem. – Eur. J.*, 2023, **29**(39), e202300087, DOI: 10.1002/chem.202300087.
145 B. Wu, C. Jia, X. Wang, S. Li, X. Huang and X. J. Yang, Chloride Coordination by Oligoureas: From Mononuclear Crescents to Dinuclear Foldamers, *Org. Lett.*, 2012, **14**(3), 684–687, DOI: 10.1021/ol2031153.

146 R. Wechsel, J. Raftery, D. Cavagnat, G. Guichard and J. Clayden, The Meso Helix: Symmetry and Symmetry-Breaking in Dynamic Oligourea Foldamers with Reversible Hydrogen-Bond Polarity, *Angew. Chem.*, 2016, **128**(33), 9809–9813, DOI: 10.1002/ange.201604496.

147 R. Wechsel, M. Žabka, J. W. Ward and J. Clayden, Competing Hydrogen-Bond Polarities in a Dynamic Oligourea Foldamer: A Molecular Spring Torsion Balance, *J. Am. Chem. Soc.*, 2018, **140**(10), 3528–3531, DOI: 10.1021/jacs.8b00567.

148 N. Gupta, M. Wilczek, L. Dobrzycki and K. Pulka-Ziach, Structural Consequences of N-Methylation of N-Terminus in Oligourea Foldamers, *ChemPlusChem*, 2022, **87**(8), e202200199, DOI: 10.1002/cplu.202200199.

149 K. J. Chang, B. N. Kang, M. H. Lee and K. S. Jeong, Oligoindole-Based Foldamers with a Helical Conformation Induced by Chloride, *J. Am. Chem. Soc.*, 2005, **127**(35), 12214–12215, DOI: 10.1021/ja0547984.

150 J. M. Suk and K. S. Jeong, Indolocarbazole-Based Foldamers Capable of Binding Halides in Water, *J. Am. Chem. Soc.*, 2008, **130**(36), 11868–11869, DOI: 10.1021/ja804845m.

151 H. Masu, I. Mizutani, T. Kato, I. Azumaya, K. Yamaguchi, K. Kishikawa and S. Kohmoto, Naphthalene- and Anthracene-Based Aromatic Foldamers with Iminodicarbonyl Linkers: Their Stabilities and Application to a Chiral Photochromic System Using Retro [4 + 4] Cycloaddition, *J. Org. Chem.*, 2006, **71**(21), 8037–8044, DOI: 10.1021/jo0611317.

152 H. G. Jeon, J. Y. Jung, P. Kang, M. G. Choi and K. S. Jeong, Folding-Generated Molecular Tubes Containing One-Dimensional Water Chains, *J. Am. Chem. Soc.*, 2016, **138**(1), 92–95, DOI: 10.1021/jacs.5b11808.

153 J. M. Suk, D. A. Kim and K. S. Jeong, Helicity Control of an Indolocarbazole Foldamer by Chiral Organic Anions, *Org. Lett.*, 2012, **14**(19), 5018–5021, DOI: 10.1021/ol3022148.

154 J. S. Kim, H. G. Jeon and K. S. Jeong, Modulation of Helix Stability of Indolocarbazole-Pyridine Hybrid Foldamers, *Chem. Commun.*, 2016, **52**(16), 3406–3409, DOI: 10.1039/c6cc00045b.

155 S. Lee, B. J. Lee, G. Song and K. S. Jeong, Helical Aromatic Foldamers with Tubular Cavities Capable of Accommodating Multiple Halide Ions, *Chem. Commun.*, 2024, **60**, 14081–14084, DOI: 10.1039/d4cc05474a.

156 Y. Zhao and Z. Zhong, Oligomeric Cholates: Amphiphilic Foldamers with Nanometer-Sized Hydrophilic Cavities, *J. Am. Chem. Soc.*, 2005, **127**, 17894–17901, DOI: 10.1021/ja056151p.

157 Y. Zhao and Z. Zhong, Detection of Hg^{2+} in Aqueous Solutions with a Foldamer-Based Fluorescent Sensor Modulated by Surfactant Micelles, *Org. Lett.*, 2006, **8**(21), 4715–4717, DOI: 10.1021/ol061735x.

158 Y. Zhao, Z. Zhong and E. H. Ryu, Preferential Solvation within Hydrophilic Nanocavities and Its Effect on the Folding of Cholate Foldamers, *J. Am. Chem. Soc.*, 2007, **129**(1), 218–225, DOI: 10.1021/ja0671159.

159 Z. Zhong and Y. Zhao, Controlling the Conformation of Oligocholate Foldamers by Surfactant Micelles, *J. Org. Chem.*, 2008, **73**(14), 5498–5505, DOI: 10.1021/jo800724j.

