Wavelength- and temperature-dependent apparent quantum yields (AQYs) for the photochemical production of acrylate in seawater

Website: https://www.bco-dmo.org/dataset/892867
Data Type: Cruise Results
Version: 1
Version Date: 2023-03-29

Project
» Photolysis and Photoproduction of Acrylate in Seawater and their Impact on the Marine Organosulfur Cycle (Impact Acrylate in Seawater)

Program
» United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)

Contributors	Affiliation	Role
Kieber, David J.	State University of New York College of Environmental Science and Forestry (SUNY ESF)	Principal Investigator
Xue, Lei	State University of New York College of Environmental Science and Forestry (SUNY ESF)	Student, Contact
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset includes wavelength- and temperature-dependent apparent quantum yields (AQYs) for the photochemical production of acrylate in 0.2-micrometer (µm) filtered seawater samples collected from coastal Rhode Island (USA), the Sargasso Sea, and two sites in the Pacific Ocean off the island of Mo'orea (French Polynesia). These data were determined using (1) a monochromatic irradiation system and (2) a Shimadzu high-performance liquid chromatography system with a UV-Vis absorbance detector. This dataset was collected by Dr. Lei Xue under the supervision of Dr. David Kieber at the State University of New York, College of Environmental Science and Forestry. These data were used to construct a global model of the depth-dependent photochemical production of acrylate in seawater. This work is part of a larger study to understand the role of photochemistry in the turnover of dissolved organic matter in the oceans.

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Coverage

Spatial Extent: **N**:41.02 **E**:-69.99 **S**:-17.48 **W**:-149.84
Temporal Extent: 2016-10-10 - 2018-04-18

Methods & Sampling

Sample collection: The Sargasso Sea and coastal Rhode Island (USA) samples were collected from 30-liter Niskin bottles secured to a CTD rosette. Samples were collected during the EN589 cruise aboard the R/V Endeavor from September 16 to October 15, 2016. Dr. David Kieber was the chief scientist for this cruise. Rolling Deck to Repository (R2R) data for EN589 can be found at http://www.rvdata.us/catalog/EN589

Samples from a Mo'orea coral reef and Pacific Ocean station (located ~2 kilometers beyond the coral reef) were collected in 2-liter opaque high-density polypropylene bottles aboard a small research boat moored at the Gump Research station. Sampling was between April 6 and April 24, 2018. Details regarding sampling should be directed to Dr. David Kieber.

Sample storage: Seawater samples from the surface were collected in 30-liter (L) Niskin bottles attached to a CTD rosette during the 2016 R/V Endeavor (EN589) Atlantic cruise or in pre-cleaned opaque polypropylene bottles by hand during the 2018 Mo'orea field trip. Following collection, water samples were gravity filtered through precleaned 0.2-micrometer (µm) pore-size POLYCAP 75 AS Nylon filters into precleaned 4 L Qorpak glass bottles. All Qorpak bottles were then filled with minimum headspace (ca. 5 milliliters (mL)), sealed tightly, and stored in the dark at 4 degrees Celsius until use for irradiation experiments.

Apparent quantum yield(AQY) method: A monochromatic irradiation system was used to determine wavelength- and temperature-dependent AQYs for the photochemical production of acrylate in 0.2 µm-filtered seawater at selected wavelengths from 290 to 400 nanometers (nm). See Zhu and Kieber (2018) for detailed setups. Briefly, for each AQY experiment, 25 mL of 0.2-µm filtered, air-saturated seawater was pipetted into a 5-centimeter (cm) pathlength, rectangular quartz cell and sealed with a Teflon-lined screw-top cap with no headspace. The filled quartz cell was placed in the sample chamber and the sample temperature inside the cell was controlled by a recirculating glycol-water bath. Parallel dark controls were obtained by blocking the incoming radiation. All irradiated samples and dark controls were continuously stirred during the experiment. For each water sample, triplicate irradiations were conducted at each wavelength, except for the duplicate irradiations at 360 nm. The photon flux in each AQY experiment was determined using nitrite actinometry (Jankowski et al. 1999) in a separate 5 cm quartz cell. The photon flux in the quartz cell was calculated using the procedure outlined in Kieber et al. (2007).

Data Processing Description

BCO-DMO Processing:
- converted dates to YYYY-MM-DD format;
- made longitude values negative to comply with BCO-DMO conventions (where East longitude is positive);
- renamed fields to comply with BCO-DMO naming conventions.

