Novel Conformational $\beta \rightarrow \alpha$ Transformation of Oligopeptides in the Solid State by Shear Stress

By RYOICHI KATAKAI* and YOHKO NAKAYAMA
(*Department of Chemistry, College of Technology, Gunma University, Tenjin-cho, Kiryu-shi* 376, *Japan*)

Summary A novel conformational transformation of oligopeptides from a β-structure to an α-helix in the solid state was found when shear stress was applied.

WE have reported that the conformation of oligopeptides in the solid state is transformed from a β-structure to an α-helix when they are reprecipitated from solution.[1-3]

Recently, we have found that the conformational transformation takes place not only in solution but also in the solid state when the oligopeptides are ground in an agate mortar with a pestle. This new transformation in the solid state is illustrated by the pentadecapeptide Nps-(L-Ala-L-Leu-Gly)$_5$-OEt. Figure 1 shows the change of the i.r. spectrum in the amide I and II regions of the peptide before and after grinding. The sample as synthesized showed the bands at 1630 and 1530 cm^{-1} characteristic of the β-structure. After grinding, the sample showed bands at 1655 and 1545 cm^{-1}, which can be assigned either to an α-helix structure or to a random structure. The far-i.r. spectrum of the samples (Figure 2) clearly demonstrates that the transformed conformation is not a random structure but that of the α-helix. The sample as synthesized showed a band at 441 cm^{-1} characteristic of L-alanine associated with the β-structure.[4] In the spectrum of the ground sample, however, the band at 441 cm^{-1} disappeared, and new bands appeared at 526, 465, 395, and 371 cm^{-1}. The bands at 526 and 371 cm^{-1} are characteristic of L-alanine and the bands at 465 and 395 cm^{-1} characteristic of L-leucine associated with the α-helical conformation.[4] Moreover the whole spectral profile is quite similar to that of the α-helical sample prepared by reprecipitation from solvents.[1]

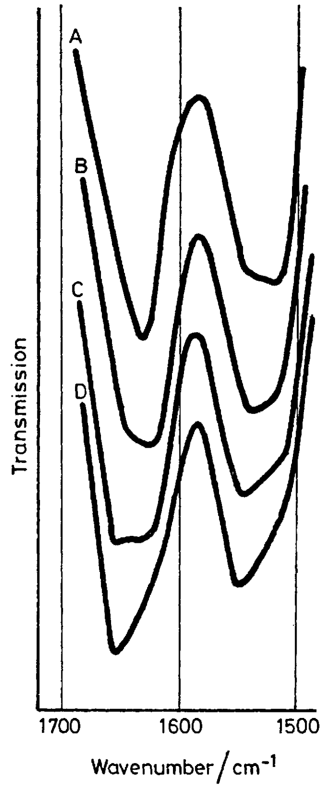

Figure 1. I.r. spectrum of Nps-(L-Ala-L-Leu-Gly)$_5$-OEt. A, sample as synthesized; B, C, and D, sample after grinding for different times.

Further evidence supporting the transformation from the β-structure to the α-helix was obtained by X-ray powder diffraction measurements. The sample as synthesized showed three peaks at 2θ = 11·3, 19·1, and 23·1°. The first and second reflections can be assigned as the (020) and (110) planes of the orthorhombic unit cell of the peptide with the β-structure.[1] The ground sample, however, showed peaks at 2θ = 10·4 and 20·1°. The first peak can be assigned to the (100) plane of the hexagonal unit cell of the peptide with the α-helix.

