PROCESS ANALYTICS

An Enlightening Shine

No sampling, no loss of time and, naturally, non-destructive – that is considered process control at its very best. With fluorescence analysis Bayer Technology Services is able to offer an effective technology that achieves just this.

Many disco club revelers will no doubt have experienced the embarrassing moment when the DJ turns up the control knob for the black light with the result that not only toothpaste flecks and detergent specks shine brightly white on one's clothes, but also signs of unsightly dandruff. This phenomenon is called fluorescence (see box). However, fluorescence is far more than just a show effect at a dance club. For example, banknotes are equipped with fluorescent security features to prove they are genuine. In biochemical analyses, specific reagents are coupled with a fluorescent dye. Under suitable irradiation, this procedure subsequently shows how much of a particular substance was bonded by the reagent.

It will soon shine in chemical production facilities too. "Fluorescence analysis is a sensitive and also a substance-specific verification procedure," says Dr. Nina Schwalb, who heads the optical engineering team in Process Technology at Bayer Technology Services. The physicochemist is well acquainted with using optical processes to look into the innermost areas of things. As part of her doctoral thesis, she processed biomolecules with light pulses only a few femtoseconds in length – such a tiny size that it is truly difficult to imagine: a quadrillion femtoseconds, i.e. one thousand trillion femtoseconds pass before the second hand moves.

In comparison to these time lengths, the light pulses Schwalb would like to use in her current project last almost an eternity. The idea is for these light pulses to make any undesirable byproducts of a polycarbonate melt process visible at intervals of milliseconds, i.e. one thousandth of a second.

Depending on the application, polycarbonate is a polymer that has to meet high requirements in terms of purity. For example, byproducts that form insoluble particles in the melt process are absolutely taboo if the polycarbonate is going to be used in the production of, for instance, optical materials such as DVDs. For this reason, the melt process at Bayer MaterialScience undergoes a filtration, followed by a lab analysis to ensure there are no unwanted particles in the product. Unfortunately, this analysis is complex. An online analysis would make this lab test unnecessary.

In the meantime Schwalb, together with her team, has designed an apparatus that emits light pulses directly into the polycarbonate melt, which has a temperature of more than 300° Celsius in the reactor. A special camera installed at a right angle registers any occurrences of fluorescence. "The undesirable particles are transparent and thus invisible to begin with," explains Christoph Hermansen, who played a decisive role in designing the analysis system for Bayer Technology Services. "We induce them to fluoresce with the right radiation wavelength – and make them visible." The results can then be fed directly into the process control system.

Obviously, the procedure is not quite so simple as it initially sounds. For example, the automatic analysis system first

Revealing Light

Atoms and molecules cannot only absorb light, but can also release it again. This emission of light is called fluorescing. The radiation wavelength is characteristic for each substance. This principle is used in fluorescence analysis – which means when fluorescent light is recorded with an optical analysis system.

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Dr. Nina Schwalb, Bayer Technology Services

Absorb light and then shine in a very specific color: what these fish are capable of doing thanks to a genetic modification can also be utilized in process analytics.

has to learn to reliably differentiate between the fluorescence of the undesirable particle and other light effects. And then there is the sensitivity. “We have to be able to record the illumination of a single particle per milliliter to guarantee the sufficient purity of the polycarbonate,” says Schwalb.

This is quite a different scale than with biological sampling, where sometimes thousands or even millions of particles shine per milliliter. A sufficiently high sampling rate must also be established. “If the pauses between light pulses are too large, there is an increased danger that a moving particle will be overlooked,” says Schwalb. However, it is not possible to do without these pauses either, as the analysis system needs time to process the photos taken.

A first test of this analytical principle is currently being prepared in a real process environment. “If a continuous control succeeds, it would bring clear savings in time and complexity,” Jochen Mahrenholtz, Head of Polycarbonate Production at the Uerdingen site of Bayer MaterialScience, confirms.

The Optical Engineering team has long supported the production of plastic film and sheet with online analytics. Any imperfections are reliably detected – even at high production speeds. If necessary, the uniform distribution of the processed substances can be controlled in the plastic material in combination with a substance-specific verification such as the fluorescence method, says Schwalb. Water/oil emulsions are a particularly interesting area of application. In the case of unstable emulsions, fluorescence analyses may also be able to help monitor droplet sizes or the transport processes between aqueous and oil phases. “For example, it would be possible to control reaction processes at phase boundaries with this method,” says Schwalb. In fact, she can imagine a lot more possibilities for making things visible in running processes that would otherwise be inaccessible to the naked eye.