Chemical Imaging of Living Algal Cells

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Up to now it is not possible to measure the entire mid-infrared (IR) spectral range under controlled aqueous environs. Commercial solutions use thick windows, thus requiring long working distances for the IR and preventing acquisition of high resolution visible images. Window materials that transmit the mid-IR range pose several problems: they are either hygroscopic, toxic or disperse/absorb portions of the biologically relevant IR bandwidth.

We designed a new flow chamber (Fig. 1, 2) in order to measure living cells under controlled aqueous environs, providing high quality data for the entire mid-IR spectral range. The flow chamber is very slim so that it can accommodate small working distances, down to 0.6 mm above the chamber and 6 mm below the chamber. This permits measurements at high magnification for both transmission and reflection geometries, in the IR (e.g., 32x, 74x) and visible (up to 100x). In contrast to commercial chambers we use sub-micron thick diamond windows due to their excellent transmission properties in the IR and visible spectrum, and to minimize fringing effects. A low-throughput pump (for instance syringe based) can be coupled to the flow chamber to exchange the medium on demand. An image of an algal cell and corresponding IR maps comparing a commercial with our new flow chamber are shown in Fig. 3.

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\begin{figure}[h]
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\includegraphics[width=0.8\textwidth]{figure1.png}
\caption{Three quarter section view of the flow chamber (green: base, blue: lid, dark gray: silicon yellow: diamond, red: spacer, magenta: rubber seals, cyan: water tubes).}
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\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure2.png}
\caption{Photo of the working flow chamber with the diamond window and the water tubes.}
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\includegraphics[width=0.8\textwidth]{figure3.png}
\caption{Images (a, VIS light) and (c, IR map: CH\textsubscript{n} stretches) show a Micrasterias alga in a conventional chamber with 3 mm thick ZnS windows, whereas (b,d) show another alga in the new flow chamber.}
\end{figure}