Publ. Astron. Obs. Belgrade No. 102 (2022), 284 - 285

THE "LEGO BRICKS" OF LIFE: A GAS-PHASE STUDY OF DIPEPTIDES

L. CARLINI, P. BOLOGNESI, J. CHIARINELLI, G. MATTIOLI,
A. CASAVOLA, M. C. CASTROVILLI, V. VALENTINI, A. DE STEFANIS,
E. M. BAUER, E. MOLTENI, D. SANGALLI and L. AVALDI

Istituto di Struttura della Materia, ISM-CNR, 00015 Monterotondo Scalo, Roma, Italy

Abstract. Linear (*ℓ*-) and cyclo (*c*-) dipeptides, obtained by linking two aminoacids via one/two peptide bonds, are the smallest and simplest peptides present in nature. They are one of the most important classes of biomolecules active in many relevant biological processes. Their use in the development of therapeutics[1] as well as for innovative preparation methods of nanomaterials[2] have made these compounds the object of widespread interest since the 50s of the previous century. It has also been proposed that *c*-dipeptides may have played a role in the emergence of life in the early universe[3] thanks to both their capability to withstand radiation and to produce crucial intermediates for the development of peptide chains[4]. Moreover, *ℓ*- and *c*-dipeptides containing an aromatic aminoacid in the side chain are of interest for the study of the dynamics involving energy and charge transfers[5] in bio-systems.

In this talk, our results on the study of *ℓ*- and *c*-dipeptides (*ℓ*-PheAla, *c*-GlyPhe, *c*-TrpTrp and *c*-TrpTyr) by mass spectrometry and photoelectron-photoion coincidence experiments (PEPICO) in the gas-phase will be presented.

Combining several different experimental techniques (mass spectrometry, infrared and Raman spectroscopy, and thermogravimetric analysis) with tight-binding and ab initio simulations, we provided evidence that the linear PheAla dipeptide can turn into the cyclic one via ‘intramolecular’ peptide bond formation accompanied by water release[6] (Figure 1, left panel). This irreversible cyclization mechanism, catalyzed by water and driven by temperature, occurs in the condensed phase. This process can be considered as a very efficient strategy to improve the dipeptide stability by turning the comparatively fragile *ℓ*-structure into the robust and more stable cyclic one.

In the case of *c*-GlyPhe, *c*-TrpTrp and *c*-TrpTyr, valence photoemission (PES) measurements and a systematic ab-initio study implemented with different computational tools has allowed a detailed investigation of the electronic energy levels of themolecules[7]. Then PEPICO experiments have been performed at the CIPO beamline of Elettra synchrotron radiation facility. The correlation between the electronic distribution of the molecular orbitals and the fragments yields has been investigated by comparing the PES spectrum and the PEPICO relative ions yields (Figure

2, right panel). The calculated branching ratios of the main fragments provided information on the fragmentation pathway channels versus binding energy (BE) as well as approximate onset for the production of specific fragments and correlation among the different channels.

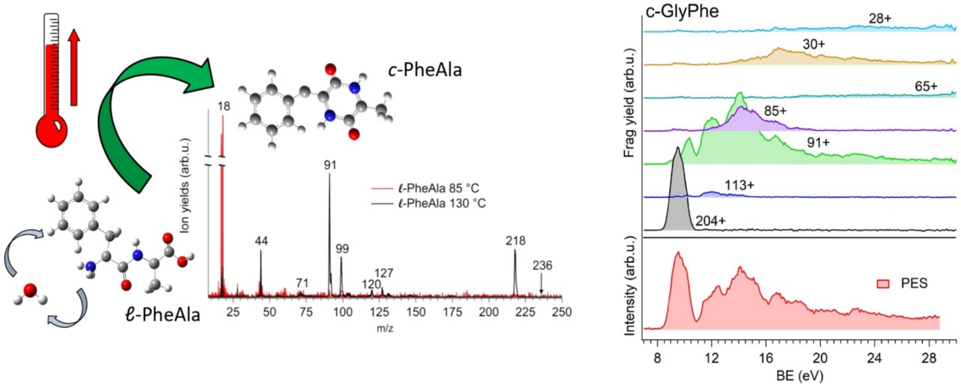

Figure 1: *Left panel* - Photoionization mass spectra of ℓ-PheAla measured at 85 (red line) and 130 °C (black line) with 21.22 eV incident radiation. A non-linear emission of water, with a dramatic increase at about 85 °C lasting several hours has been detected. At 130 °C the mass spectrum is dominated by the m/z fragments assigned to the *c*-structure. The linear parent (m/z=236) has never been observed throughout the heat-up of the sample. *Right panel* - The state-selected fragmentation of *c*-GlyPhe molecule studied by PEPICO experiments in the BE range from the ionization threshold up to 30 eV. In the bottom panel the the PES spectrum is shown while in the other panels the PEPICO relative yields for several m/z fragments are reported.

Acknowledgments

COST (European Cooperation in Science and Technology) Action CA18212−Molecular Dynamics in the GAS phase (MD-GAS) and PRIN Project 20173B72NB “Predicting and controlling the fate of biomolecules driven by extremeultraviolet radiation”.

References

[1] Zorzi, A. et all., *Curr. Opin. Chem. Biol.* 2017, **38**, 24−29.
[2] Ziganshin, M. A. et all., *Phys. Chem. Chem. Phys.* 2017, **19**, 13788−13797.
[3] Ying, J. Et all., *Sci. Rep.* 2018, **8**, 936.
[4] Barreiro-Lage, D. et all.,*J. Phys. Chem. Lett.* 2021, **12**, 7379−7386.
[5] R. Weinkauf et al, *J. Phys. Chem.* 1995, **99**, 11255-11265.
[6] Carlini, L. et all., *J. Phys. Chem. B* 2022, **126**, 2968−2978.
[7] Molteni E. et all., *Phys. Chem. Chem. Phys.*, 2021, **23**, 26793.