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Data Files

File	
acrylate_photoproduction_aqy_data.csv	(Comma Separated Values (.csv), 8.41 KB) MD5:fb7087fcfadc62ba2c6e870cc45a0462
Primary data file for dataset ID 892867	

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Related Publications

Jankowski, J. J., Kieber, D. J., & Mopper, K. (1999). Nitrate and Nitrite Ultraviolet Actinometers. Photochemistry and Photobiology, 70(3), 319–328. https://doi.org/10.1111/j.1751-1097.1999.tb08143.x
Methods

Kieber, D. J., Toole, D. A., Jankowski, J. J., Kiene, R. P., Westby, G. R., del Valle, D. A., & Slezak, D. (2007). Chemical “light meters” for photochemical and photobiological studies. Aquatic Sciences, 69(3), 360–376.

https://doi.org/10.1007/s00027-007-0895-0
Methods

Xue, L. (2020). Acrylate: The missing carbon in the marine organosulfur cycle. Ph.D. Dissertation, State University of New York, College of Environmental Science and Forestry. https://suny-esf-researchportal.esploro.exlibrisgroup.com/esploro/outputs/graduate/Acrylate-The-missing-carbon-in-the/99871049004826#file-0
Results

Zhu, Y., & Kieber, D. J. (2018). Wavelength- and Temperature-Dependent Apparent Quantum Yields for Photochemical Production of Carbonyl Compounds in the North Pacific Ocean. Environmental Science & Technology, 52(4), 1929–1939. doi:10.1021/acs.est.7b05462
Methods

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Related Datasets

IsRelatedTo

Kieber, D. J. (2022) **Photochemical production rates of acrylate in seawater following exposure to sunlight from a variety of marine environments between 2011-2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-03-22 doi:10.26008/1912/bco-dmo.871691.1 [view at BCO-DMO]
Relationship Description: Samples used for the AQY study were used to model photochemical production rates of acrylate in seawater samples exposed to solar radiation at the sea surface.

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Parameters

Parameter	Description	Units
Sample_Date	Date of sample collection	unitless
Cruise_or_Station	Cruise ID and vessel name or Field Station name	unitless
Sampling_Site	Sampling location	unitless
Latitude	Sample collection location; North is positive (South is negative)	decimal degrees
Longitude	Sample collection location; East is positive (West is negative)	decimal degrees
Depth_Sample_Collected	Depth below surface	meters (m)
Irradiation_Temperature	Temperature in Kelvin	Kelvin (K)
Irradiation_Wavelength	Wavelength	Nanometers (nm)
AQY	Apparent quantum yields for the photochemical production of acrylate in seawater	moles acrylate photoproduced / mol photons absorbed by dissolved organic matter (moles/(mole quanta))

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Instruments

Dataset-specific Instrument Name	Shimadzu high performance liquid chromatography
Generic Instrument Name	High-Performance Liquid Chromatograph
Dataset-specific Description	Acrylate quantification: A Shimadzu high performance liquid chromatography system with a model SPD-20A UV-Vis absorbance detector.
Generic Instrument Description	A High-performance liquid chromatograph (HPLC) is a type of liquid chromatography used to separate compounds that are dissolved in solution. HPLC instruments consist of a reservoir of the mobile phase, a pump, an injector, a separation column, and a detector. Compounds are separated by high pressure pumping of the sample mixture onto a column packed with microspheres coated with the stationary phase. The different components in the mixture pass through the column at different rates due to differences in their partitioning behavior between the mobile liquid phase and the stationary phase.

Dataset-specific Instrument Name	monochromatic irradiation system
Generic Instrument Name	irradiation system
Dataset-specific Description	AQY determination: A monochromatic irradiation system consists of a model LTIX-1002W-HS 1000 W xenon lamp (Royal Philips), a GM 252 high-intensity grating monochromator (Spectral Energy), and an enclosed temperature-controlled sample chamber (Spectral Energy).
Generic Instrument Description	A system of instruments/devices that provide irradiation of materials. Irradiation is an energy transfer process during which a material entity receives energy through radiation.

