MATERIALS SCIENCE

Glowing fabrics communicate

An approach has been developed for incorporating optoelectronic devices into polymer fibres, which can be woven into fabrics. Such materials could have applications in both telecommunication and health monitoring. SEE LETTER P.214

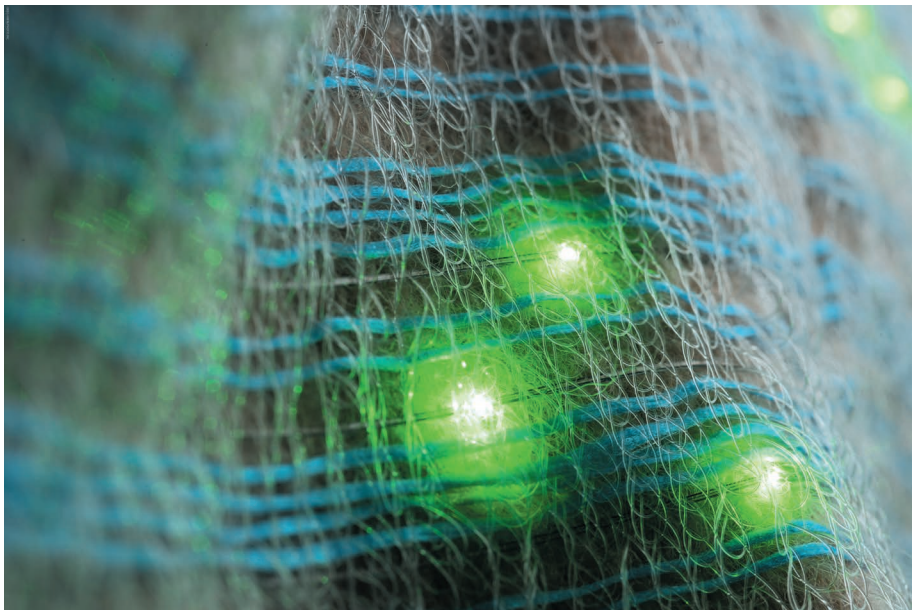
WALTER MARGULIS

From time immemorial, textiles have covered our skin and protected it from rain, cold weather and sunlight. The introduction of novel materials and automation techniques widened the use of textiles to carpets, backpacks and car seats. On page 214, Rein *et al.*[1] breathe new life into textiles. The authors present an approach for integrating optoelectronic devices — such as light-emitting diodes — that are commonly used in consumer electronics into fabrics. They demonstrate an optical communication link between two pieces of fabric, and show that their technology can be used to monitor a person's heart rate.

To achieve these feats, Rein and colleagues exploited ready-made, high-quality optoelectronic devices in the form of chips. Such chips are typically a few micrometres in size, and need to be in electrical contact with conducting wires. There are two main challenges to the use of these chips for fabric-based optoelectronics. First, both the chips and the wires need to be protected from the environment — for example, from water. Second, electrical contacts cannot be established for each chip individually, because this would be too costly and time-consuming.

Rein *et al.* addressed the first challenge by embedding the chips and wires in optical fibres made of a transparent polymer. These fibres not only allowed light to be emitted and detected, but also shielded the chips and wires from the environment. The authors then wove the fibres into textiles (Fig. 1). They found that the optoelectronic devices maintained their performance even after ten cycles of a commercial machine-wash.

The authors solved the problem of electrical contacting by means of the method they used to embed the chips and wires in the optical fibres. Optical-fibre fabrication starts with a glass or polymer rod called a preform, which is typically about 2.5 cm in diameter and tens of centimetres in length[2]. The preform is heated in a furnace, and the resulting molten, viscous material is drawn into a fine strand of submillimetre diameter: a fibre. Assuming that the conditions are correct, the fibre has a cross-section that replicates that of the preform, but on a much smaller scale. Consequently, two holes separated by 1 mm in the preform could end up as two holes separated by 10 μm in the fibre.



