Photochemical production rates of acrylate in seawater following exposure to sunlight from a variety of marine environments between 2011-2018.

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Data Type: Other Field Results
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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
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Abstract
These data summarize the photochemical production rates of acrylate in 0.2 µm-filtered seawater following their exposure to sunlight at the Richard Gump Research Station. Samples were collected from various marine environments between 2011 and 2018, including shallow-water coral reefs and sites of Mo'orea, French Polynesia. These data are published in Xue and Kieber 2021.

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Coverage

Spatial Extent: **N**:55.85 **E**:-67.48 **S**:-17.5 **W**:-153.04
Temporal Extent: 2011-09-11 - 2018-04-25

Methods & Sampling

Sample collection: Sea-surface water samples were collected in Niskin bottles during cruises in the Pacific

Ocean, Atlantic Ocean, and the Gulf of Mexico. For a map of the sample, locations see Xue and Kieber 2021 (Figure S1). In the coral reef and Pacific Ocean samples offshore from the island of Mo'orea (French Polynesia), samples from the surface were hand-collected using a polypropylene bucket and then poured into an opaque polypropylene bottle. All water samples were gravity filtered through a 0.2 µm POLYCAP 75 AS Nylon filter into Qorpak glass bottles. Filtered samples were stored in dark at 4 degrees C until use, except for the Mo'orea samples which were used the same day in sunlight exposure experiments. The polypropylene bucket and bottles were rinsed several times using high-purity laboratory water (Milli-Q) and seawater prior to use. All glass bottles were rinsed using Milli-Q and baked at 550 degrees C for 6 hours.

Photochemical experiments: 0.2 µm-filtered samples were gently pulled into eight Teflon-sealed quartz tubes (Kieber et al. 1997) with no headspaces. Four quartz tubes wrapped with aluminum foil served as dark controls. The dark controls and four remaining quartz tubes were exposed to sunlight for 8 to 30 hours in a circulating water bath. At the end of an exposure experiment, a 15 milliliter (mL) aliquot of each sample was collected and stored frozen or at room temperature after acidification until the analysis for acrylate concentrations. Nitrate and nitrite actinometer solutions were irradiated along with the quartz tubes to determine photon exposure between 311 and 333 nm and between 330 and 380 nm, respectively (Jankowski et al. 1999; Kieber et al. 2007).

Acrylate quantification: A precolumn derivatization HPLC method was used to quantify acrylate (Tyssebotn et al. 2017; Xue and Kieber, 2021). Briefly, 300 µL of thiosalicylic acid reagent (20 mM) was added to a 3 mL seawater sample in a Qorpak borosilicate vial with the pH adjusted to 4.0. Samples were incubated in a 90 oC water bath for 6 hours. After the reacted sample was filtered through a 0.2 µm Nylon filter, 1 mL of the sample was injected into a Shimadzu reverse-phase HPLC with UV detection at 257 nm. The limit of detection for this method was 0.2 nM for an injection volume of 1 mL.

All samples were irradiated on the rooftop of the Jahn Laboratory in Syracuse, NY, except for the Pacific Ocean and Mo'orea coral reef samples (these two samples were irradiated in a water bath at the Gump Research Station). Seawater samples were filtered through a 0.2 m Nylon filter and stored in a pre-baked glass bottle with no headspace. All samples were irradiated on the rooftop of the Jahn Laboratory in Syracuse, NY, except for the Pacific Ocean and Mo'orea coral reef samples (these two samples were irradiated in a water bath at the Gump Research Station. *a*330 is the absorption coefficient at 330 nm of each 0.2 µm-filtered seawater sample. Photon-based production rates were calculated by dividing the acrylate production by the photon exposure between 330 and 380 nm determined by nitrite actinometry. To determine the photochemical production of acrylate in seawater, four samples were exposed to sunlight for 8 - 30 hours; four samples were wrapped in aluminum foil to serve as dark controls. The sunlight photon exposures for each sunlight-exposure experiment between 311 and 333 nm and between 330 and 380 nm were determined using nitrate and nitrite actinometry. The concentration of acrylate produced in an experiment was calculated as the acrylate concentration in each light sample at the end of irradiation minus the average concentration in the dark controls. The hourly rate of acrylate production is determined by dividing the amount of acrylate produced by the time of sunlight exposure in sunlight exposure time in hours. The photon-based rate of acrylate production is equal to 1000 times the amount of acrylate produced divided by the nitrite photon exposure.