160 X. Pan and Y. Zhao, Efficient Construction of Oligocholate Foldamers via "Click" Chemistry and Their Tolerance of Structural Heterogeneity, *Org. Lett.*, 2009, **11**(1), 69–72, DOI: 10.1021/ol802364c.

161 V. Maurizot, S. Massip, J. M. Léger and G. Déléris, Cylindrical Sheet Formation of Oligo-*Meta*-Aniline Foldamers, *Chem. Commun.*, 2009, **38**, 5698–5700, DOI: 10.1039/b909446f.

162 L. Sebaoun, V. Maurizot, T. Granier, B. Kauffmann and I. Huc, Aromatic Oligoamide β-Sheet Foldamers, *J. Am. Chem. Soc.*, 2014, **136**(5), 2168–2174, DOI: 10.1021/ja412729s.

163 A. Lamouroux, L. Sebaoun, B. Wicher, B. Kauffmann, Y. Ferrand, V. Maurizot and I. Huc, Controlling Dipole Orientation through Curvature: Aromatic Foldamer Bent β-Sheets and Helix-Sheet-Helix Architectures, *J. Am. Chem. Soc.*, 2017, **139**(41), 14668–14675, DOI: 10.1021/jacs.7b07961.

164 J. L. Hou, X. B. Shao, G. J. Chen, Y. X. Zhou, X. K. Jiang and Z. T. Li, Hydrogen Bonded Oligohydrazide Foldamers and Their Recognition for Saccharides, *J. Am. Chem. Soc.*, 2004, **126**(39), 12386–12394, DOI: 10.1021/ja047436p.

165 W. Cai, G. T. Wang, Y. X. Xu, X. K. Jiang and Z. T. Li, Vesicles and Organogels from Foldamers: A Solvent-Modulated Self-Assembling Process, *J. Am. Chem. Soc.*, 2008, **130**(22), 6936–6937, DOI: 10.1021/ja801618p.

166 S. Liu, P. Y. Zavalij, Y. F. Lam and L. Isaacs, Refolding Foldamers: Triazene-Arylene Oligomers That Change Shape with Chemical Stimuli, *J. Am. Chem. Soc.*, 2007, **129**(36), 11232–11241, DOI: 10.1021/ja073320s.

167 J. J. Han, A. D. Shaller, W. Wang and A. D. Q. Li, Architecturally Diverse Nanostructured Foldamers Reveal Insightful Photoinduced Single-Molecule Dynamics, *J. Am. Chem. Soc.*, 2008, **130**(22), 6974–6982, DOI: 10.1021/ja078302p.

168 F. Chen, J. Shen, N. Li, A. Roy, R. Ye, C. Ren and H. Zeng, Pyridine/Oxadiazole-Based Helical Foldamer Ion Channels with Exceptionally High K^+/Na^+ Selectivity, *Angew. Chem.*, 2020, **132**(4), 1456–1460, DOI: 10.1002/ange.201906341.

169 Y. Jin, P. K. Mandal, J. Wu, N. Böcher, I. Huc and S. Otto, (Re-)Directing Oligomerization of a Single Building Block into Two Specific Dynamic Covalent Foldamers through pH, *J. Am. Chem. Soc.*, 2023, **145**(5), 2822–2829, DOI: 10.1021/jacs.2c09325.

170 F. Bie, Y. Wang, J. Shang, N. M. Gallagher and H. Jiang, Synergistic Recognition of Halide Anions and Saccharides by Oligohydrazide Foldamers, *Eur. J. Org. Chem.*, 2013, 8135–8144, DOI: 10.1002/ejoc.201300817.

171 H. Zhao, J. Shen, C. Ren, W. Zeng and H. Zeng, A Foldamer-Based Organocatalyst for Direct Arylations of Unactivated Arenes, *Org. Lett.*, 2017, **19**(8), 2190–2193, DOI: 10.1021/acs.orglett.7b00921.

172 S. H. Ahn and J. W. Grate, Foldamer Architectures of Triazine-Based Sequence-Defined Polymers Investigated with Molecular Dynamics Simulations and Enhanced Sampling Methods, *J. Phys. Chem. B*, 2019, **123**(44), 9364–9377, DOI: 10.1021/acs.jpcb.9b06067.

173 C. G. Pappas, P. K. Mandal, B. Liu, B. Kauffmann, X. Miao, D. Komáromy, W. Hoffmann, C. Manz, R. Chang, K. Liu, K. Pagel, I. Huc and S. Otto, Emergence of Low-Symmetry Foldamers from Single Monomers, *Nat. Chem.*, 2020, **12**(12), 1180–1186, DOI: 10.1038/s41557-020-00565-2.

