4. BIOPOLYMER STRUCTURE AND SYMMETRY OPERATIONS IN PARTIALLY DISSOLVED AND FRAGMENTED SCLEREIDS OF ARMENIACA VULGARIS LAM.

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Abstract

In our previous paper, the methods and results of the LM investigation of the partially dissolved and fragmented sclereids of *Armeniaca vulgaris* were published. For biopolymer symmetry operations the results of experiment No: 1616 (dissolution with diethylamine, on 30 °C, during 90 days) were the best. Two pentagonal and one hexagonal biopolymer units were investigated by several kinds of symmetry operations with the modified Markham rotation method. New methods were also introduced for the investigation of the basic elements of the fullerene-like biopolymer structures.

Key words: Armeniaca vulgaris, sclereids, TEM, biopolymer symmetry.

Introduction

The first results on the TEM investigations of partially degraded and fragmented sclereids of *Armeniaca vulgaris* were published in 1991 (KEDVES, KEDVES and ROJIK) and in 1992 by KEDVES. Regular basic pentagonal polygon in Å dimension and different kinds of highly organized units (filamentous, larger globular, single compound and open polygons) were established.

Results of the TEM investigations of partially degraded sclereids were published by KEDVES and PÁRDUTZ (1992). In our previous paper (KEDVES and BORBOLA, 1997), the methods and the LM results of our long-lasting dissolution experiment were published.

This contribution presents the TEM results of partially dissolved and fragmented sclereids and in particular the results of the symmetry operations of the pentagonal and hexagonal biopolymer units.

Material and Methods

The material and the dissolution method was published in our previous paper (p. 64, 67, KEDVES and BORBOLA, 1997). One part of the partially dissolved sclereids was fragmented with a magnetic stirrer in watered medium, during 30 minutes. The fragmented sclereids were dropped on a grid covered with collodium pellicle and then dried. The electron microscopical investigatons were made an Opton EM-902 (resolution 2–3

Å) at the Hungarian Academy of Sciences Biological Research Center, EM Laboratory of the Department of Biophysics.

Results

1. Until 20 days of dissolution by both solvents (diethylamine, merkaptoethanol) the fragments were not sufficiently unfolded the biopolymer structures.

2. After 25 days of partial dissolution the larger biopolymer structures of the wall appeared. Until 8 month of dissolution different kinds of biopolymer units were observed.

3. From 9 to 12 month, the largest part of the wall components were more or less desintegrated.

4. For our biopolymer symmetry operations the results of the experiment No: 1616 (dissolution with diethylamine, temperature: 30 °C, length of time: 90 days) were the best. Two regular pentagonal (Plate 4.1.), and one hexagonal (Plate 4.2.) biopolymer unit was chosen for symmetry operations.

BIOPOLYMER I
(Plate 4.1., plate 4.3., figs. 1–6, plate 4.4., figs. 1,2)

Primary rotations

C.P.5.A.5.5. (Plate 4.3., fig. 1)

Around the basic pentagon several light and dark points of symmetries appeared, forming further larger regular pentagons. The outermost rotation area is more or less pentagonal star form.

C.P.5.A.5.10. (Plate 4.3., fig. 2)

The secondary points of symmetry are not so well expressed. But around the light rotation centrum it is a dark circle, bordered with ten points of symmetry. These points of symmetry are continued by radially oriented dark fields. The rotation area is characteristic.

Secondary rotations

C.S.$X_{+1/2}$.5.5. – C.P.5.A.5.5. (Plate 4.3., fig. 3)

A very characteristic light star forming field appeared after this rotation. This star is surrounded by narrow light arched fields forming a more or less complete circle. In this way five dark points of symmetry can be recognized within this light circle.

C.S.$X_{+1/5}$.5.5. – C.P.5.A.5.5. (Plate 4.3., fig. 5)

Around the rotation centrum there are five dark points of symmetry in a light not completely regular light pentagonal fields. Sometimes the apices of the pentagon are slightly bifurcated. This light rotation area is embedded in a dark field.

C.S.$X_{-2/1}$.5.5. – C.P.5.A.5.5. (Plate 4.4., fig. 1)

The negative secondary rotation centrum resulted in five dark points of symmetry forming a regular pentagon. This is surrounded by another well defined pentagon of five light points. Around this pentagon further dark and light points of symmetry can be recognized but its distribution is not so regular.

C.S.$X_{+1/6}$.5.10. – C.P.5.A.5.10. (Plate 4.3., fig. 4)

This kind of secondary rotation resulted in dark and light points of symmetry which form regular pentagons around the centrum of the rotation. It is a characteristic light rotation area. Around this area there are further dark points of symmetry.