GREG HREN

Figure 1 | Optical fibres containing light-emitting diodes integrated into a knitted fabric.

Rein and colleagues discovered that if two fine, hard wires of tungsten or copper are inserted into separate holes in the preform and continuously fed into the preform during fibre drawing[3], they can be separated by only a few micrometres in the final fibre. The wires are electrically isolated from each other and are fully encapsulated by the surrounding polymer. Furthermore, a chip that was embedded between the two holes in the preform can end up touching the two wires in the drawn fibre, thus establishing an electrical connection between the chip and the wires. Crucially, individual chips placed near to one another in the preform continue to be operational as a string of devices after fibre drawing. The fabrication technique therefore avoids the need for individual electrical contacting.

Having overcome the challenges of protection and electrical contacting, Rein *et al.* demonstrated potential applications for their fibres. In a beautiful experiment, after mechanically weaving fibres into a textile, the authors lit up many embedded light-emitting diodes of red, green and blue colours. The resulting glowing fabric could be used for decorative, display or safety purposes. The fabrication technique is also equally suitable for other types of optoelectronic device, such as photodiodes, which generate electrical signals in response to light.

Rein and colleagues used the electrical connections in the fibres both to operate the devices and to convey, through electrical current, information about a device's illumination level. They found that, with one fibre emitting light and one detecting light, an optical communication link could be established. In particular, pulses of light emitted by a fabric at a frequency of up to 3 megahertz could be sensed by a nearby fabric, demonstrating the possibility of transmitting information by optical means.

The authors also explored altering the shapes of the fibres so that they acted as lenses, collimating the light from light-emitting diodes and focusing the light collected by photodiodes. Such alterations improved the efficiency of the demonstrated communication link and increased the maximum distance of the link to about a metre. As a final application, Rein *et al.* show that, if a person presses a finger against a light-emitting fibre and a light-detecting fibre that are near each other, the intensity of the light collected by

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the light-detecting fibre varies according to the person's heart rate[4]. This physiological application of textiles could be used in primary-care settings.

Rein and colleagues' results pave the way for integrating low-cost electronic components into fabrics. Wearable lasers and light detectors and the ability to communicate through garments are some of the possibilities opened up by this work. A strength of the study is the use of high-performance devices that are already available, as opposed to previously reported competing materials and components based on compounds known as chalcogenides[5] that are still far from reaching the market.

This work describes only the initial phases of the technique, and much optimization remains to be done. One key step in the fabrication procedure is the mounting of the chips in the preform, which at present is done manually. A mechanized approach could take the technology to a higher level of reproducibility and maturity.

As is the case in many fields, whether or not the technology will enter the market will probably be dictated by economic rather than scientific factors. Nevertheless, practical applications of the fabrics can already be envisaged. Although a high-quality communication link will probably find fierce competition from available technologies, one might more readily expect to see the fabrics used for a hospital bed sheet to monitor a patient's physiological state, or for a glowing flag in a football stadium. ■

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PARASITOLOGY

Drug candidate and target for leishmaniasis

Better treatments are needed for the neglected tropical disease leishmaniasis. The development of a compound that tackles the disease in mice, and the identification of the protein it targets, offer a way forward. SEE ARTICLE P.192

CAROLINA M. C. CATTA-PRETA & JEREMY C. MOTTRAM

The parasite-mediated disease visceral leishmaniasis is prevalent in the tropics and causes 20,000–40,000 deaths across the globe each year[1]. The drug treatments currently used for this condition have substantial side effects, are difficult to administer and can result in the evolution of treatment-resistant parasite strains. On page 192, Wyllie *et al.*[2] present studies of a series of related drug-candidate molecules that are being developed for leishmaniasis treatment. They also identify the target of the most promising compound.

