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Short Research Article

Microsensor for radioactivity†

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Introduction

Microsensors for a variety of chemical compounds have been developed[1]. Their application has enormously enhanced the insight in the functioning of dense microbial communities, as occuring in biofilms, sediments and microbial mats, in which metabolic processes are typically confined to narrow zones of 0.1–10 mm wide. With microsensors high spatial resolution studies are possible towards transport and conversion[2], however, the range of compounds that can be measured with chemical microsensors is limited. The here described microsensor for radioactivity allows studies towards transport and binding of all compounds that can be radioactively labelled.

Results

The measurement of the diffusion constant with ^{14}C of radioactive agar into non-radioactive agar is shown in Figure 1. A background was not subtracted from the data. A fit to the diffusion model is shown by the solid curve. There is an excellent agreement between the diffusion theory and the experimental points.

Diffusion measurements have been carried out also for ^{36}Cl, ^{45}Ca, ^{35}S. All the measurements gave very good results, with practically no background.

Profile measurement

Another measurement has been carried out on a microbial mat. ^{14}C has been incorporated by photosynthesis of [^{14}C]bicarbonate. After 4 days of light-dark illumination, a profile has been measured with the detector. A strong photosynthetic activity is recorded.

Figure 2 shows two peaks, one at 1 mm and a second one at 4 mm. The profile has been measured in 0.25 mm steps. There are certainly two thin layers of bacteria being detected in the mat.

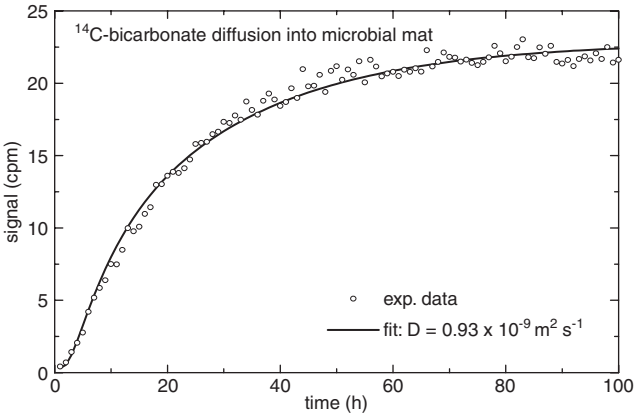

Figure 1 Measurement of the diffusion constant of ^{14}C. Development of the radioactivity signal (cpm) after the addition of agar containing 5 MBq ^{14}C on top of a radioactivity-free agar. The signal was measured 1 cm below the surface of the initially radioactivity-free agar. The signal was fitted to the diffusion model (line).

Summary

We have developed a microsensor for radioactivity that allows the detection of β-radiation with submillimeter spatial resolution. The microsensor comprises a scintillating sphere (diameter $\approx$ 200 μm) glued to a tip of a tapered optical fiber (140 μm core diameter). Radioactivity is detected using YLu in a powder form (3 μm grains), which is embedded in methacrylate.

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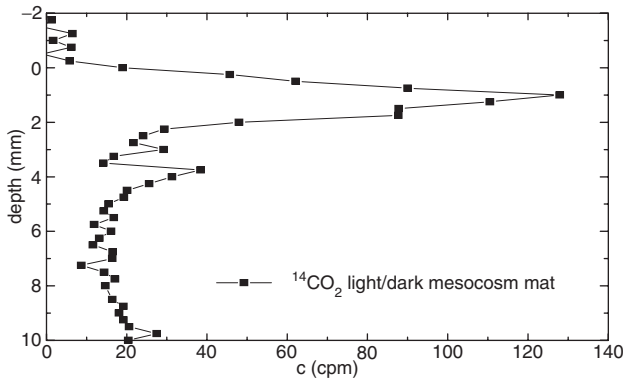

Figure 2 Depth profile of [^{14}C]-bicarbonate in a microbial mat after incubation of the mat in the presence of [^{14}C]-bicarbonate.

The optical fiber is connected to two photomultipliers (Hamamatsu) which count the photons generated in the scintillator. The background was dramatically reduced, 80 times, by using the two photomultipliers in coincidence.

Preliminary applications of the microsensor were related to the field of marine microbiology and included (a) the determination of the diffusion coefficient of a number of radiolabeled specimens (e.g, ^{14}C, ^{45}Ca, ^{36}Cl, ^{35}S) in agar and in microbial mats (Figure 1) and (b) the study of incorporation of labeled $^{14}CO_2$ in a microbial mat (Figure 2).

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