174 S. Lee, G. Song and K.-S. Jeong, N -Arylene Ethynylene Foldamers: Structures and Functions, *Acc. Chem. Res.*, 2025, **58**, 2466–2476, DOI: 10.1021/acs.accounts.5c00358.

175 H. Juwarker and K. S. Jeong, Anion-Controlled Foldamers, *Chem. Soc. Rev.*, 2010, **39**, 3664–3674, DOI: 10.1039/b926162c.

176 J. M. Suk, V. R. Naidu, X. Liu, M. S. Lah and K. S. Jeong, A Foldamer-Based Chiroptical Molecular Switch That Displays Complete Inversion of the Helical Sense upon Anion Binding, *J. Am. Chem. Soc.*, 2011, **133**(35), 13938–13941, DOI: 10.1021/ja206546b.

177 D. Meshcheryakov, V. Böhmer, M. Bolte, V. Hubscher-Bruder, F. Arnaud-Neu, H. Herschbach, A. Van Dorsselaer, I. Thondorf and W. Mögelin, Two Chloride Ions as a Template in the Formation of a Cyclic Hexaurea, *Angew. Chem., Int. Ed.*, 2006, **45**(10), 1648–1652, DOI: 10.1002/anie.200503766.

178 V. Diemer, L. Fischer, B. Kauffmann and G. Guichard, Anion Recognition by Aliphatic Helical Oligoureas, *Chem. – Eur. J.*, 2016, **22**(44), 15684–15692, DOI: 10.1002/chem.201602481.

179 Y. X. Xu, G. T. Wang, X. Zhao, X. K. Jiang and Z. T. Li, Folding of Aromatic Amide-Based Oligomers Induced by Benzene-1,3,5- Tricarboxylate Anion in DMSO, *J. Org. Chem.*, 2009, **74**(19), 7267–7273, DOI: 10.1021/jo901293b.

180 F. C. Parks, E. G. Sheetz, S. R. Stutsman, A. Lutolli, S. Debnath, K. Raghavachari and A. H. Flood, Revealing the Hidden Costs of Organization in Host-Guest Chemistry Using Chloride-Binding Foldamers and Their Solvent Dependence, *J. Am. Chem. Soc.*, 2022, **144**(3), 1274–1287, DOI: 10.1021/jacs.1c10758.

181 E. A. John, C. J. Massena and O. B. Berryman, Helical Anion Foldamers in Solution, *Chem. Rev.*, 2020, **120**(5), 2759–2782, DOI: 10.1021/acs.chemrev.9b00583.

182 J. L. Sessler, P. A. Gale and W. S. Cho, *Anion Receptor Chemistry*, ed. J. F. Stoddart, RSC, Cambridge, UK, 2006.

183 P. A. Gale, Structural and Molecular Recognition Studies with Acyclic Anion Receptors, *Acc. Chem. Res.*, 2006, **39**(7), 465–475, DOI: 10.1021/ar040237q.

184 F. M. Ashcroft, *Ion Channels and Disease*, Acedemic Press, San Diego, 2000.

185 J. Shang, W. Si, W. Zhao, Y. Che, J. L. Hou and H. Jiang, Preorganized Aryltriazole Foldamers as Effective Transmembrane Transporters for Chloride Anion, *Org. Lett.*, 2014, **16**(15), 4008–4011, DOI: 10.1021/ol501772v.

186 H. Valkenier, C. M. Dias, C. P. Butts and A. P. Davis, A Folding Decalin Tetra-Urea for Transmembrane Anion Transport, *Tetrahedron*, 2017, **73**(33), 4955–4962, DOI: 10.1016/j.tet.2017.04.064.

187 D. Mondal, M. Ahmad, P. Panwaria, A. Upadhyay and P. Talukdar, Anion Recognition through Multivalent C–H Hydrogen Bonds: Anion-Induced Foldamer Formation and Transport across Phospholipid Membranes, *J. Org. Chem.*, 2022, **87**(1), 10–17, DOI: 10.1021/acs.joc.1c01408.

188 T. Yan, S. Liu, J. Xu, H. Sun, S. Yu and J. Liu, Unimolecular Helix-Based Transmembrane Nanochannel with a Smallest Luminal Cavity of 1 Å Expressing High Proton Selectivity and Transport Activity, *Nano Lett.*, 2021, **21**(24), 10462–10468, DOI: 10.1021/acs.nanolett.1c03858.

