Biomaterials

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The cement float: morphology, biochemistry and mechanical properties of the cement of the barnacle *Dosima fascicularis* (Crustacea, Cirripedia Thoracica)

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These days, natural adhesives are one of the focal points of research [1,2]. Marine animals like barnacles, echinoderms, mussels and tubeworms are of particular interest because they produce adhesives which cure under water. The understanding of these adhesives can be helpful for the production of non-toxic artificial glues for medical and technical applications [3].

The barnacle adhesive is called cement. It is used for the attachment of the animal to the substratum. Our interest focuses on the stalked barnacle *Dosima fascicularis* which is unique in using its foam-like cement not only for attachment, but also as a float allowing the sedentary organism some mobility [4]. The cement is produced in large gland cells “Figure 1” in the upper part of the stalk and transported through a canal system to the base of the stalk where it is extruded through pores “Figure 2”. In the fibrous cement “Figure 3” are gas-filled bubbles enclosed. The cement is deposited in concentric layers around the stalk. The outer layers are narrow forming a kind of rind and enclose small bubbles. Inside the float are large, elongate bubbles radiating outwards “Figure 4”.

EELS and EDX spectra of the cement float show high counts of carbon, oxygen and nitrogen “Figure 5”, corresponding to the organic nature of the cement. Biochemical analyses indicate that the cement is made up of at least 85% of proteins. Gel electrophoresis of the polymerized cement revealed six prominent protein bands which are different in comparison with other barnacles. Infrared spectral analysis indicates the presence of amide I, II and III bands in the *D. fascicularis* cement. DOPA, a posttranslational modification of tyrosine, which plays an important role in the adhesive system of mussels and tubeworms, has not been identified in the cement of *Dosima* nor in that of any other barnacle [5]. Mechanical properties were studied by means of micro-indentation. The results show that the *Dosima* cement is much softer than any other barnacle cement. The elastic modulus of the wet cement lies in the range of 5-20 kPa and the hardness in the range of 1-3 kPa. Dehydration hardens the originally soft barnacle adhesive “Figure 6”. The dry cement has an elastic modulus of about 0.8 MPa and a hardness of about 40 kPa. Further, the barnacle cement has visco-elastic properties, which is common in natural fibrous structures [6]. The cement of *D. fascicularis* differs from that of all the other barnacles in the high amount which is produced, the morphological appearance, the protein composition and its softness.

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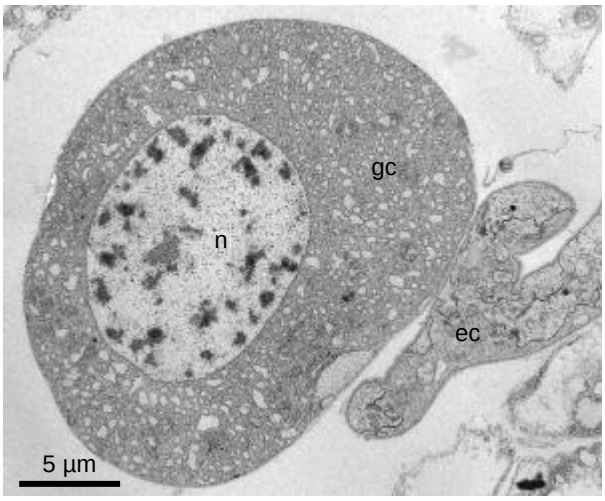

Figure 1. Overview of a cement gland cell (gc) of *Dosima fascicularis*. The extracellular canal (ec) is seen next to the gland cell; nucleus (n)

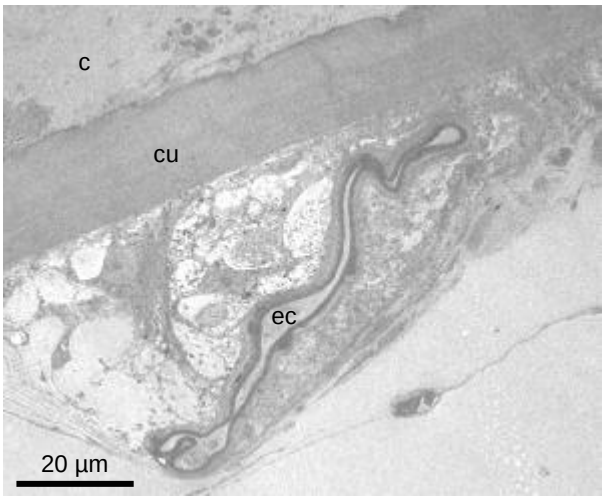

Figure 2. Extracellular canal (ec) next to the base of the stalk before opening through a pore in the cuticle (cu); cement (c)