Dataset-specific Instrument Name	30-liter Niskin bottles
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Sample collection: 30 L Niskin bottles attached to a CTD rosette equipped with Sea-Bird Electronic sensors for conductivity, temperature, and pressure.
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

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Deployments

EN589

Website	https://www.bco-dmo.org/deployment/710271
Platform	R/V Endeavor
Report	http://dmoserv3.bco-dmo.org/data_docs/Refractory_DOC_Recycling/EN589_Post_Cruise_Report_10.20.16.pdf
Start Date	2016-09-16
End Date	2016-10-15
Description	The main purpose of this cruise was to study the organic matter put into the atmosphere as particles (also called aerosols) that are generated from bursting bubbles at the sea surface. To do this, the investigators deployed an aerosol generator to reproduce a model surface ocean using the ship's clean flow-through seawater system. The ship occupied four hydrographic stations: two biologically productive stations and two stations in the Sargasso Sea. To support the aerosol generator work, over fifty CTD casts were conducted to collect seawater and to characterize the physical, chemical, and biological properties of the water column. Cruise description excerpted from EN589 post-cruise report: EN589_Post_Cruise_Report_10.20.16.pdf. Related documents: EN589_Cruise_Plan.pdf

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Project Information

Photolysis and Photoproduction of Acrylate in Seawater and their Impact on the Marine Organosulfur Cycle (Impact Acrylate in Seawater)

Website: https://mooreareefresearch.wordpress.com/

Coverage: Gump Research Station on the island of Mo'orea in French Polynesia (17.50 °S, 149.833 °W), State University of New York, College of Environmental Science and Forestry (43.034° N, 76.137° W)

NSF Award Abstract:

This project would investigate the marine chemistry of the compound acrylate. Acrylate is a mostly overlooked by-product of a very well-studied process through which a compound known as DMSP (dimethylsulfoniopropionate), a compound produced by phytoplankton, is converted to the gas dimethylsulfide (known as DMS). This process is an important part of understanding the marine cycling of sulfur, and DMS plays a role in cloud formation and climate. Thus, these aspects of the conversion of DMSP to DMS have received considerable attention. On the other hand, very little is known about acrylate concentrations, fluxes, or impacts in the oceans, even though it is produced during the conversion of DMSP to DMS. Acrylate concentrations and fluxes should at times be substantial, especially in shallow-water coral reefs or during blooms of DMSP-rich phytoplankton that are common throughout the world's oceans and often harmful or toxic. It is likely that acrylate is a reactive form of marine organic matter that significantly impacts the carbon cycle and ecology of the upper ocean. This project will foster research and educational opportunities for undergraduates and one graduate student through several avenues including field work with international collaborators, attendance at national and local meetings, mentoring, preparing for and delivering college-level lectures, and presentations made to the general public at forums such as Syracuse's Milton J. Rubenstein Museum of Science. Results will be disseminated through peer-reviewed publications, media communications, web-based data bases, and presentations at scientific meetings, public forums and in the classroom.

A three-year project is proposed to study the effect of sunlight on the formation and loss of acrylate in seawater, to model these processes in the water column, and to determine if photoproduction and photolysis are important pathways in the marine acrylate cycle in a shallow-water coral reef. Four objectives are planned to carry out this research: (1) synthesize radiocarbon-labeled DMSP as a source of radiocarbon-labeled acrylate for photolysis and uptake studies; (2) conduct laboratory experiments using a solar simulator to study the photolysis and photoproduction of acrylate in water and seawater under varying conditions (e.g., pH, temperature, oxygen concentration); (3) determine temperature and wavelength-dependent quantum yields for acrylate photolysis and acrylate photoproduction in seawater using a monochromatic irradiation system; and (4) conduct a field study at the Richard Gump Research Station to determine rates of photolysis, photoproduction and microbial consumption of acrylate in a shallow-water coral reef.

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Program Information

United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)

Website: http://www.us-solas.org/

Coverage: Global

The Surface Ocean Lower Atmosphere Study (SOLAS) program is designed to enable researchers from different disciplines to interact and investigate the multitude of processes and interactions between the coupled ocean and atmosphere.

Oceanographers and atmospheric scientists are working together to improve understanding of the fate, transport, and feedbacks of climate relevant compounds, and also weather and hazards that are affected by

processes at the surface ocean.

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Physical, chemical, and biological research near the ocean-atmosphere interface must be performed in synergy to extend our current knowledge to adequately understand and forecast changes on short and long time frames and over local and global spatial scales.

The findings obtained from SOLAS are used to improve knowledge at process scale that will lead to better quantification of fluxes of climate relevant compounds such as CO2, sulfur and nitrogen compounds, hydrocarbons and halocarbons, as well as dust, energy and momentum. This activity facilitates a fundamental understanding to assist the societal needs for climate change, environmental health, weather prediction, and national security.

The US SOLAS program is a component of the International SOLAS program where collaborations are forged with investigators around the world to examine SOLAS issues ubiquitous to the world's oceans and atmosphere.

Â» International SOLAS Web site

Science Implementation Strategy Reports

US-SOLAS (4 MB PDF file)
Other SOLAS reports are available for download from the US SOLAS Web site

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756907

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