189 S. Qi, C. Zhang, H. Yu, J. Zhang, T. Yan, Z. Lin, B. Yang and Z. Dong, Foldamer-Based Potassium Channels with High Ion Selectivity and Transport Activity, *J. Am. Chem. Soc.*, 2021, **143**(9), 3284–3288, DOI: 10.1021/jacs.0c12128.

190 C. Dutta, P. Krishnamurthy, D. Su, S. H. Yoo, G. W. Collie, M. Pasco, J. K. Marzinek, P. J. Bond, C. Verma, A. Grélard, A. Loquet, J. Li, M. Luo, M. Barboiu, G. Guichard, R. M. Kini and P. P. Kumar, Nature-Inspired Synthetic Oligourea Foldamer Channels Allow Water Transport with High Salt Rejection, *Chem*, 2023, **9**(8), 2237–2254, DOI: 10.1016/j.chempr.2023.04.007.

191 A. Petitjean, L. A. Cuccia, J. M. Lehn, H. Nierengarten and M. Schmutz, Cation-Promoted Hierarchical Formation of Supramolecular Assemblies of Self-Organized Helical Molecular Components, *Angew. Chem., Int. Ed.*, 2002, **41**(7), 1195–1198, DOI: 10.1002/1521–3773(20020402)41:7<1195::AID-ANIE1195>3.0.CO;2-L.

192 J. Tian, L. Zhang, Z. Lin, S. Mao and Z. Dong, Helical Foldamers Replicating Membrane-Spanning Gramicidin a with PH Responsiveness and Ultrafast Potassium Permeability, *Chem. Sci.*, 2025, **16**, 15111–15120, DOI: 10.1039/2d5sc01362c.

193 Z. Lin, S. Yu, J. Chen, J. Tian, Z. Xu, C. Yao and Z. Dong, Artificial Foldamer-Based Calcium Ion Carriers with High Ca^{2+}/Mg^{2+} Selectivity Ratio, *Chin. J. Chem.*, 2025, **43**(19), 2485–2490, DOI: 10.1002/cjoc.70132.

194 Z. Xu, N. Han, M. Wang, B. Yang and Z. Dong, Membrane-Spanning Aromatic Foldamers with Tunable Pore Diameters Synthesized via Suzuki Coupling for Mass Transport, *Sci. China: Chem.*, 2025, **68**(11), 6012–6019, DOI: 10.1007/s11426-025-2813-8.

195 J. Shen, R. Deepa, Z. Li, H. Oh, H. Behera, H. Joshi, M. Kumar, A. Aksimentiev and H. Zeng, Sulfur-Containing Foldamer-Based Artificial Lithium Channels, *Angew. Chem., Int. Ed.*, 2023, **62**(39), e202305623, DOI: 10.1002/anie.202305623.

196 I. Zubair, L. Martínez-Crespo and S. J. Webb, Foldamer-Mediated Transport across Phospholipid Bilayers, *Curr. Opin. Chem. Biol.*, 2025, **84**, 102549, DOI: 10.1016/j.cbpa.2024.102549.

197 C. Yao, Z. Xu, J. Tian, Z. Lin, C. Zhang, Y. Ge, L. Zhang, S. Wang and Z. Dong, Alkali-Cation-Selective Arylation

Promoted by Ion Recognition of Foldamers, *Org. Lett.*, 2025, **27**(1), 129–133, DOI: 10.1021/acs.orglett.4c04055.

198 Y. Zhao and Z. Zhong, Tuning the Sensitivity of a Foldamer-Based Mercury Sensor by Its Folding Energy, *J. Am. Chem. Soc.*, 2006, **128**, 9988–9989, DOI: 10.1021/ja062001i.

199 Z. Zhong and Y. Zhao, Cholate-Glutamic Acid Hybrid Foldamer and Its Fluorescent Detection of Zn^{2+}, *Org. Lett.*, 2007, **9**, 2891–2894, DOI: 10.1021/ol071130g.

200 J. Ramírez, A. M. Stadler, L. Brelot and J. M. Lehn, Coordinative, Conformational and Motional Behaviour of Triazine-Based Ligand Strands on Binding of Pb(II) Cations, *Tetrahedron*, 2008, **64**(36), 8402–8410, DOI: 10.1016/j.tet.2008.05.138.

201 J. L. Algar, J. A. Findlay and D. Preston, Roles of Metal Ions in Foldamers and Other Conformationally Flexible Supramolecular Systems, *ACS Org. Inorg. Au*, 2022, **2**, 464–476, DOI: 10.1021/acsorginorgau.2c00021.