C.S.$X_{+1/8}$.5.10. – C.P.5.A.5.10. (Plate 4.3., fig. 6)

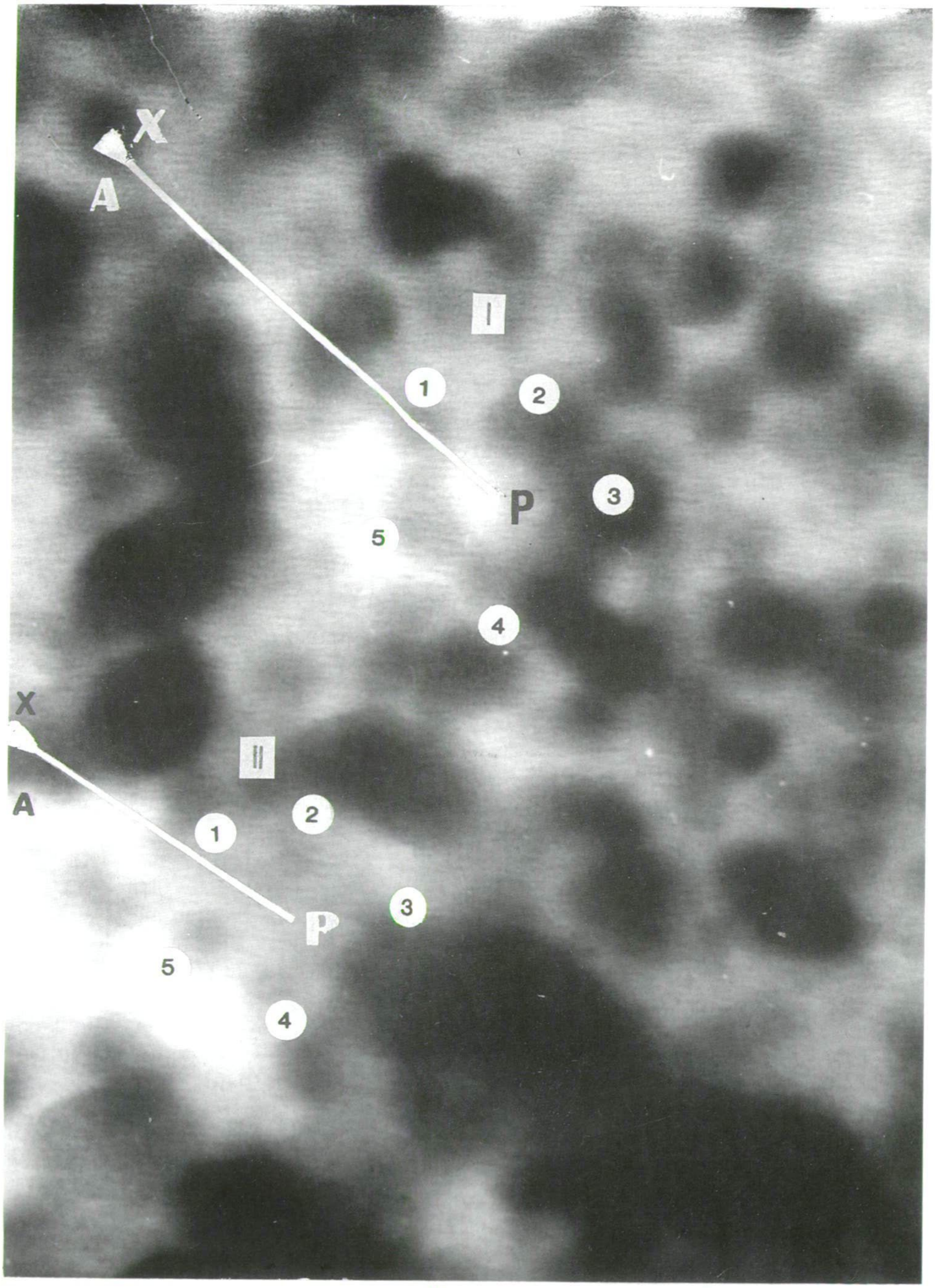

Plate 4.1.

TEM picture of the partially degraded sclereids of *Armeniaca vulgaris* LAM. Experiment No: 1616. The investigated pentagonal biopolymer units are indicated. Negative no: 3182, 1.000.000x.

