

Editorial

Chiral Molecules: Properties, Synthesis and Analysis

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Chirality is a fundamental dimension of molecular structures and plays a central role in living processes, in the transfer of biological intra- and inter-species information, and in the activity and properties of exogenous compounds as drugs, agrochemicals, flavors and food additives.

The synthesis of chiral compounds in enantiopure form and their characterization, as well as the study of the influence of chirality on molecular properties, often require a variety of approaches and advanced analytical techniques. In order to stimulate the development of new theoretical and experimental investigation in the field, the present Special Issue of *Symmetry*, titled “Chiral Molecules: Properties, Synthesis and Analysis”, was launched at the beginning of 2020. In the same period, the whole world came face-to-face with the SARS-CoV-2 pandemic, which deeply impacted on researchers’ work. Despite the difficult time, this Special Issue features contributions of valuable interest for the variety of the addressed topics.

In their review, Patti and Sanfilippo [1] describe the latest advances in biocatalyzed reactions applied to the desymmetrization of *meso*-compounds or symmetric prochiral molecules. The coupling of the desymmetrization strategy—which, compared to the resolution of a racemate, offers the advantage of potential yield of 100% of the target chiral compounds—with biocatalysis opens the way to the preparation, even on a large scale, of many structurally different compounds in optically active form, thanks to the growing portfolio of efficient biocatalysts (purified enzymes of whole-cell systems) presently available. Some basic concepts and examples of processes scaled up for the preparation of drugs are also presented.

Supramolecular assembling of chiral molecules is influenced by their optical purity, and in their research article, Bredikhin and coauthors [2] report the PXRD characterization of gels and xerogels deriving from some *para*-alkylphenylglycerol ethers, both in enantiopure and racemic forms, and provide evidence that only enantiopure samples exhibit features as organogelators. The X-ray analysis of the crystalline samples of gelators allows them to identify seven different types of supramolecular crystal-formative motifs, two of which, associated with a flexible 2D-bilayer network of intermolecular hydrogen bonds around screw axes, are predominant in chiral samples compared to the racemic ones and are proposed as favorable for gel formation.

The strong preference of amino acids for homochiral over heterochiral cluster ions has been proposed to be involved in chirogenesis. In this context, Kong and coworkers carried out a systematic and detailed investigation of threonine clusters by ESI mass spectrometry [3]. By comparing the ESI spectra of enantiopure and racemic threonine, the study highlights an outstanding homochiral preference for $[\text{Thr}_{14} + 2\text{H}]^{2+}$ as well as for single-charged ions $[\text{Thr}_7 + \text{H}]^+$ and $[\text{Thr}_8 + \text{H}]^+$, while some triply charged ions are characterized by heterochiral preference. The analysis of a wide range ($7 \leq n \leq 78$) of threonine clusters allows data to be obtained that will reveal the relationship between chiral preference and cluster size.

For the analysis of conformationally chiral compounds and the determination of their enantiomerization barrier, dynamic HPLC, often coupled with computational techniques,

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is an effective approach. This was demonstrated by the research of Villani's group, which considers a group of 1,4-benzodiazepine drugs whose chirality arises from two interconverting and non-superimposable boat-shaped conformations of the core seven-membered ring present in the structure [4]. In this paper, the authors describe a set of dynamic chromatography experiments on chiral HPLC columns, and in the range from room temperature to $-50\text{ }^{\circ}\text{C}$ for four 1,4-benzodiazepines, extracting the data for the best analytical conditions for their enantiomeric separation. The analysis of experimental and simulated chromatograms at different temperatures allows us to determine the kinetic parameters for the on-column enantiomerization, and the ΔG^{\ddagger} values of these stereolabile compounds show some correlation with steric and/or electronic effects of the substituents.

Chiroptical spectroscopy supported by DFT calculation can provide useful data for the understanding the conformational behavior of chiral compounds and assigning their absolute configuration. The study by Abbate and coworkers [5] sheds light on the influence of conformational mobility and interchromophoric interactions in the chiroptical VCD and ECD response of two C_2 -symmetric bicyclononane-diones. By comparing the experimental spectra with those predicted by DFT calculations, based on a careful conformational analysis, the authors evaluate the conjugation of a double bond with the carbonyl group, and this is rationalized by enhancing the CD intensity of the associated transitions.

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Abbreviations

PXRD: powder X-ray diffraction; ESI: electrospray ionization; HPLC: high-performance liquid chromatography; DFT: density functional theory; VCD: vibrational circular dichroism; ECD: electronic circular dichroism; CD: circular dichroism

References

1. Patti, A.; Sanfilippo, C. Breaking Molecular Symmetry through Biocatalytic Reactions to Gain Access to Valuable Chiral Synthons. *Symmetry* **2020**, *12*, 1454. <https://doi.org/10.3390/sym12091454>.
2. Bredikhin, A.A.; Gubaidullin, A.T.; Bredikhina, Z.A.; Fayzullin, R.R.; Lodochnikova, O.A. Chirality, Gelation Ability and Crystal Structure: Together or Apart? Alkyl Phenyl Ethers of Glycerol as Simple LMWGs. *Symmetry* **2021**, *13*, 732. <https://doi.org/10.3390/sym13040732>.
3. Jiao, L.; Du, M.; Hou, Y.; Ma, Y.; Kong, X. Homochiral or Heterochiral: A Systematic Study of Threonine Clusters Using a FT ICR Mass Spectrometer. *Symmetry* **2022**, *14*, 86. <https://doi.org/10.3390/sym14010086>.
4. Franzini, R.; Rosetti, A.; Villani, C. Low Temperature Dynamic Chromatography for the Separation of the Interconverting Conformational Enantiomers of the Benzodiazepines Clonazepam, Flubromazolam, Diclazepam and Flurazepam. *Symmetry* **2021**, *13*, 1012. <https://doi.org/10.3390/sym13061012>.
5. Mazzeo, G.; Abbate, S.; Boiadjev, S.E.; Lightner, D.A.; Longhi, G. Vibrational Circular Dichroism Detects Symmetry Breaking due to Conformational Mobility in C_2 -Symmetry Chiral Molecules and Provides Further Insight into Inter-Chromophoric Interactions. *Symmetry* **2020**, *12*, 1752. <https://doi.org/10.3390/sym12111752>.