Chemical Nose for Finding Landmines

An estimated 120 million landmines are hidden all over the world, in developing countries such as Ethiopia or Zimbabwe, but also in countries like Germany and Denmark. UN estimate that $33 billion and about 1100 years would be required to remove all landmines with current technology. But over the last years Jye-Shane Yang and Timothy M. Swager from the Massachusetts Institute of Technology (MIT) in the United States have developed a different approach - they use fluorescent polymers[1,2].

Getting an amplified signal: "molecular wires"

There is a standard approach to identify a particular substance: One must react the species one wants to detect (the analyte) with a receptor molecule, the complex shows different physical properties which can be more or less easily detected. This conventional approach is shown in the upper half of figure 1, where one can detect a signal proportional to the concentration of the complex. The researchers at MIT pursued a different approach. They linked the receptors to a molecular wire, as shown in the lower half of the picture. The effect is that one analyte molecule docks to the chain of receptors – and changes a physical property of the *whole chain*. Therefore with a small concentration of the analyte one produces a change in a lot of receptor molecules, which means that a much bigger and therefore easier detectable signal is produced.

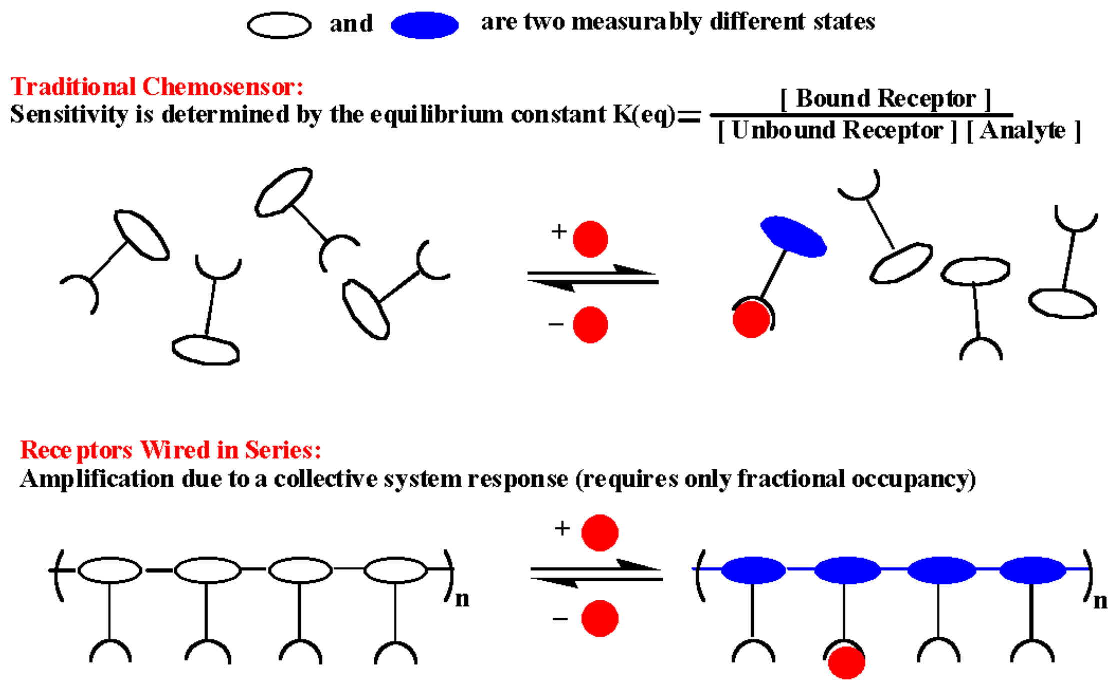

Figure 1: the difference between conventional chemosensors and wired sensors

Fluorescence and conductivity

Two physical properties are suitable for detection, fluorescence and conductivity. A polymer is a conductor if it has delocalised electrons – but for this delocalisation a planar arrangement of atoms within a molecule is necessary. If the sensor bonds to an analyte molecule, the chain twists – and the conductivity is decreased measurably.

In the case of the TNT detectors the measured property was the fluorescence - that means the absorption of light of a definite wavelength (e.g. invisible UV-light) and emission of light of a longer wavelength (e.g. visible, blue light). Everyone knows this phenomenon from “black light” bulbs used in nightclubs.

What happens in the presence of the analyte TNT?

If a suitable molecule comes in contact with the sensor it forms a complex – the detector molecule (as a host) accommodates the TNT molecule (as a guest).