202 H. Juwarker, J. M. Suk and K. S. Jeong, Foldamers with Helical Cavities for Binding Complementary Guests, *Chem. Soc. Rev.*, 2009, **38**(12), 3316–3325, DOI: 10.1039/b909034g.

203 J. Kang and J. Rebek, Acceleration of a Diels-Alder Reaction by a Self-Assembled Molecular, *Nature*, 1997, **385**, 50–52, DOI: 10.1038/385050a0.

204 D. Ma, G. Hettiarachchi, D. Nguyen, B. Zhang, J. B. Wittenberg, P. Y. Zavalij, V. Briken and L. Isaacs, Acyclic Cucurbit[n]Uril Molecular Containers Enhance the Solubility and Bioactivity of Poorly Soluble Pharmaceuticals, *Nat. Chem.*, 2012, **4**(6), 503–510, DOI: 10.1038/nchem.1326.

205 M. Yoshizawa, T. Kusukawa, M. Fujita and K. Yamaguchi, Ship-in-a-Bottle Synthesis of Otherwise Labile Cyclic Trimers of Siloxanes in a Self-Assembled Coordination Cage, *J. Am. Chem. Soc.*, 2000, **122**, 6311–6312, DOI: 10.1021/ja000779c.

206 W. Wang, W. Wan, A. Stachiw and A. D. Q. Li, Foldamers with Hybrid Biological and Synthetic Sequences as Selective DNA Fluorescent Probes, *Biochemistry*, 2005, **44**(32), 10751–10756, DOI: 10.1021/bi050945z.

207 C. Li, G. T. Wang, H. P. Yi, X. K. Jiang, Z. T. Li and R. X. Wang, Diastereomeric Recognition of Chiral Foldamer Receptors for Chiral Glucoses, *Org. Lett.*, 2007, **9**(9), 1797–1800, DOI: 10.1021/ol070492l.

208 A. M. Abramyan, Z. Liu and V. Pophristic, Mechanistic and Dynamic Insights into Ligand Encapsulation by Helical Arylamide Foldamers, *Phys. Chem. Chem. Phys.*, 2014, **16**(38), 20406–20410, DOI: 10.1039/c4cp02839b.

209 N. Chandramouli, Y. Ferrand, B. Kauffmann and I. Huc, Citric Acid Encapsulation by a Double Helical Foldamer in Competitive Solvents, *Chem. Commun.*, 2016, **52**(20), 3939–3942, DOI: 10.1039/c6cc00190d.

210 J. Y. Hwang, H. G. Jeon, Y. R. Choi, J. Kim, P. Kang, S. Lee and K. S. Jeong, Aromatic Hybrid Foldamer with a Hydrophilic Helical Cavity Capable of Encapsulating Glucose, *Org. Lett.*, 2017, **19**(20), 5625–5628, DOI: 10.1021/acs.orglett.7b02768.

211 D. W. Zhang, X. Zhao and Z. T. Li, Aromatic Amide and Hydrazide Foldamer-Based Responsive Host-Guest Systems, *Acc. Chem. Res.*, 2014, **47**(7), 1961–1970, DOI: 10.1021/ar5000242.

212 N. Chandramouli, Y. Ferrand, G. Lautrette, B. Kauffmann, C. D. MacKereth, M. Laguerre, D. Dubreuil and I. Huc, Iterative Design of a Helically Folded Aromatic Oligoamide Sequence for the Selective Encapsulation of Fructose, *Nat. Chem.*, 2015, **7**(4), 334–341, DOI: 10.1038/nchem.2195.

213 G. Lautrette, B. Wicher, B. Kauffmann, Y. Ferrand and I. Huc, Iterative Evolution of an Abiotic Foldamer Sequence for the Recognition of Guest Molecules with Atomic Precision, *J. Am. Chem. Soc.*, 2016, **138**((32)), 10314–10322, DOI: 10.1021/jacs.6b05913.

214 P. Mateus, N. Chandramouli, C. D. Mackereth, B. Kauffmann, Y. Ferrand and I. Huc, Allosteric Recognition of Homomeric and Heteromeric Pairs of Monosaccharides by a Foldamer Capsule, *Angew. Chem.*, 2020, **132**(14), 5846–5854, DOI: 10.1002/ange.201914929.

215 Y. Ge, W. Li, J. Tian, H. Yu, Z. Wang, M. Wang and Z. Dong, Single-Stranded Nucleic Acid Transmembrane Molecular Carriers Based on Positively Charged Helical Foldamers, *Adv. Sci.*, 2024, **11**(28), 2400678, DOI: 10.1002/advs.202400678.

216 T. Berggård, S. Linse and P. James, Methods for the Detection and Analysis of Protein-Protein Interactions, *Proteomics*, 2007, 2833–2842, DOI: 10.1002/pmic.200700131.