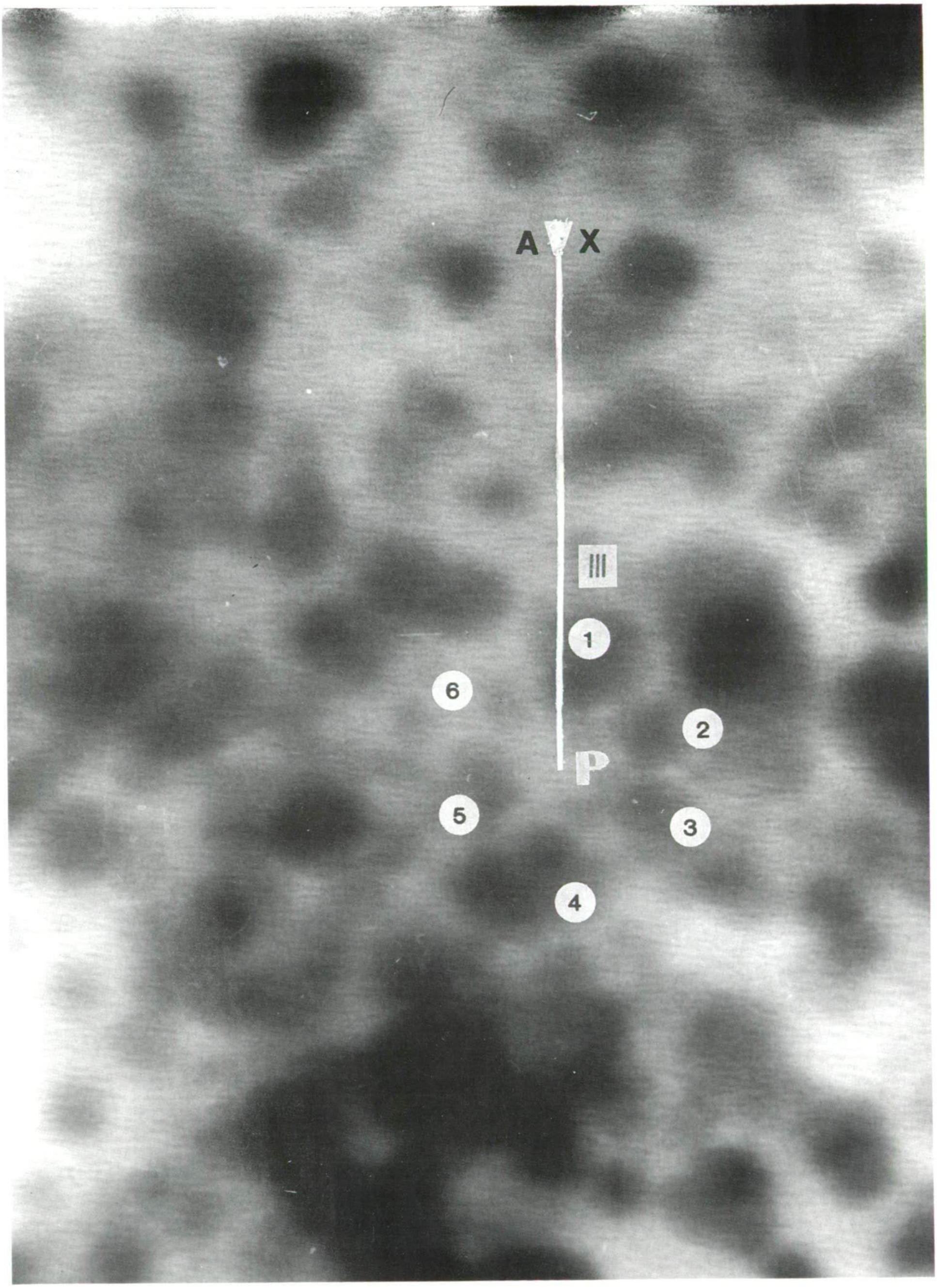

Plate 4.2.

TEM picture of the partially degraded sclereids of *Armeniaca vulgaris* LAM. Experiment No: 1616. The investigated hexagonal biopolymer unit is indicated. Negative no: 3182, 1.000.000x.

