Infrared Spectroscopy: A New Technique to Understand the Drivers of Southern Ocean Primary Productivity

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Each year, marine phytoplankton (unicellular microalgae) convert ~50 Tg of inorganic carbon into organic matter. This massive quantity of organic carbon, which is approximately equal to carbon assimilation by all the terrestrial rainforests on earth, provides nutrition and energy to marine food webs and is known as primary productivity. At present estimations of oceanic primary productivity are quite crude limited to biomass determination using a combination of satellite chlorophyll fluorescence imaging and ground based turbidity measurements. These current measurements lack definition in terms of quantifying species composition within the phytoplankton blooms nor do they define the physiological status of the different species and how this is affecting carbon uptake and partitioning of carbon within cells. Infrared spectroscopy is a powerful new tool in this area of research having potential for both species identification and characterisation of physiological responses of living phytoplankton to the environment in terms of carbon partitioning at the single cell level [1]. A significant breakthrough in this context is the modelling of infrared spectroscopy against ^{13}C uptake in cells and mass spectroscopy measurements of carbon and nitrogen to perform "snapshot" predictions of primary productivity and macromolecular composition based on single infrared measurements [2].

We have been extending this knowledge obtained from the laboratory to the field [3]. Enhanced supply of nutrient-rich waters along the coast of the subantarctic Kerguelen Island provided a valuable opportunity to examine the responses of phytoplankton to natural Fe enrichment. Synchrotron radiation -FTIR microspectroscopy enabled the analysis of individual diatom cells from mixed communities of field-collected samples, thereby providing insight into responses to changes in Fe availability. Phenotypic responses were taxon-specific in terms of intraspecific variability and changes in proteins, amino acids, phosphorylated molecules, silicate and carbohydrates. Data pooled across all measured taxa showed different patterns in macromolecular composition compared to those for individual taxon underscoring the value of the single cell analyses.

The field research has been extended recently to in-situ measurements on board ship during the maiden voyage of the Australian Marine National Facility research vessel *Investigator* in the Southern Ocean. Sequential size fractionation filtration methods concentrated phytoplankton samples from ocean water obtained during transects across nutrient upwelling eddies, with deposition of samples onto filters composed from pure silver for ATR-FTIR spectroscopy.

References

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