217 J. A. Wells and C. L. McClendon, Reaching for High-Hanging Fruit in Drug Discovery at Protein-Protein Interfaces, *Nature*, 2007, 1001–1009, DOI: 10.1038/nature06526.

218 V. Azzarito, K. Long, N. S. Murphy and A. J. Wilson, Inhibition of α-Helix-Mediated Protein-Protein Interactions Using Designed Molecules, *Nat. Chem.*, 2013, **5**, 161–173, DOI: 10.1038/nchem.1568.

219 M. K. P. Jayatunga, S. Thompson and A. D. Hamilton, α-Helix Mimetics: Outwards and Upwards, *Bioorg. Med. Chem. Lett.*, 2014, **24**, 717–724, DOI: 10.1016/j.bmcl.2013.12.003.

220 S. Kwon, V. Morozov, L. Wang, P. K. Mandal, S. Chaignepain, C. Douat and I. Huc, Interrogating the Potential of Helical Aromatic Foldamers for Protein Recognition, *Org. Biomol. Chem.*, 2024, **22**(48), 9342–9347, DOI: 10.1039/d4ob01436g.

221 J. Buratto, C. Colombo, M. Stupfel, S. J. Dawson, C. Dolain, B. Langlois d'Estaintot, L. Fischer, T. Granier, M. Laguerre, B. Gallois and I. Huc, Structure of a Complex Formed by a Protein and a Helical Aromatic Oligoamide Foldamer at 2.1 Å Resolution, *Angew. Chem., Int. Ed.*, 2014, **53**(3), 883–887, DOI: 10.1002/anie.201309160.

222 P. K. Mandal, B. Benoît, B. Langlois d'Estaintot, B. Kauffmann and I. Huc, Multivalent Interactions between an Aromatic Helical Foldamer and a DNA G-Quadruplex in the Solid State, *ChemBioChem*, 2016, **17**, 1911–1914, DOI: 10.1002/cbic.201600281.

223 M. Jewginski, T. Granier, B. Langlois d'Estaintot, L. Fischer, C. D. Mackereth and I. Huc, Self-Assembled Protein-Aromatic Foldamer Complexes with 2:3 and 2:2:1 Stoichiometries, *J. Am. Chem. Soc.*, 2017, **139**(8), 2928–2931, DOI: 10.1021/jacs.7b00184.

224 M. Vallade, M. Jewginski, L. Fischer, J. Buratto, K. Bathany, J. M. Schmitter, M. Stupfel, F. Godde, C. D. Mackereth and I. Huc, Assessing Interactions between Helical Aromatic Oligoamide Foldamers and Protein Surfaces: A Tethering Approach, *Bioconjugate Chem.*, 2019, **30**(1), 54–62, DOI: 10.1021/acs.bioconjchem.8b00710.

225 D. Talukdar and B. Gole, Foldamer-Based Mechanoresponsive Materials: Molecular Nanoarchitectonics to Advanced Functions, *Langmuir*, 2024, **40**, 18791–18805, DOI: 10.1021/acs.langmuir.4c01252.

226 A. Khan and S. Hecht, Towards Photocontrol over the Helix-Coil Transition in Foldamers: Synthesis and Photoresponsive Behavior of Azobenzene-Core Amphiphilic Oligo(*Meta*-Phenylene Ethynylene)s, *Chem. – Eur. J.*, 2006, **12**(18), 4764–4774, DOI: 10.1002/chem.200501564.

227 A. Khan, C. Kaiser and S. Hecht, Prototype of a Photoswitchable Foldamer, *Angew. Chem., Int. Ed.*, 2006, **45**(12), 1878–1881, DOI: 10.1002/anie.200503849.

228 Z. Yu, S. Weidner, T. Risse and S. Hecht, The Role of Statistics and Microenvironment for the Photoresponse in Multi-Switch Architectures: The Case of Photoswitchable Oligoazobenzene Foldamers, *Chem. Sci.*, 2013, **4**(11), 4156–4167, DOI: 10.1039/c3sc51664d.

229 S. Steinwand, Z. Yu, S. Hecht and J. Wachtveitl, Ultrafast Dynamics of Photoisomerization and Subsequent Unfolding of an Oligoazobenzene Foldamer, *J. Am. Chem. Soc.*, 2016, **138**(39), 12997–13005, DOI: 10.1021/jacs.6b07720.

230 R. M. Meudtner and S. Hecht, Responsive Backbones Based on Alternating Triazole-Pyridine/Benzene Copolymers: From Helically Folding Polymers to Metallosupramolecularly Crosslinked Gels, *Macromol. Rapid Commun.*, 2008, **29**(4), 347–351, DOI: 10.1002/marc.200700817.

