Controlling the release rate of actives in industrial areas

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INTRODUCTION

Controlled release of actives has been focus of many studies for many years, from purely academic studies to applied research for everyday life products.
Here, protection of the active substance from degrading environment or targeted release are the main drivers for this research in order to deliver at the desired time, at the desired location, and in the desired amount in an economical way.

Dependent on the application of the delivery device, the desired delivery time may vary from a few minutes (burst release) to several years of constant release (long lasting zero order release). In order to meet these demands, release systems need to be tailored accordingly.

Encapsulation of actives in more inert materials is a common concept to control release. Depending on the chosen shell material and the application environment, the release mechanism is based on diffusion, chemical or mechanical erosion/dissolution of the shell, swelling, ionic interference, and combinations thereof. In order to control the release rate, one has to be aware of these mechanisms and adapt the delivery device accordingly.

In this paper, different strategies to control the release rate in two different applications are presented and discussed.

MATERIALS AND METHODS

For delivery of active oxygen a spray drying process was used. The particles used for the spray coating process had a size of about 0.5 mm. The particles were spray coated with a waterborne latex dispersion. The release of active oxygen into water was measured with analysis of the conductivity of the aqueous solution.

Mesoporous silica particles were loaded with biocide and had a size of about 5 µm. The particles were coated performing a precipitation process. Release was not measured analytically, but fouling experiments of a formulated paint were performed to show the impact of encapsulation of the biocide on anti-fouling performance. The formulated paints were applied on filter paper and subjected to water running at about 1 L/minute for two days corresponding to two years outdoor exposure. The filter papers were placed in agar dishes and the painted papers were tested against growth of three different moulds.

RESULTS AND DISCUSSION

Release of active oxygen into water was measured with conductivity determination of the solution in dependence of time. The results show that different coating treatments of the active have a clear impact on the release profile, varying from a burst release to very slow but even release into the aqueous media.

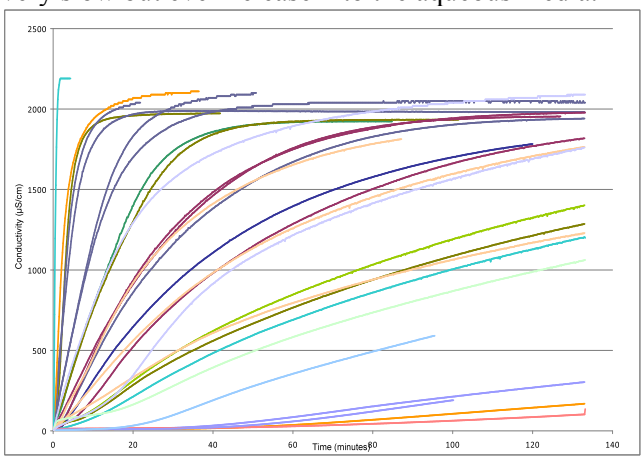

Figure 1: Conductivity of aqueous solution versus time.

Figure 1 shows the conductivity of the aqueous solution of the release experiments. As can be seen, uncoated active is completely dissolved ("released") within few minutes. Depending on the applied coating, the release rate can be tailored to meet the demanded time frame to up to 30 hours.

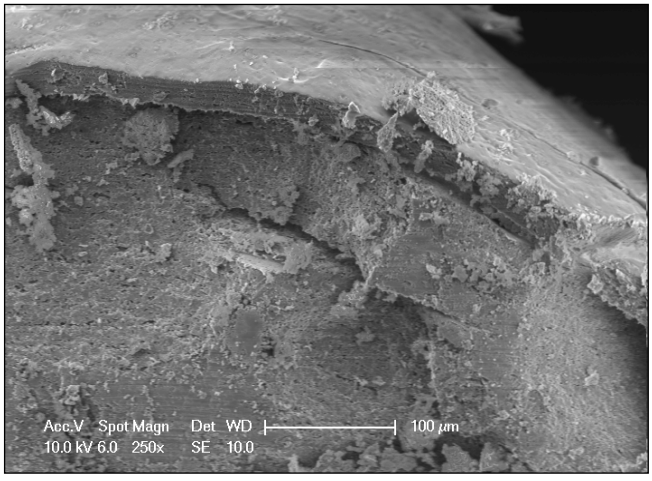

Figure 2: SEM image of encapsulated active, showing both the active substance and the regulating coating.

Figure 2 shows a SEM image of a particle of this series. It clearly shows the protective coating regulating the release properties.

Slow release of biocides is of interest for the coating industry to achieve cleaner surfaces for a longer period, to extend the service life of coatings and minimize cost and need for labour by the end user. Accordingly, biocides are formulated into paint. However, with a service time of several years, it is important to use some sort of controlled delivery of the biocide to ensure the wanted effect over a long time span.

In order to meet this demand, an encapsulation of the biocide into mesoporous silica is a well-known concept.

At YKI a large research effort is performed related to these particles as carriers. The particles have a well-defined pore size that can be precisely controlled in the region 2-15 nm. Figure 3 (left) shows a transmission electron microscope (TEM) image of a mesoporous particle produced in a spray reactor at YKI. In order to prolong the release time, a polymeric coating was applied to the particles. The result can be seen in Figure 3 (left), a uniform 9 nm thick coating of the particle.

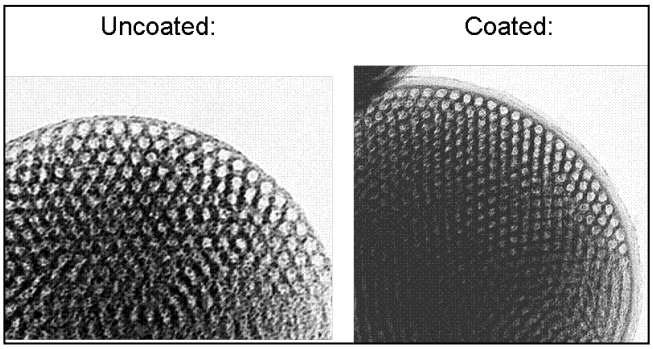

Figure 3: TEM images of uncoated (left) and coated silica particle.

Figure 4: Agar diffusion test of a paint without biocide.

Figure 4 to 6 show the impact of biocide encapsulation on the anti-moulding performance of a paint film on filter paper. As expected the paint with no biocide (Fig. 4) cannot withstand mould growth even on a freshly painted surface. State-of-the-art formulations (Fig. 5) lose quickly their performance probably due to too fast leakage of biocide from the paint. The paint with the biocide encapsulated in coated mesoporous particles (Fig. 6) performed excellent even after the aging procedure.

Figure 5: Agar diffusion test of a paint with biocide.

Figure 6: Agar diffusion test of a paint with biocide.

CONCLUSIONS

Varying the encapsulation strategy and the protective material is a strong tool to tailor the release time of actives.

As for the polymeric encapsulation for active oxygen release, the design of the coating material allows to vary the release rate between a few minutes to hours. The results of the biocide encapsulation experiments indicate that a slower release rate of the biocide into the coating can enhance the durability of paint against mould growth.