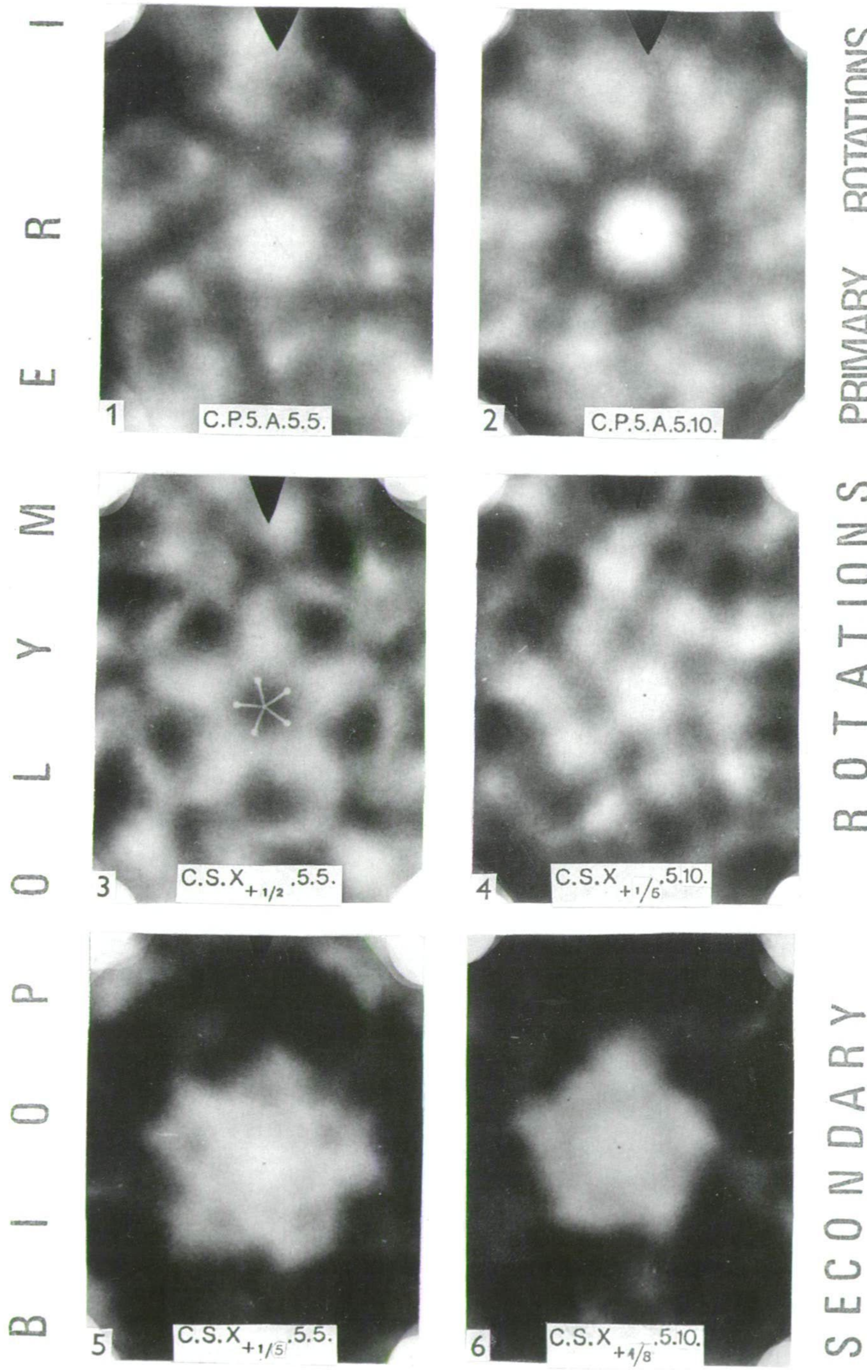

Plate 4.3.

Biopolymer I
1. Five-fold primary rotation picture. 500.000x.
2. Ten-fold primary rotation picture. 500.000x.
3–6. Secondary rotation pictures. 500.000x.

A light, pentagonal area appeared in a dark field. This is similar to the secondary rotation picture illustrated in Plate 4.3., fig. 5. In this case the not wholly discovered molecular system of the rotation centrum is the reason of this result.

C.S.$X_{-2/9}$.5.10. – C.P.5.A.5.10. (Plate 4.4., fig. 2)

Similarly to the previous rotation a light pentagonal field appeared after this kind of rotation. This light field is surrounded by a dark pentagon. There are more or less radially oriented light bands rectangular to the sides of the light pentagon. Probably these light bands surround larger, dark biopolymer units.

BIOPOLYMER II

(Plate 4.1., plate 4.4., figs. 3–6, plate 4.5., figs. 1–4)

Primary rotations

C.P.5.A.5.5. (Plate 4.4., fig. 3)

The dark pentagonal unit is surrounded by a light pentagon. But between two larger light points of symmetry there are further not so characteristic light points of symmetry. In this way there is a more or less circular light field around the centrum of the rotation. There are more or less radially oriented light points of symmetry coming from the larger points of symmetry of the light pentagon.

C.P.5.A.5.10. (Plate 4.4., fig. 4)

Ten, not so characteristic dark points of symmetry appeared which are surrounded by further ten light points of symmetry, and so it is a very characteristic spherical light field. This is surrounded by further ten dark points. Finally ten more or less characteristic light radially oriented further light points.

Secondary rotations

C.S.$X_{-1/1}$.5.5. – C.P.5.A.5.5. (Plate 4.4., fig. 5)

The central pentagon of dark points of symmetry is followed by another pentagon of light points. This is surrounded by another larger pentagon, but towards the edges there are two larger dark points.

C.S.$X_{-1/2}$.5.5. – C.P.5.A.5.5. (Plate 4.5., fig. 1)

In a light pentagonal field a not so characteristic dark star appeared. The light pentagonal field is surrounded by a characteristic dark pentagon. Around this there are five large points of symmetry forming another pentagon.

C.S.$X_{-1/3}$.5.5. – C.P.5.A.5.5. (Plate 4.5., fig. 3)

A pentagon appeared after this rotation. The apices of this pentagon continue by a radially oriented system of dark lines, which delineate supplementary light fields. There is a circular light rotation area with small ten angles in a dark basic field.

