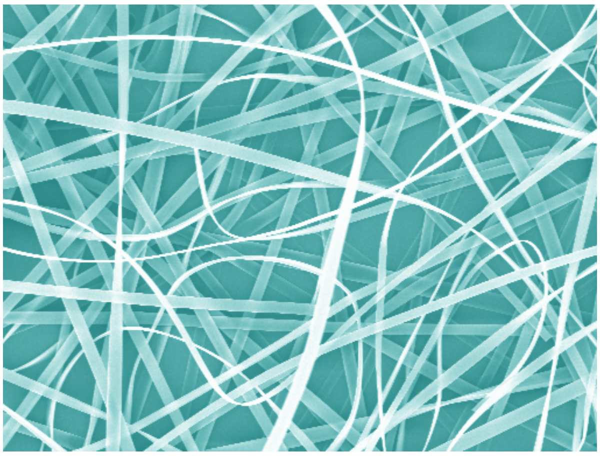
*E*lectro*SPUN*

A multidisciplinary research programme focused on nano and micro scale fibres prepared by electrospinning

News November 2007



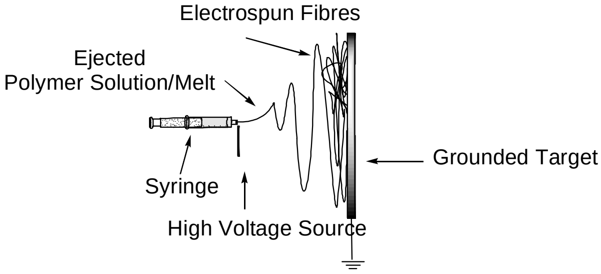
Electrospinning provides an effective route to the preparation of nano and micro fibres of synthetic and biological polymers. It is an enabling technology with applications in medical, pharmaceutical, chemical, textile, electronic industries. The technique produces very fine, nano to micrometer diameter, fibres in random matts as shown above or in more controlled structures.

The *ESPUN* programme at Reading has a dedicated high voltage electrospinning facility based in the Physics Building and makes extensive use of instrumentation in the Centre for Advanced Microscopy and in the Schools of Chemistry, Food Biosciences and Pharmacy and Mathematics, Meteorology and Physics. The team has performed the world's first neutron scattering experiments at ISIS on electrospun polymer fibres to reveal quantitative detail of the complex molecular reorganisation which accompanies electrospinning with further beam-time later this year. The *ESPUN* Team has been awarded beam time at the Diamond Synchrotron Source to exploit in-situ x-ray scattering studies of the nanostructure formation during the electrospinning process.

The *ESPUN* programme is working with an SME on a project to scale up the electrospinning process for the manufacturer of nanodefined filtration units for medical applications.

We have listed below just a few of the areas where scientists around the world are exploring the potential of electrospun fibres:
Biomedical, Biological structures, Drug Delivery System, Composites, Filtration for water, gases, viruses, Imobilisation of enzymes and catalysts Photonics, Photovoltaics, Scaffolds, Nano-structures from inorganic materials, Sensors, Structural studies, Textiles, Tissue Engineering.

Electrospinning Basics



Electrospinning is observed when a high electric field is applied to a polymer solution or melt. This usually involves a polymer solution in a syringe with an electrically conducting needle and collecting electrode. The application of a large electric field leads to a jet, which is elongated and the process of solvent evaporation leads to the formation of nano-scale fibres. This is illustrated in the figure above (reproduced from F.J. Davis and G.R. Mitchell in 'Bio-Materials and Prototyping Applications in Medicine' ed P.Bartolo Springer 2007). The fibres may contain nanoparticles to provide active function in both medical & physical science applications. A reasonable review is "An Introduction to Electrospinning and Nanofibers" S. Ramakrishna World Scientific Publishing 2005

People

The ESPUN programme is a multidisciplinary programme involving researchers across the life and physical sciences. It is led by Dr Fred Davis

from the School of Chemistry, Food Biosciences and Pharmacy and Professor Geoffrey Mitchell from the Centre of Advanced

Microscopy and the School of Mathematics, Meteorology and Physics. The programme builds on the extensive expertise and experience at the University of Reading on the synthesis / preparation / structure / properties relationships of synthetic & biological polymers.

More Information

There any many applications for the use of electrospinning across the physical, life and medical sciences. For more information or if you would like to get involved in the *E*lectro*SPUN* programme please contact either Professor Geoffrey Mitchell g.r.mitchell@reading.ac.uk, 0118 3788573, or Dr Fred Davis f.j.davis@reading.ac.uk 0118 3788455.