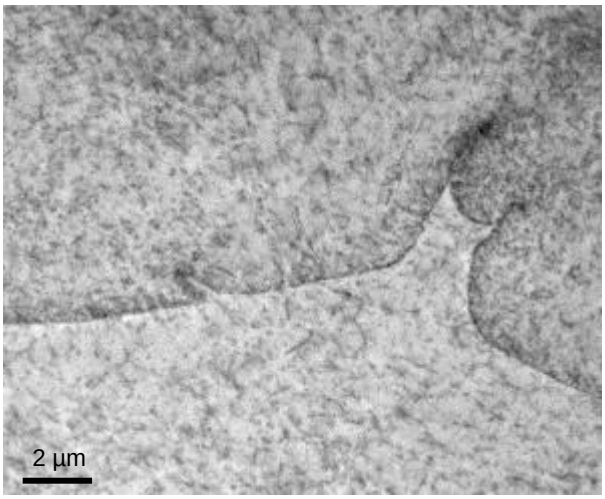

Figure 3. The fibrous structure of the cement.

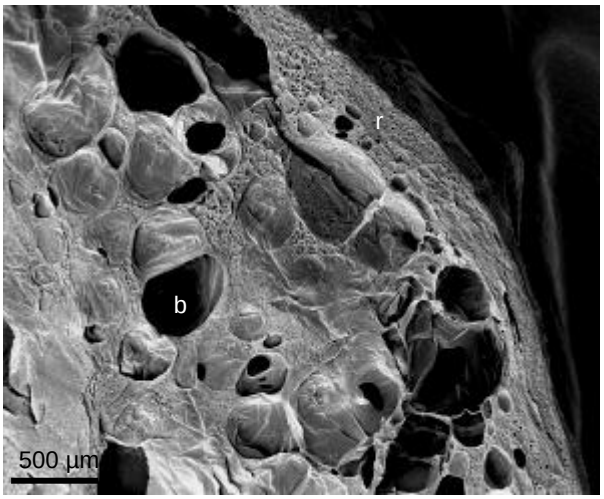

Figure 4. Cross section through the cement float. The outer region forming a rind (r) contains small bubbles, in the inner region are larger bubbles (b).

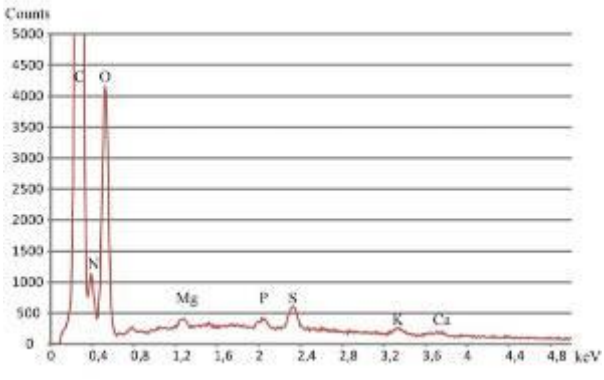

Figure 5. The EDX spectrum of the cement shows high counts of carbon, oxygen and nitrogen. Magnesium, phosphorus and sulphur are only detected in small quantities.

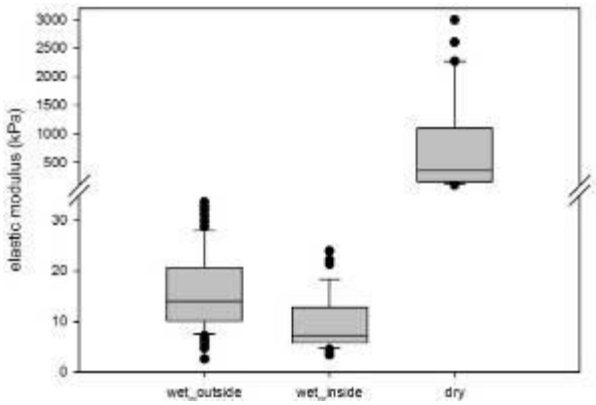

Figure 6. Comparison of the elastic modulus of the wet and the dry cement. The wet cement, measured outside and inside, is much softer than the dry cement.