A BEAM OF LIGHT IN NEW MATERIAL DESIGN

A conversation with **PROFESSOR CHRISTOPHER BARNER-KOWOLLIK**, Head of the Soft Matter Materials Laboratory at Queensland University of Technology

Using the power of light to control and programme the shape of materials, Australian Laureate Fellow, Professor Barner-Kowollik, leads researchers studying complex polymer reactions with real-world applications. The group's pioneering work includes the use of light for soft matter material design with applications ranging from dentistry, to 3D laser lithography.

What type of research are you doing in your lab?
We work with polymers, in particular constructing and altering their properties with light.

Using light to trigger chemical reactions offers key advantages over using heat. Light affords both temporal control (it can be switched on and off easily) and spatial control (a beam of light can be directed where you want the reaction to occur or even confined in 3D space using high light intensities).

What are some applications of your work?
Light is used in a range of applications that affect everybody. When you have a filling at the dentist, for example, it contains a polymer composite material that is typically hardened (cured) using light.

For example, we are investigating the use of light in advanced dental materials. Instead of using a drill, the dentist could shine light of a different wavelength on the filling than the one used for curing, which would liquefy and be readily removed from the cavity. On a chemical level this is quite hard to do. The concept is called wavelength orthogonality. It means that in the same reaction mixture — the filling in this case — one colour of light could harden the filling and a different colour of light could soften it. This technology of light-reversible adhesion could have other dental applications, e.g. braces are normally glued to the teeth and then they have to be cracked off, which damages the tooth enamel. Applying this concept, light could be used to remove the glue in a very soft and gentle way.

Another application is 3D printing, where light is one of the most common ways to print polymeric materials. We are particularly interested in printing micro and nano-materials, using a process known as 3D laser lithography.

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Some of the interesting potential applications could be using a 3D printer to print conducting molecular circuitry — computer chip manufacture for example.

Our research can also be applied to the problem of waste. Many packaging materials cannot be recycled because the components are glued together. Electronics, such as smart phones for example, are difficult to take apart. If we could use light of a particular wavelength to unglue them, the components could be recycled, moving closer to a circular economy.

Describe your group at QUT?
We have a group of about 40 researchers, consisting of PhD students, honours students, postdoctoral fellows and other academic staff. We are a close team, and, importantly, we work in an open project environment.

The PhD students have their individual projects, but essentially every project is open for everybody to contribute. We put the science first, we want the best outcome and ask everyone to put their egos aside and contribute to the big picture. This approach allows us to really focus on the science and has enabled us to publish more than 40 high-impact papers each year.

Our research is funded about 70% from public sector sources such as the ARC and 30% from industry.

Do you work closely with other groups?
Over the past 20 years, we have collaborated with more than 150 different institutions in 27 countries. We work with a range of the largest chemical companies in the world, and smaller start-ups in a wide range of industries. These industry partners range from transnational chemical giants such as BASF, Merck and Evonik to recycling companies, 3D printing companies and the manufacturers of light emitting displays.

We have a portfolio of about 22 patents. Some of our systems in the field of light-controlled, self-healing polymers have been taken up by Evonik, so we have made a few inroads into commercial exploitation of these technologies.

What sets you apart from other research groups in the same field?
Only a few groups work with light-driven research in the field of soft matter materials science, and we are the leaders in using light to such a high degree of precision. We have a very high-powered, dedicated laser facility where we can access finely gated monochromatic light to induce chemical reactions.

As we work a lot with lasers, our group entails physicists as well as chemists. We have a state-of-the-art chemistry wet laboratory next to our laser facility — a combination which is quite rare and thus chemists and physicists can work together in one space.

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