Sustainable Materials for a Greener Future by **Dr Ana Sobrido**, on 29th October 2021

Dr Sobrido is a reader in Sustainable Materials at Queen Mary College, London. She leads an eight strong research group working on developing new sustainable, electroactive materials and processes for energy conversion and storage. She has recently been awarded a prestigious Future Leaders Fellowship for £1.5m to develop electrodes for redox flow batteries.

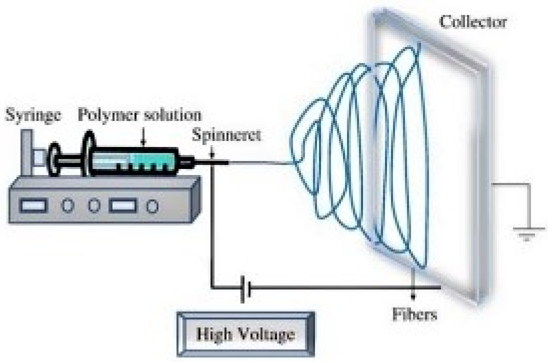
She began with a slide with a picture of the group, but also showing pictures of material textures with µm and nm scales. These are of highly porous electrodes with a vast surface area for their size. Present commercial electrode materials have a fibre size about 25 times larger, and correspondingly poorer performance.

There is a vital need for high-capacity storage batteries to handle peaks in electrical demand, which cannot be met, for instance, by a steady wind driven source.

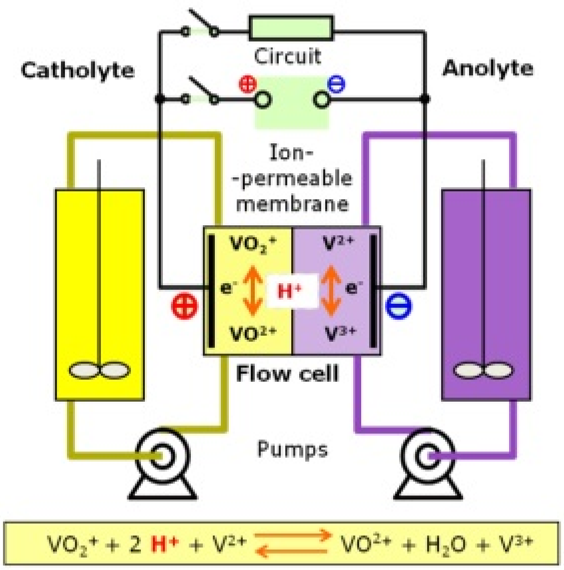
She mentioned Lithium-Ion batteries, and developments in Lithium-Sulphur* and related technologies. A major problem with Li-Ion batteries is the great difficulty of recycling their materials when they wear out – something not costed into their manufacture. Can we make sustainable but equally efficient materials?

If you want to do something dirt cheap, make it out of dirt (Prof D Sadoway at the MIT).

Biomass waste is plentiful. From it, **polymers**, whether in straight or branched chains, cross linked, or complex molecules, can be extracted and made into a viscous solution. This can be extruded from a syringe and be drawn into a fine fibre by a 15-20 kV electric charge. The fibre can be collected by an earthed frame to form a freestanding functional material. **Lignin** forms the cell wall of plant fibres – it can be similarly spun into very thin sheets. These can be stabilised at 300^{O}C then baked at 900^{O}C to produce a sheet of carbon fibres. Several parameters can be adjusted to optimise results.



The team has developed a machine in which a sheet of supporting material is drawn from a cylindrical reel to a take-up cylinder through a collector electrode. It produces a film 35cm wide.



Redox Flow Batteries (Reduction/Oxidation)

Unlike batteries where the reacting elements are held in, or form, the electrodes, in a Redox battery the charge is distributed throughout the liquids in a pair of cells, each with an electrode, either side of a membrane to prevent the contents mixing, but to permit charge flow between them.

Dr Sobrido described a battery based on Vanadium. It has two tanks connected to a flow cell. When the battery is charged the Vanadium in one tank (shown yellow) is in a V^{2+} state, and that in the other tank is in a V^{3+} state.

When connected to a load, current flows and the Vanadium oxidation states gradually revert. When discharged, the load is disconnected and a generator (eg a wind farm) is connected.

The capacity of the battery is determined by the size of the tanks. Redox flow batteries are suitable for energy storage with power ratings from tens of kWh to tens of MWh. Present designs are about 70% efficient.

Lignin based electrodes in the Flow Cell greatly increase the efficiency of the battery, compared with present commercial batteries. One improvement in the latter had been to add phosphates to the electrodes; however, a (laboratory) lignin based battery, already superior, was not further improved by adding phosphates.

Dr Sobrido concluded by saying: Energy storage is key for the decarbonisation of energy supply: Batteries well placed to achieve this, though materials and safety need to improve; Redox flow batteries are an alternative to Li-ion for large capacity applications.

New chemistries and technologies that are more sustainable and reliable are on their way.

***** *see*: **Future Battery Technologies - Lithium-Sulphur** by **Dr Monica Marinescu**, on 20 January 2017