It is more than 100 years[3] since drugs based on the chemical element antimony[4] were first used to treat visceral leishmaniasis, also known as black fever or kala-azar. This sandfly-transmitted disease is caused by the protozoan parasites *Leishmania donovani* in the Old World and *Leishmania infantum* in both the Old World and the New World. Antimony-based drugs are still used today as part of a small range of treatments for the condition. In 2012, the World Health Organization reviewed[5] the global impact of neglected tropical diseases in the developing world and identified the control of leishmaniasis worldwide and its elimination on the Indian subcontinent as priority targets. To achieve these goals, methods are needed to identify compounds with potent anti-parasitic activity that are suitable for safe and effective therapies.

Parasites from the *Leishmania* genus live and replicate inside a membrane-bound vacuole in macrophage cells of the immune system. Wyllie and colleagues studied compounds called pyrazolopyrimidines, which are effective against a related protozoan parasite, *Trypanosoma brucei*. The authors optimized the compounds by assessing their effect on *in vitro* infection of macrophages by *Leishmania* and by testing them using a mouse model of visceral leishmaniasis. They selected one named compound 7 as the best candidate for additional study because it had a good safety profile, high potency and suitable properties for development as an orally administered drug. However, the compound's mode of action was unknown, so the authors sought to identify its molecular target in the parasite. Such target identification is important because it can aid the assessment of possible off-target effects in humans, as well as the likelihood of the emergence of drug resistance.

The authors used a biochemical approach to find proteins that bind to compound 7, and identified three enzymes of interest: CRK3, CRK6 and CRK12. These are similar to cyclin-dependent kinases (CDKs), protein kinases that need to bind a cyclin regulatory protein to enable their kinase activity[6]. When the authors

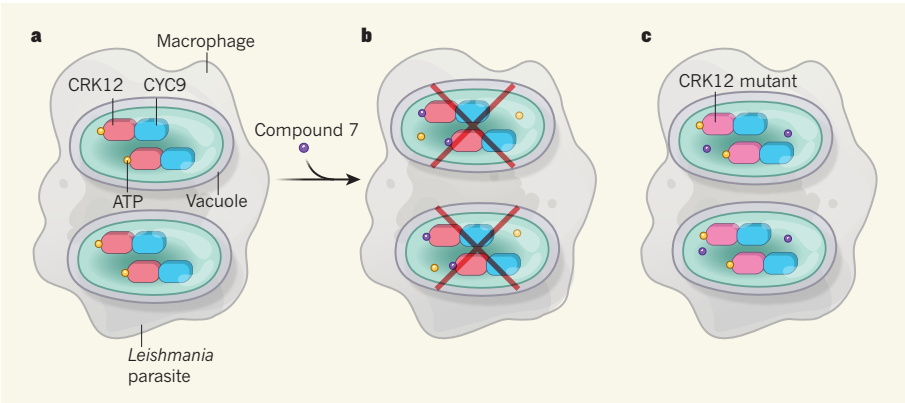

Figure 1 | How a drug candidate targets the *Leishmania* parasite. Wyllie *et al.*[2] have identified candidate drug molecules for treating the tropical disease leishmaniasis, which they tested in mouse models of the disease. The most promising molecule is called compound 7. **a**, The protozoan *Leishmania* parasite causes leishmaniasis. It infects host immune cells called macrophages and resides in a membrane-bound vacuole. The authors identified the protein kinase enzyme CRK12 as a target of compound 7. This enzyme is similar to cyclin-dependent kinases, has a binding pocket for the molecule ATP and is found in complex with the cyclin protein CYC9. **b**, The level of parasites in mice treated with compound 7 was reduced. The authors' computational modelling studies indicate that compound 7 binds in the ATP-binding pocket of CRK12, thus preventing ATP binding and inhibiting the enzyme's activity, leading to parasite death. **c**, The authors identified a mutation in the catalytic domain of CRK12 that was associated with drug resistance that arose in a laboratory setting. When *Leishmania* parasites were engineered to express this mutant version of CRK12, the effectiveness of compound 7 was reduced. It seems reasonable to speculate that the mutation alters the binding affinity of compound 7 to CRK12, but not that of ATP.

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