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Current *ESPUN* projects

The Reactive Electrospinning Project with *Delyth Elliott* focuses on developing new materials and new structures by inducing chemical reactions during the electrospinning process. One possibility is that we start with monomers and produce polymers in-situ during electrospinning or that we modify the polymers during the electrospinning process for example through cross-linking. A review on the 'Potential for Reactive Electrospinning' by F.J.Davis and G.R.Mitchell will be available shortly

The *ESPUN* Team is collaborating with the Wayne Hayes Group in Chemistry on the use of electrospinning to study self-assembling polymers. This has proved invaluable in identifying the effectiveness of the molecular interactions in these novel molecules.

Professor Mahadevappa Kariduraganavar, a Commonwealth Fellow, is exploring how nanoscale fibres with monodomains of Liquid Crystalline Polymers and Elastomers can be prepared using electrospinning. We are focusing on how the preparation of nano and micro sized fibres affects the formation of the liquid crystal state and on the use of liquid crystal elastomers as novel transducer systems.

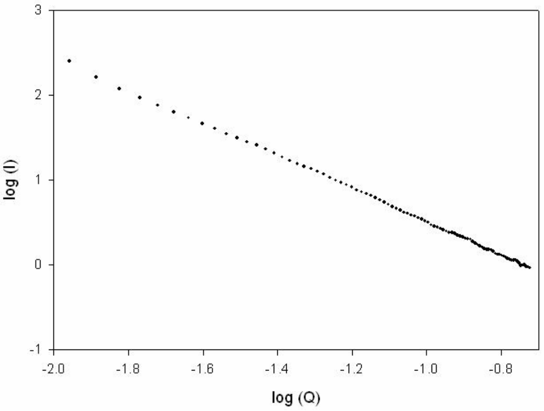
Sujat Sen is exploring how electrospinning provides an effective route to the preparation of nanoscale conducting fibres with potential for use in nerve repair and other applications. We are examining whether it is possible to spin electrically conducting fibres directly or whether these need a carrier polymer matrix.

Key to exploiting electrospinning is the collection of the nanofibres. *Saeed Mohan* is developing structured electrodes to yield organised fibre matts as well as using small-angle neutron and x-ray scattering techniques to evaluate the structure evolution during electrospinning. We are developing a novel electrospinning stage which allows the fibres to spun in-situ whilst performing time-resolving x-ray scattering measurements on how the structure develops in the fibre as the solvent is lost and the fibre extended.

Robert Olley is exploring how crystallisation can be controlled in biodegradable polymers with potential for use in tissue engineering, drug delivery and other medical applications. A central topic is whether the growth of crystals and the structure and morphology of those crystals is modified by the scale of the fibres.

Highlights of current research

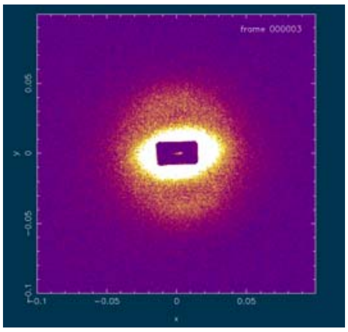
Polymer chain conformations in electrospun fibres



Small-angle neutron scattering is a powerful technique available at the nearby ISIS facility to evaluate the shape and size of the polymer chain configurations in the electrospun fibres. We have used mixtures of deuterated and hydrogenated polystyrene to show that the polymer chains are expanded from their normal bulk state and that the chains are preferentially aligned along the fibre axis. The figure shows the neutron scattering data; the slope of the line provides a quantitative view of the chain shape. Further experiments to be performed in December 2007 will provide a more detailed picture of how the shape and size of the polymer chains in the fibres are influenced by preparation conditions. G.R.Mitchell, M.B.Belal, C.D.Asuzu, F.J.Davis 'Chain Dimensions in Electrospun Fibres of Polystyrene' Polymer

Biodegradable Nano/Micro Fibres

We have used electrospinning to prepare fibres from biodegradable polymers such as polylactide and polycaprolactone. These have widespread application potential in biomedical applications for example as scaffolds for tissue engineering, drug delivery and wound dressings. The image shows a small-angle x-ray scattering pattern obtain at the synchrotron source which reveals both a highly aligned domain structure in this blend (central ellipse) but some rather weak crystalline component (outer scattering). A knowledge and control of this scale structure is vital to achieve the target properties.



The ElectroSPUN programme is part of the Nanoscience and Materials Research Theme at the University of Reading
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