Development of novel silica hydrogels with improved structure properties to support growth of entrapped diatoms

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In marine microalgae research slow cell growth, costly downstream processing and low benefits have so far hindered the implementation of production processes[1]. Studies have shown that immobilisation in hydrogels can enhance algal growth rates, allow continuous production of extracellular compounds and simplify separation of biomass from the medium[2]. In marine systems, silica hydrogels are advantageous over the conventional immobilisation matrix calcium alginate due to their improved physicochemical stability in presence of chelating agents and cations[3,4].

This doctoral research within the BMBF project COMBINE aims to develop novel silica hydrogels for marine diatoms with improved diffusion properties as well as a more flexible gel structure to support cell division, achieve higher growth rates, higher biomass loading and prevent cell leakage. Preliminary results show that diatom growth was reduced by 60 % in silica hydrogels as compared to calcium alginate. Light limitations by reduced transparency of the silica hydrogels were excluded since the inorganic gels show nearly 60 % less wavelength absorption in the PAR region than the organic ones. However, self-shading events in hydrogels with high biomass loading must be considered. A decrease of the silica concentration by the factors 2 and 4 increased growth by approximately 30 % and 80 % respectively, indicating a correlation between the gel density and the cell division capacity. These findings are supported by light microscopical analysis showing inhomogeneous, spotted cell growth within the gel matrix and a changed cell morphology, which may be attributed to space limitations and low elasticity of the matrix. At the same time, we observed a size reduction of highly loaded hydrogels by almost 50 % and subsequent 4-fold increased cell leakage into the medium. This indicates breakage of the brittle gel due to the pressure of dividing cells from the inside. Reduction of the particle volume by the factors 10, 40 and 80 increased cell growth approximately 3-, 10- and 20-fold, respectively, and a growth gradient towards the center of the matrix was observed, indicating volume-specific diffusion limitations.

We will present our recent findings together with a comparison of novel silica hydrogels from various mixtures of functional silica precursors investigated towards gel structure, diffusion capacities and cell growth to overcome current stiffness and diffusion limitations and shed more light into immobilisation materials facilitating the profitable production of high-value extracellular algal products.

REFERENCES

[1] Gifuni *et al.* (2018) Trends in Biotechnology. 37. 242-252

[2] Vasilieva *et al.* (2016) Moscow University Biological Sciences Bulletin. 71. 170–176

[3] Moreno-Garrido (2008) Bioresource Technology. 99. 3949–3964

[4] Homburg *et al.* (2019) Journal of Biotechnology. 302. 58–66