C.S.$X_{+2/2}$.5.10. – C.P.5.A.5.10. (Plate 4.4., fig. 6)

This secondary rotation resulted in a central dark star-shaped pentagon. This is encircled by a light-star, but the apices of this latter one are ramifying. Five large dark points are around the light star-shape regular pentagon.

C.S.$X_{+2/3}$.5.10. – C.P.5.A.5.10. (Plate 4.5., fig. 2)

A dark regular pentagon appeared after this rotation. This is surrounded by a light pentagon of ramifying apices. Five large dark points are around this rotation area.

C.S.$X_{+2/4}$.5.10. – C.P.5.A.5.10. (Plate 4.5., fig. 4)

A small dark area appeared near the rotation centrum. This is surrounded by a light pentagonal field. Further light areas of irregular shape coming from the sides of the pentagon represent another, outest rotation area.

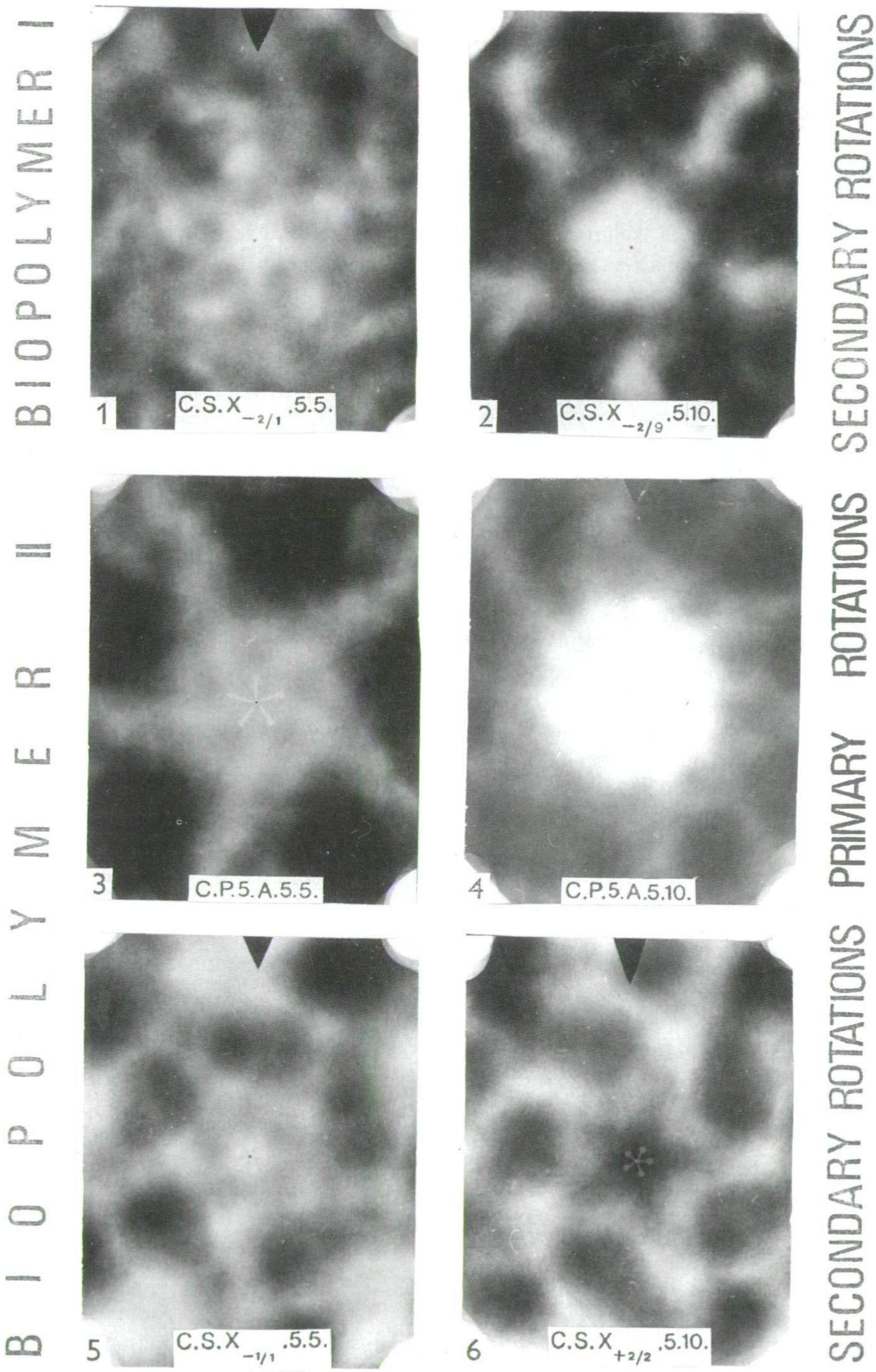

Plate 4.4.

