In the eye of the beholder

James Dimond

Contact lenses that change colour in the wearer's field of vision to warn of bio-agents in the war-field, dangerous increases of poisons in mine shafts or fluctuating glucose levels in diabetic patients are about to become science fact

Professor Chris D. Geddes and his team of researchers at the Institute of Fluorescence at the University of Maryland Biotechnology Institute are bringing radical new applications to disposable contact lenses.

One of the world's leading authorities on fluorescence-based technologies, Geddes is bent on revolutionising the way we see—and see through—contact lenses. He has designed a contact lens capable of monitoring glucose levels in diabetic patients, potentially saving millions of people from drawing blood multiple times each day to measure their glucose levels.

The lenses use fluorescent probes that respond to changing glucose levels in the tears of diabetic patients, alerting them to fluctuations by altering the lens colour. The sensors can be worn in or out of the wearer's field of vision; those that choose the latter option track the changes by looking in a mirror and comparing the colour of their lenses to a colorimetric strip of paper.

The changing lens colour acts as an alert for wearers and would be particularly useful for older people and children, both of whom are generally reticent about having to draw blood many times a day to measure their glucose levels, says Geddes.

'It means that parents can monitor their diabetic children, as can care workers for the elderly.' The size of the sensors could be enlarged to make glucose changes more noticeable to parents.

Sizable market

Geddes says there are currently 18 million diagnosed diabetic sufferers in the USA and approximately that number again who have not discovered they have the condition. He expects that with the growing obesity epidemic, that figure will skyrocket in coming years and says that the contact lenses would offer diabetic patients a number of advantages.

'First, continuous monitoring would be a big advantage. The average diabetic in America finger pricks and self-tests four times a day. The contact lens is completely continuous, reflecting the continuous daily fluctuations of glucose levels. It has been clinically shown that fluctuations in glucose levels are most adverse to health conditions—the peak and trough periods are most problematic to diabetics.

'Second, it is non-invasive. Middle-aged diabetic patients, for the most part, do not mind finger-pricking but children and older people are less enthusiastic about it.'

Geddes says that financially, the lenses would be within budget for the average contact lens wearer or diabetic patient.

'We envisage this technology as being completely disposable; they would be daily disposable lenses.

The lens functions well in a laboratory setting, says Geddes. His research team is seeking financing through potential industrial partners for the product to progress to clinical trials.

'Clinical trials in America are an extremely costly endeavour and we are looking for commercial partners.'

The new technology has already garnered much attention from the media. In April 2005, Geddes appeared on Discovery Canada's website to explain the technology and its potential applications (http://www.exn.ca/news/video/exn2005/04/28/exn20050428-contact.asx).

'It is very much a shock and awe technology for the marketplace, in that to get people to use a new technology after decades of using a finger-pricking glucose-based oxidase stick is a bit dramatic. It means that the implementation is harder but when it does happen, it will probably go gangbusters.'

On the front-line

The potential applications for the technology do not stop at diabetes—Geddes is applying the technology to monitor a range of physiological conditions and has developed lenses capable of detecting harmful chemical bio-agents.

The technology has garnered the interest of military figures who see the lenses as being useful in battlefield and first-responder situations.

For detecting bio-agents, it was the capacity of the lenses to alert wearers to changes in their physiology that was particularly attractive, says Geddes.

'All the special force personnel these days have eyepieces that send biometric readings back to the remote-viewing position where other officers monitor their progression. If you could also send biological data back, that would be of great interest.'

In a new take on the canary down the mine trick, Geddes says that the technology could be adapted

to monitor cyanide levels in mine shafts. People who work in the amalgam business extracting gold use cyanide extraction to separate gold and silver ores from rocks.

'These miners are exposed to high levels of cyanide; most cyanide deaths occur in industry, especially in the polymer business.'

Geddes says that our eyes offer us a window on our physiology and that the contact lenses could be used to detect a host of physiological conditions including changes in cholesterol, core body temperature, potassium and lithium levels, even to tell whether someone is complying with their medication schedule. Different sensors could be incorporated into the one lens to track multiple physiological events simultaneously.

'It occurred to me that in addition to glucose, there are a lot of physiological analytes that one would want to detect. As well as bio-agents there are a lot of physiological conditions that you can detect in tears, for example sodium and potassium levels for hypertension, lithium for stability—a lot of people take lithium daily to have stable lifestyles.

'Even body core-temperature could be monitored with this technology. I envisage a contact lens for clinical assessment, where one can measure on the surface of a contact lens all the different clinical analytes that are in tears.'

Geddes hopes the technology is adopted in hospital emergency rooms to monitor fluctuating physiological conditions, alleviating the need to submit patients to needles and probes.

Fluorescent technology is already widely used in medical procedures, most notably the dyes used in cancer imaging, oncology and retinal angiography. Geddes says that the potential uses for these contact lenses are a reflection of the wide-ranging applications of fluorescent technology.

'Fluorescence touches all walks of life, from chlorophyll synthesis in plants to money—nearly all currency around the world uses banknotes that use fluorescence. Just about every example of life has some instance of fluorescence.' ■

Use all treatments tools before you refer

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'Leading-edge formulations provide superior lubrication and significantly extend tear film break-up time with the added benefit of being preservative-free in the eye, making them suitable for sensitive eyes.'

What happens in practice?

One optometrist who has no qualms about tackling contact lens related dry eye is Adelaide-based David O'Brien.

'I generally don't refer a dry-eye patient until I have used up my complete tool kit,' he says.

'When a patient presents with dry eye the most important thing is to sit down with them and go through their history so both of us have an accurate idea of what we're working with or against. Education is paramount; we need to know which factors may be exacerbating the condition and if there are any mitigating factors.'

These can include an air-conditioned work environment, long days in front of a computer, antihistamines for hayfever that will worsen dry eye, advanced age, which may lead to reduced tear volume, or being a smoker.

'A good 10 or 15 minutes of discussion is usually required to cover everything,' says O'Brien.

He says that when patients describe the severity of their symptoms they may sound much worse than they are on examination so it's important to try to restore some perspective.

'Taking their history into account I will then look for blepharitis or marginal lid disease; are the Meibomian glands doing what they should?' he says.

'I will look for underlying ocular surface disease, conjunctival or corneal staining and try to clear these up. If you try to put a lens on a compromised surface, you're already on the back foot.'

'If it hasn't been done already, I will look at changing them to any of the newer generation of lens materials—the newer daily disposables, biomimetic materials or silicone hydrogels for example—generally lenses with a lower water content.

'Cases are highly individual as surface deposition on different lens materials affects wearer comfort and varies from patient to patient.

'I will often try a patient with a different type of contact lens in each eye to see if there is a preference for one. Even if there is a marked improvement in comfort, some lenses can still prove unsuitable when you look at their effects on the eye.

'Next I might try non-preserved lubricants, then perhaps temporary punctal plugs. If these make a difference I will probably insert long-term punctal plugs. I only rarely refer a patient for cautery because it's permanent,' says O'Brien. ■