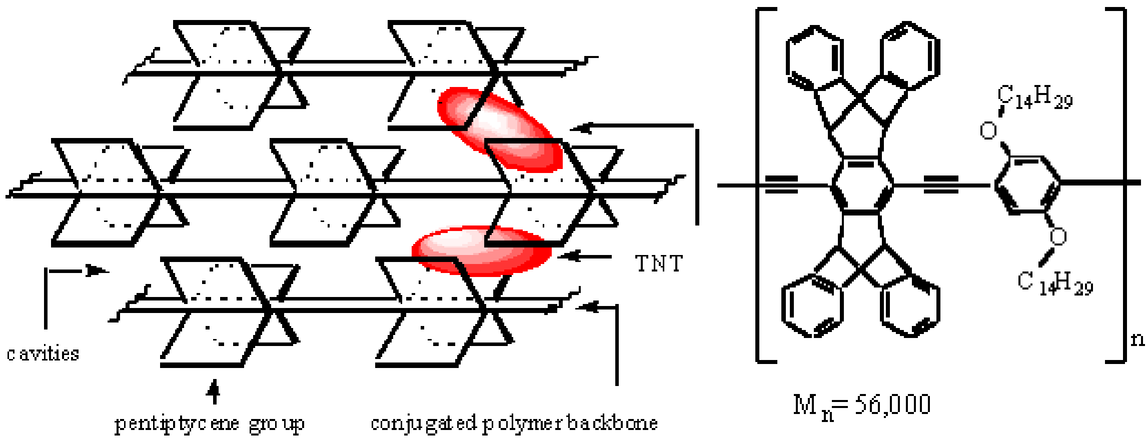

Figure 2, the intercalation of TNT in the receptor and the structure of the receptor molecule

This complex changes the fluorescence properties of the polymer, so we can measure the concentration of TNT by the strength of the characteristic wavelength emitted by the complex.

But there were practical hurdles to overcome – only 1 out of 100 000 000 particles of the explosive leaking from the mine is dispersed in the air, therefore an incredible sensitivity of the detector is required. We asked Prof. Swager about the applicability of his concept.

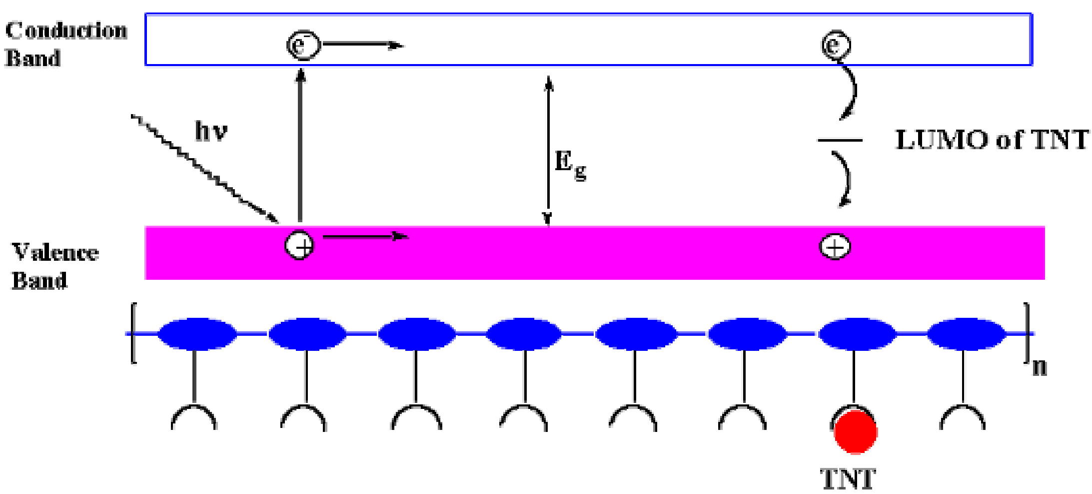

Figure 3 – How TNT changes the fluorescence properties of the polymer

How far away from reality? An interview with Prof. Swager.

A.B.: Prof. Swager, after working in this area for several years – how far is this method away from being used in real mine fields?

T.M.S.: Our polymers have been field tested in a simulated minefield at the Army base Fort Leonard Wood, in the state of Missouri. These tests were performed under rigorous scientific conditions under the direction of the Defense Advanced Projects Agency. You should be aware that many systems claiming to be useful in landmine detection have not been subjected to such tests. A company called Nomadics Inc. in Stillwater Oklahoma developed the prototypes[3]. In short, if dogs (currently the best method to find landmines) can find the mines, so to can the Nomadics Team. We have conducted many blind tests at the Missouri site that confirm that we have a solid method (perhaps the best hand held technology).

A.B.: Your development is sometimes called a "chemical nose". Is there really something in common with the natural process of smelling?

T.M.S.: The Nose concept is based on a cross-reactive array and vapour phase detection. Our best polymers are selective enough that an array (pattern recognition) detection scheme may be unnecessary. However, it is established technology and shouldn't be a problem to bring into the sensor if necessary.

A.B.: What will be your next research in this area?

T.M.S.: Our amplification technology is universal and can be applied to many different problems[4]. In general wherever added amplification is an issue our molecular wire approach will have applicability. We have a number of projects ongoing, but it is too early to comment.

A.B.: Thank you for this interview Prof. Swager.

---

[1] http://web.mit.edu/tswager/www/Sensor.htm
[2] Jye-Shane Yang and Timothy M. Swager, J. Am. Chem. Soc. 1998 (120) 11864-11873
[3] www.nomadics.com
[4] See: Swager, T. M. "The Molecular Wire Approach to Sensory Signal Amplification" *Accts. Chem. Res.* 1998 (31) 201-207.

(762 words with endnotes, without descriptions of figures)

Written by Andreas Bender, bender@jyi.org

Dublin, Wednesday, 01 March 2000

This document is available for download as a Word-Document at
http://www.andreasbender.de