Biopolymer I
1,2. Secondary rotation pictures. 500.000x.

Biopolymer II
3. Five-fold primary rotation picture. 500.000x.
4. Ten-fold primary rotation picture. 500.000x.
5,6. Secondary rotation pictures. 500.000x.

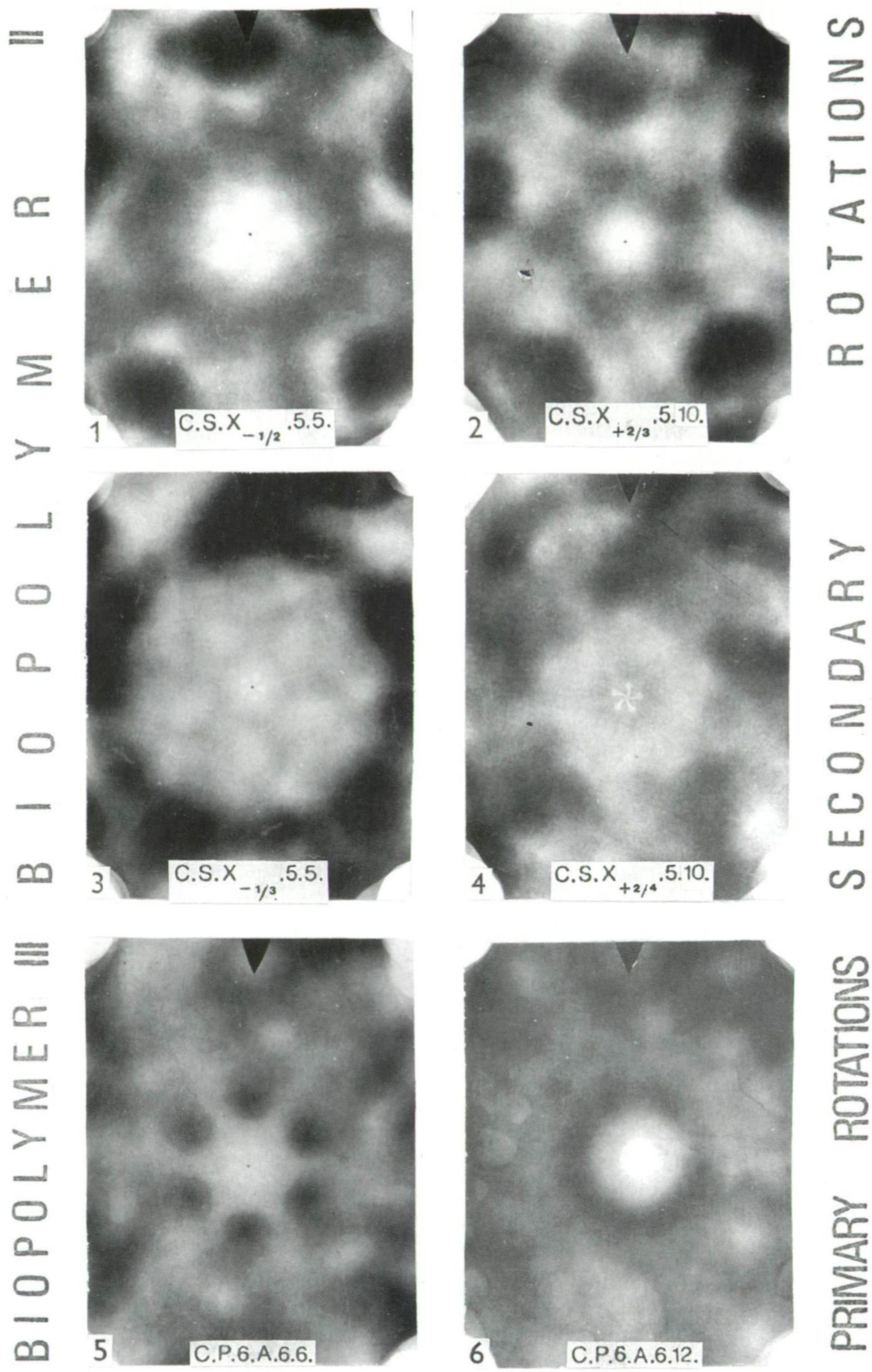

Plate 4.5.

Biopolymer II

1–4. Secondary rotation pictures. 500.000x.

Biopolymer III

5. Six-fold primary rotation picture. 500.000x.
6. Twelwe-fold primary rotation picture. 500.000x.

BIOPOLYMER III

(Plate 4.2., plate 4.5., figs. 5,6, plate 4,6., figs. 1,2, plate 4.7., figs. 1–6)

In contrast to the previous ones this biopolymer unit is hexagonal and not pentagonal.