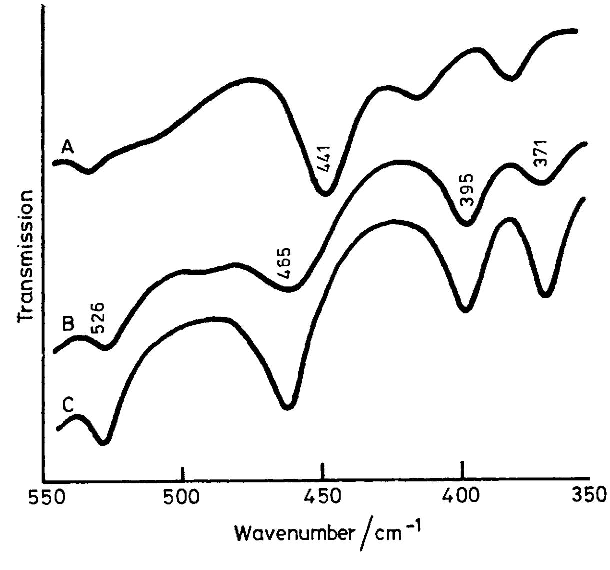

Figure 2. Far-i.r. spectrum of Nps-(L-Ala-L-Leu-Gly)$_5$-OEt. A, sample as synthesized; B, sample after grinding; C, sample precipitated from trifluoroethanol.

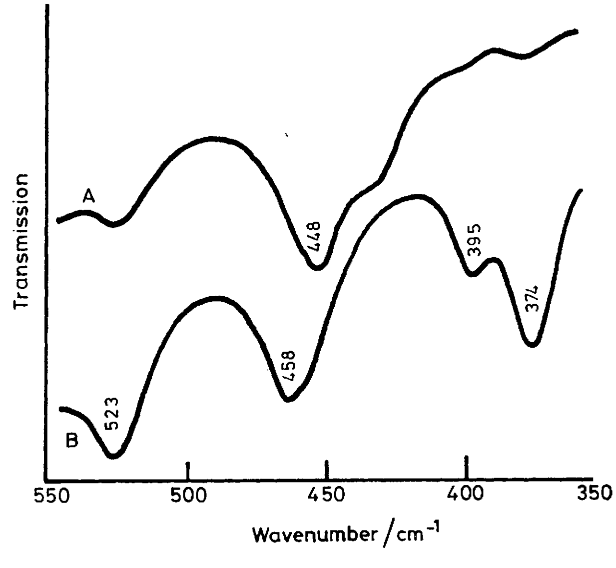

Figure 3. Far-i.r. spectrum of Nps-(L-Ala-L-Leu-L-Ala)$_5$-OEt. A, sample precipitated from hexafluoropropan-2-ol; B, sample after grinding.

The far-i.r. spectrum (Figure 3) of Nps-(L-Ala-L-Leu-L-Ala)$_5$-OEt also illustrates the conformational transformation in the solid state. This peptide is of special interest because grinding the sample is essential for the transformation.[5] A sample reprecipitated from solvents showed a band at 448 cm^{-1}, which suggests that it is still in the

β-conformation. The ground sample showed the bands at 523, 458, 395, and 373 cm^{-1} characteristic of the α-helix. The *X*-ray powder diffraction pattern of the ground sample supported the conformational transformation.†

It is unclear at this stage why grinding the solid induces this transformation. Many forces are applied to the sample when it is ground. We believe that shear stress may be the most effective force, because neither hydrostatic pressure nor a trace of solvent in the sample can induce the transformation. The heat dissipated during grinding of the sample may also be responsible.

(*Received*, 19*th September* 1977; *Com.* 985.)

---

† The sample reprecipitated from solvents showed three prominent peaks at 2θ = 10·4 (020), 19·1 (100), and 23·1°, while the ground sample showed two prominent peaks at 2θ = 9·6 (100) and 19·3°.

[1] R. Katakai, *J. Amer. Chem. Soc.*, 1977, **99**, 232.
[2] R. Katakai, *J.C.S. Perkin I*, 1977, 1193.
[3] R. Katakai and Y. Nakayama, *Polymer*, 1977, **18**, 755.
[4] K. Itoh and H. Katabuchi, *Biopolymers*, 1973, **12**, 921.
[5] R. Katakai and Y. Nakayama, *J.C.S. Chem. Comm.*, 1977, 805.