

Structure and Properties

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BSS

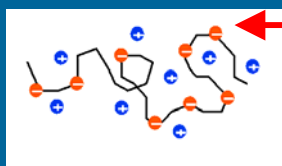
*Biological
and Soft
Systems*

My research is concerned with studying the interplay between microstructure at supramolecular levels, and the consequent properties. We use a wide range of characterisation techniques including different types of microscopy and scattering approaches, as well as micro-mechanical testing. The field of polymer physics is well advanced, but we are pushing the areas of applications more widely to include polymers of biological origin, such as polysaccharides and proteins. In addition, since many biological systems are necessarily hydrated, we have been developing the comparatively new technique of Environmental Scanning Electron Microscopy (ESEM), working closely with the instrument manufacturers to unleash its full potential for insulating and wet systems.

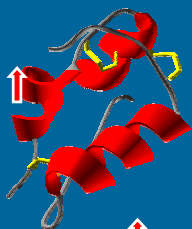
Polymers and Biopolymers



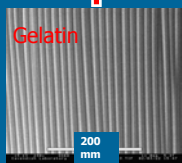
Electron Microscopy of Soft Systems



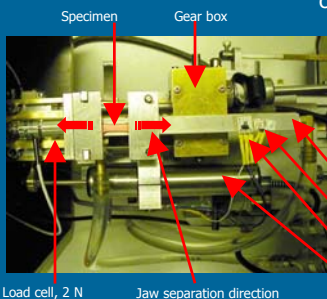
Polyelectrolytes are polymers with charge distributed along the backbone. In solution, counterions surround the chain as shown. The **chain conformation now depends on the ionic strength** of the surrounding medium, and the coil can shrink or expand.



Many **proteins** (here insulin is shown) are also charged, and if the secondary structure is destabilised by e.g. heat, the chain can be considered in the same way as for a synthetic polyelectrolyte.

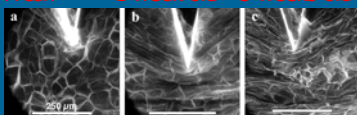


If films are now made from these proteins/polyelectrolytes, we would therefore expect the mechanical properties to reflect the underlying chain conformation in some way. To date we have studied films of hydrated gelatin, which show an interesting surface instability. The studies are to be extended to other charged polymers.



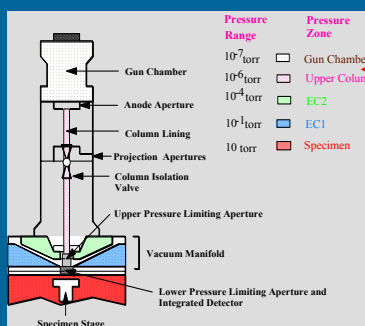
In-situ straining, in the ESEM using an in-house built rig, allows us to **follow the deformation, obtain quantitative stress-strain data and keep the sample hydrated, all at the same time.**

Blade penetration into a carrot:
Fresh 1 week old 3 weeks old

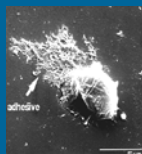


As the tissue ages and cell contents are lost, the turgor pressure reduces. This leads to a change in deformation from a quasi-brittle failure in the cell walls, to a compression of a large area. We perceive this as a loss of crispness upon biting!

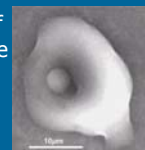
This approach will allow us to study plant tissue deformation, and relate the **mechanical properties both to genetic background and also to treatments required e.g for processing to minimise waste and environmental impact.**



Layout of the **Environmental Scanning Electron Microscope**, indicating the different pressure zones. VP of water vapour can be maintained around the sample, permitting hydrated samples to be maintained in their native state.

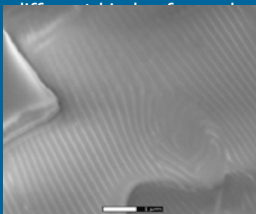


Conventional SEM of fixed and dried spore of *Enteromorpha*; adhesive pad looks fibrillar.

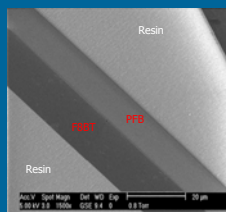


Hydrated spore in the ESEM, showing that the adhesive pad is not really fibrillar, but appears to be structureless.

Conventional SEM can provide **misleading information** on naturally hydrated systems; hence developing ESEM is very important for such systems. There are many open questions about image formation, optimisation of detectors and experimental design. In addition, we have recently been loaned a **dual beam instrument which permits in-situ sectioning through samples** by the instrument manufacturers, who are working closely with us. We will be developing protocols to enable precision sectioning of insulating – and therefore challenging – samples. This requires a combination of practical skills and understanding of the underlying ion and electron physics and the way the beams interact with the sample.



For **block copolymers**, with their complex morphology of rather chemically similar components, the ESEM offers a way of obtaining contrast **without the need to stain or etch components**. This figure shows the case of a block copolymer of polystyrene–polyisoprene, with a volume fraction of ~50% polystyrene. The polystyrene forms the darker lamellae in this case.



This source of contrast is also proving useful for the polymers used in **optoelectronic devices**, such as PFB and F8BT. In this case the **contrast can also be altered by the application of a voltage**, as would occur in a real device. This helps us to understand the role of charge carriers as they affect the electron emission from the sample.