231 Y. Hua and A. H. Flood, Flipping the Switch on Chloride Concentrations with a Light-Active Foldamer, *J. Am. Chem. Soc.*, 2010, **132**(37), 12838–12840, DOI: 10.1021/ja105793c.

232 Y. Wang, F. Bie and H. Jiang, Controlling Binding Affinities for Anions by a Photoswitchable Foldamer, *Org. Lett.*, 2010, **12**(16), 3630–3633, DOI: 10.1021/ol1014043.

233 S. Lee, Y. Hua and A. H. Flood, β-Sheet-like Hydrogen Bonds Interlock the Helical Turns of a Photoswitchable Foldamer to Enhance the Binding and Release of Chloride, *J. Org. Chem.*, 2014, **79**(17), 8383–8396, DOI: 10.1021/jo501595k.

234 L. Hardoin, R. Kdouh, Y. Aidibi, S. Azar, B. Siegler, M. Allain, S. Goeb, E. Levillain, P. A. Bouit, O. Galangau, M. Sallé and D. Canevet, Photoresponsive Helical Foldamers: Conformational Control Through Double Helix Formation and Light-Induced Protonation, *Chem. – Eur. J.*, 2025, **31**(11), e202403771, DOI: 10.1002/chem.202403771.

235 H. Y. Hu, J. F. Xiang, Y. Yang and C. F. Chen, Chiral Induction in Phenanthroline-Derived Oligoamide Foldamers: An Acid- and Base-Controllable Switch in Helical Molecular Strands, *Org. Lett.*, 2008, **10**(6), 1275–1278, DOI: 10.1021/ol8001688.

236 C. Sun, Y. Liu, J. Liu, Y. J. Lu, L. Yu, K. Zhang and H. Zeng, Computational Insights into Processes Underlying the Amine-Induced Fluorescence Quenching of a Stimuli-Responsive Phenol-Based Hexameric Foldamer Host, *J. Org. Chem.*, 2014, **79**(7), 2963–2973, DOI: 10.1021/jo500028t.

237 J. Brioche, S. J. Pike, S. Tshepelevitsh, I. Leito, G. A. Morris, S. J. Webb and J. Clayden, Conformational Switching of a Foldamer in a Multicomponent System by pH-Filtered Selection between Competing Noncovalent Interactions, *J. Am. Chem. Soc.*, 2015, **137**(20), 6680–6691, DOI: 10.1021/jacs.5b03284.

238 S. Kimura, F. Takeda, A. Ikeda, A. Tanimoto, K. Katagiri, M. Kawahata, Y. Okada, N. Kobayashi, H. Kagechika and A. Tanatani, Acid-Induced Conformational Switching of Helical Foldamers Containing Imidazole Amide, *Bull. Chem. Soc. Jpn.*, 2024, **97**(9), uoae094, DOI: 10.1093/bulcsj/uoae094.

239 Y. Liu, F. C. Parks, W. Zhao and A. H. Flood, Sequence-Controlled Stimuli-Responsive Single-Double Helix Conversion between 1:1 and 2:2 Chloride-Foldamer Complexes, *J. Am. Chem. Soc.*, 2018, **140**((45)), 15477–15486, DOI: 10.1021/jacs.8b09899.

240 A. M. Kuznetrsov, *Charge Transfer in Physics, Chemistry and Biology Physical Mechanisms of Elementary Processes and an Introduction to the Theory*, CRC Press, London, 1st edn, 1995.

241 J. D. Rochaix, Regulation of Photosynthetic Electron Transport, *Biochim. Biophys. Acta, Bioenerg.*, 2011, **1807**, 375–383, DOI: 10.1016/j.bbabio.2010.11.010.

242 T. Ritz, A. Damjanović and K. Schulten, The Quantum Physics of Photosynthesis, *ChemPhysChem*, 2002, **3**, 243–248, DOI: 10.1002/1439-7641(20020315)3:3<243::AID-CPHC243>3.0.CO;2-Y.

243 N. Nelson and C. F. Yocum, Structure and Function of Photosystems I and II, *Annu. Rev. Plant Biol.*, 2006, **57**, 521–565, DOI: 10.1146/annurev.arplant.57.032905.105350.

244 S. Y. Reece, J. M. Hodgkiss, J.-A. Stubbe and D. G. Nocera, Proton-Coupled Electron Transfer: The Mechanistic Underpinning for Radical Transport and Catalysis in Biology, *Philos. Trans. R. Soc. Lond., B*, 2006, **361**(1472), 1351–1364, DOI: 10.1098/rstb.2006.1874.