Primary rotations

C.P.6.A.6.6. (Plate 4.5., fig. 5)

This rotation reinforced the hexagonal biopolymer system. Not so characteristic, further points of symmetry appeared forming a nearly circular light rotation area, with further light ramifications.

C.P.6.A.6.12. (Plate 4.5., fig. 6)

Light and dark concentric zones appeared after this rotation. The points of symmetry are not well expressed. The outer rotation area is more or less circular.

Incomplete rotations

I.P.6.A.6.$3_{1,3,5}$ (Plate 4.6., fig. 1)

It is interesting that after this incomplete three-fold rotation all six points of the biopolymer unit appeared. Further points of symmetry appeared with further more or less network-like points of symmetry.

I.P.6.A.$3_{2,4,6}$ (Plate 4.6., fig. 2)

This incomplete rotation resulted essentially in those of the previous one.

TICOS polyhedra rotations of the hexagonal biopolymer unit

This kind of rotation was used only once (KEDVES, 1991).

C.$P._{4,6}$.4.A.4.4. (Plate 4.7., fig. 1)

After this rotation the secondary points of symmetry represent three tetragons, in two areas. The inner one is more or less rhombus-like oriented in the rotation axis. The other is a tetragon perpendicular to the rotation axis. The outer rhombus is composed of large points of symmetry obliquely to the rotation axis.

C.$P._{-5}$.0.-A.5.5. (Plate 4.7., fig. 3)

This rotation resulted in an inner opposite pentagon, and further larger points of symmetry of one pentagon.

C.$P._{4,6}$.5.A.5.5. (Plate 4.7., fig. 5)

The points of symmetry and the pentagonal areas are oblique to the rotation axis.

New method of rotation in the investigation of the fullerene-like biopolymer structures

In this case an attempt was made to establish a method for the connection of the hexagonal and pentagonal biopolymer organizations. This is essentially a peculiar radial rotation. The axis of the rotation is a linear feature between the centre of the hexagonal biopolymer unit and the mid-point of the side of the hexagon. The rotation centrum was indicated as follows. Perpendicular to the sides of the hexagon the rotation centrum was measured to the rotation axis, this is the half size of the diameter of the regular pentagonal unit. After this a fivefold rotation was made. In this paper three such kinds of rotation are presented.

C.H.5_0.R.$6_{1,2}$.5.5. (Plate 4.7., fig. 2)

This rotation resulted in a dark more or less pentagonal field. This field is surrounded by a light area. There are further light lines originating from this light zone.

C.H.5_0.R.$6_{2,3}$.5.5. (Plate 4.7., fig. 4)

A regular dark pentagonal unit appeared after this rotation, together with further points of symmetry. This may be one connected element to the hexagonal biopolymer system.

C.H.5_0.R.$6_{3,4}$.5.5. (Plate 4.7., fig. 6)

This rotation resulted also in a regular pentagon, but this is a little larger than the previous one. Further points of symmetry appeared as well.

Discussion and Conclusions

The long-lasting partially dissolved sclereids of *Armeniaca vulgaris* with diethylamine and merkaptoethanol unfolded step by step by the length of time the biopolymer structure of the wall. Regular pentagonal and hexagonal basic units were established. The primary and the secondary rotations of the regular pentagonal biopolymer unit verified again the presence of the quasi-periodic lattice. But there are several new data on further kinds of biopolymer structures.

We payed peculiar attention to the hexagonal biopolymer unit in our material by the following methods:

1. We tryed the so-called TICOS polyhedra method (KEDVES, 1991b) to establish whether it is a real hexagon or two regular pentagon is in a peculiar opposite position. The results of these rotations are not convincing.

2. After this we started to elaborate a new method on the hypothesis that this regular hexagon is a structural element of a fullerene-like – quasi-equivalent – organization. The starting point of this method is that there are regular pentagons around this hexagon. Based on our first results using this recently elaborated method the hypothetical regular pentagon units were verified.

In summary we hope that with these data we advanced towards a better knowledge of this peculiar biological organization. As it was emphasized in several previous papers in the future the destabilized quasi-periodic biological structures of the oil shale or of the sclereids or other plant cell wall may be a new energy basis of environmental protective character.

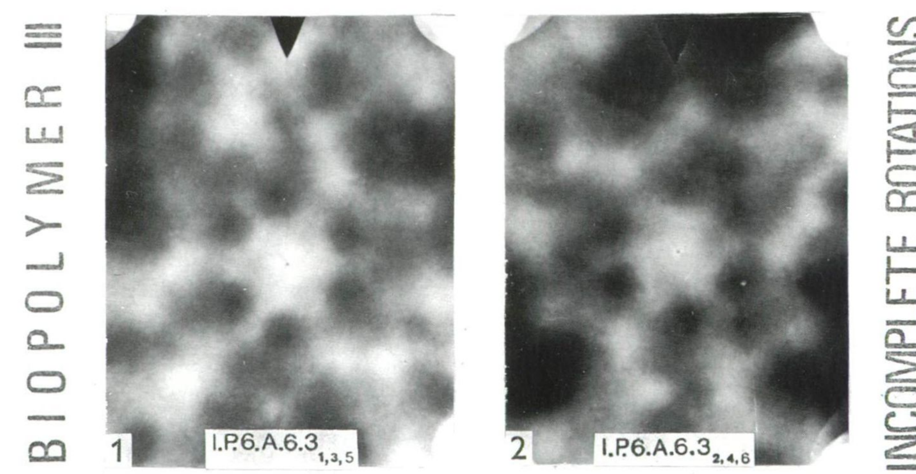

Plate 4.6.

