Merino wool dyed with different sizes of "nanosilver". Photo: Victoria University of Wellington

Gold, Silver and Green for Synchrotron Scientists

The Australian Synchrotron is solving some intriguing material science challenges.

Green Cement

Cement literally glues our buildings together, but the way we make cement – by cooking calcium carbonate – is responsible for up to 8% of our greenhouse gas emissions.

With the help of synchrotron light, University of Melbourne researchers have invented a better cement. It's produced with one-fifth of the CO_2 emissions, and it's made with waste ash from coal-fired power stations.

Melbourne company Zeobond has built a pilot plant making concrete – known as E-Crete – from the new cement. The new concrete is already being used to build footpaths in Melbourne's northern suburbs.

Since the 1950s scientists have been exploring the potential of so-called green cement – also known as geopolymer cement – that uses aluminosilicates instead of calcium oxide. These silicates are a major component of waste fly ashes from power stations and slags from mineral processing. Millions of tonnes go to landfill each year, but most could be used to make concrete instead.

John Provis and his research team at the University of Melbourne have been set the challenge of understanding the basic chemistry of green cement. "We need to understand how the individual particles interact," he says. "That will allow us to improve the manufacturing process and the strength of the concrete it produces.

"Lab-based tools don't have the resolution we need, so we turned to synchrotron light. The synchrotron's intense infra-red beam reveals the surface chemistry of individual particles while the soft X-ray spectroscopy beamline can identify individual chemical bonds."

Provis' research has taken him to synchrotrons in New York and Taiwan. "But it's much easier to drive out to Clayton," he says.

A Truly Golden Fleece

New Zealand researchers are creating a new high fashion garment – one that combines the touch and feel of merino wool with the special properties of "nano" gold and silver.

Fern Kelly, a PhD student working with Prof Jim Johnston from the School of Chemical and Physical Sciences at Victoria University of Wellington, brought samples of their merino textiles treated with silver nanoparticles to the Australian Synchrotron to investigate the chemistry and to help ensure that the silver is strongly bound to the individual fibres and won't wash out.

The merino textiles contain 1–2% silver. The silver particles are less than 100 nm, or just one 10,000th of a millimetre.

The size of the silver particles determines the colour of the fabric. Fern and her colleagues have created yellow, peach, pink, purple and some shades of green. The colours don't fade in sunlight, and the dyeing process is less polluting than conventional dyeing.

In addition, the nanoparticles of silver are toxic for a wide range of microbes but benign to human cells – which could be a boon for applications as diverse as bandages, hospital blankets and high occupancy seats in theatres, buses and aircraft.

But will the silver stay where it's put? That's the question that's brought Kelly to the Australian Synchrotron. Silver chemistry is complex, and she needs to be certain that the silver nanoparticles will bond permanently to the fibre so that they do not get washed out. Not only would that degrade the special properties of the textiles, it would create a new pollution risk.

Last year Kelly obtained some preliminary results from a powder diffraction beamline at a synchrotron in Stanford. The results surprised her because the silver had bonded to the fibres in an unexpected form. Now she is using the powder diffraction beamline in Melbourne to help her identify the phases of silver in the fabric, and how it is bonding to the wool

The very narrow wavelength of the synchrotron beam allows her to resolve what's happening to the silver on and just under the surface of the wool fibres. It gives information that conventional X-ray powder diffraction just can't see.

If her work progresses well, she anticipates that the patented technology will be available in shops within 2 years.

Visit www.synchrotron.org.au for more information.