245 D. R. Weinberg, C. J. Gagliardi, J. F. Hull, C. F. Murphy, C. A. Kent, B. C. Westlake, A. Paul, D. H. Ess, D. G. McCafferty and T. J. Meyer, Proton-Coupled Electron Transfer, *Chem. Rev.*, 2012, **122**, 4016–4093, DOI: 10.1021/cr200177j.

246 X. Li, N. Markandeya, G. Jonusauskas, N. D. McClenaghan, V. Maurizot, S. A. Denisov and

I. Huc, Photoinduced Electron Transfer and Hole Migration in Nanosized Helical Aromatic Oligoamide Foldamers, *J. Am. Chem. Soc.*, 2016, **138**(41), 13568–13578, DOI: 10.1021/jacs.6b05668.

247 A. Méndez-Ardoy, N. Markandeya, X. Li, Y. T. Tsai, G. Pecastaings, T. Buffeteau, V. Maurizot, L. Muccioli, F. Castet, I. Huc and D. M. Bassani, Multi-Dimensional Charge Transport in Supramolecular Helical Foldamer Assemblies, *Chem. Sci.*, 2017, **8**(10), 7251–7257, DOI: 10.1039/c7sc03341a.

248 K. Pulka-Ziach, A. K. Puszko, J. Juhaniewicz-Debinska and S. Sek, Electron Transport and a Rectifying Effect of Oligourea Foldamer Films Entrapped within Nanoscale Junctions, *J. Phys. Chem. C*, 2019, **123**(2), 1136–1141, DOI: 10.1021/acs.jpcc.8b11046.

249 L. A. Estroff, C. D. Incarvito and A. D. Hamilton, Design of a Synthetic Foldamer That Modifies the Growth of Calcite Crystals, *J. Am. Chem. Soc.*, 2004, **126**, 2–3, DOI: 10.1021/ja037614z.

250 K. Ghosh and J. S. Moore, Foldamer Structuring by Covalently Bound Macromolecules, *J. Am. Chem. Soc.*, 2011, **133**(. DOI), 19650–19652, DOI: 10.1021/ja2087163.

251 H. G. Jeon, H. B. Jang, P. Kang, Y. R. Choi, J. Kim, J. H. Lee, M. G. Choi and K. S. Jeong, Helical Aromatic Foldamers Functioning as a Fluorescence Turn-on Probe for Anions, *Org. Lett.*, 2016, **18**(17), 4404–4407, DOI: 10.1021/acs.orglett.6b02156.

252 P. R. Bueno, R. Hein, A. Santos and J. J. Davis, The Nanoscopic Principles of Capacitive Ion Sensing Interfaces, *Phys. Chem. Chem. Phys.*, 2020, **22**(7), 3770–3774, DOI: 10.1039/c9cp05543f.

253 L. Zheng, D. Zheng, Y. Wang, C. Yu, K. Zhang and H. Jiang, Chiral Bisphosphine Ligands Based on Quinoline Oligoamide Foldamers: Application in Asymmetric Hydrogenation, *Org. Biomol. Chem.*, 2019, **17**(44), 9573–9577, DOI: 10.1039/c9ob01649j.

254 A. B. Bornhof, A. Bauzá, A. Aster, M. Pupier, A. Frontera, E. Vauthey, N. Sakai and S. Matile, Synergistic Anion-(π)n-π Catalysis on π-Stacked Foldamers, *J. Am. Chem. Soc.*, 2018, **140**(14), 4884–4892, DOI: 10.1021/jacs.8b00809.

255 L. Hou, L. Gao, W. Zhang, X. J. Yang and B. Wu, Quaternary Cocrystals Based on Halide-Binding Foldamers through Both Hydrogen and Halogen Bonding, *Cryst. Growth Des.*, 2021, **21**(5), 2837–2843, DOI: 10.1021/acs.cgd.1c00034.

256 V. Laffilé, K. Moreno, E. Merlet, N. McClenaghan, Y. Ferrand and C. Olivier, CPL-Active Water-Soluble Aromatic Oligoamide Foldamers, *Org. Biomol. Chem.*, 2023, **21**(17), 3644–3649, DOI: 10.1039/d3ob00455d.

257 L. Mauran, C. Assailly, S. R. Goudreau, B. Odaert, G. Guichard and M. Pasco, Short Oligourea Foldamers as N- or C-Caps for Promoting α-Helix Formation in Water, *ChemBioChem*, 2024, **25**(20), e202400427, DOI: 10.1002/cbic.202400427.