Biopolymer III

1,2. Incomplete rotation pictures. 500.000x.

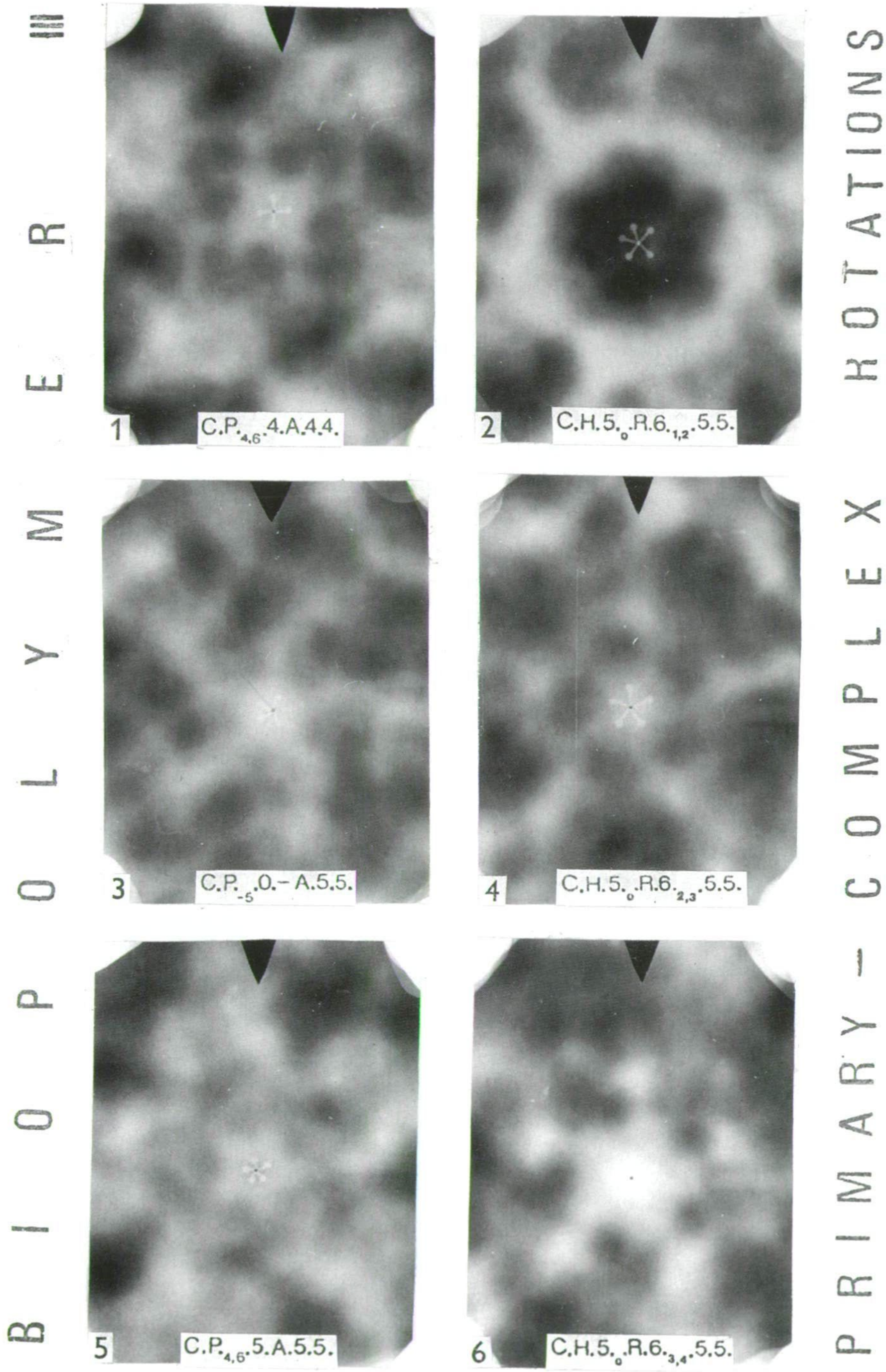

Plate 4.7.

1,3,5. TICOS modelling rotation pictures. 500.000x.
2,4,6. Complex rotation pictures. 500.000x.

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