Data Processing Description

BCO-DMO processing description:
- Converted dates to YYYY-MM-DD format
- Adjusted field/parameter names to comply with BCO-DMO naming conventions
- Converted longitude values to East to comply with BCO-DMO standards
- Added a conventional header with dataset name, PI names, version date

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Data Files

File
acrylate_photochemical_production.csv (Comma Separated Values (.csv), 3.17 KB) MD5:f297c17ca2e22e87876c81503fa81bab Primary data file for dataset ID 871691

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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

Kieber, D. J., Yocis, B. H., & Mopper, K. (1997). Free-floating drifter for photochemical studies in the water column. Limnology and Oceanography, 42(8), 1829–1833. Portico. https://doi.org/10.4319/lo.1997.42.8.1829
Methods

Tyssebotn, I. M. B., Kinsey, J. D., Kieber, D. J., Kiene, R. P., Rellinger, A. N., & Motard-Côté, J. (2017). Concentrations, biological uptake, and respiration of dissolved acrylate and dimethylsulfoxide in the northern Gulf of Mexico. Limnology and Oceanography, 62(3), 1198–1218. Portico. https://doi.org/10.1002/lno.10495
Methods

Xue, L., & Kieber, D. J. (2021). Photochemical Production and Photolysis of Acrylate in Seawater. Environmental Science & Technology, 55(10), 7135–7144. https://doi.org/10.1021/acs.est.1c00327
Results

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Related Datasets

IsRelatedTo

Xue, L., Kieber, D. J. (2023) **Wavelength- and temperature-dependent apparent quantum yields (AQYs) for the photochemical production of acrylate in seawater.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-03-29 doi:10.26008/1912/bco-dmo.892867.1 [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
Sampling_Date_Start	Date of sampling	unitless
Sampling_Date_End	Date of sampling end	unitless
Cruise_ID_Vessel_name	Name of research vessel (cruise ID)	unitless

Sampling_Site	Sampling region (GOM denotes the Gulf of Mexico)	unitless
Latitude	sample collection location, North (South is negative)	decimal degrees
Longitude	sample collection location, East (West is negative)	decimal degrees
Salinity	salinity of sample	parts per thousand (ppt)
Date_Sample_Exposed_Sunlight_Start	Date that sample was exposed to sunlight	unitless
Date_Sample_Exposed_Sunlight_End	End Date that sample was exposed to sunlight	unitless
a330	the absorption coefficient at 330 nm of each 0.2 µm-filtered seawater sample	m-1
Sunlight_Exposure_Time	Duration of sunlight exposure (between 8 and 30 hours)	unitless
Light_Exposed_Sample_Replicate_1	Acrylate Concentration in Light-exposed samples	Nanomolar (nM)
Light_Exposed_Sample_Replicate_2	Acrylate Concentration in Light-exposed samples	Nanomolar (nM)
Light_Exposed_Sample_Replicate_3	Acrylate Concentration in Light-exposed samples	Nanomolar (nM)
Light_Exposed_Sample_Replicate_4	Acrylate Concentration in Light-exposed samples	Nanomolar (nM)
Dark_Control_Replicate_1	Acrylate Concentration in Dark Controls	Nanomolar (nM)
Dark_Control_Replicate_2	Acrylate Concentration in Dark Controls	Nanomolar (nM)
Dark_Control_Replicate_3	Acrylate Concentration in Dark Controls	Nanomolar (nM)
Dark_Control_Replicate_4	Acrylate Concentration in Dark Controls	Nanomolar (nM)

Average_Dark_Control	average concentration of dark control samples	Nanomolar (nM)
Acrylate_Produced_Rep1	the concentration of acrylate produced in an experiment, calculated as the acrylate concentration of "Light_Exposed_Sample_Replicate_1" at the end of an irradiation minus the average concentration in the dark controls ("Average_Dark_Control")	Nanomolar (nM)
Acrylate_Produced_Rep2	the concentration of acrylate produced in an experiment, calculated as the acrylate concentration of "Light_Exposed_Sample_Replicate_2" at the end of an irradiation minus the average concentration in the dark controls ("Average_Dark_Control")	Nanomolar (nM)
Acrylate_Produced_Rep3	the concentration of acrylate produced in an experiment, calculated as the acrylate concentration of "Light_Exposed_Sample_Replicate_3" at the end of an irradiation minus the average concentration in the dark controls ("Average_Dark_Control")	Nanomolar (nM)
Acrylate_Produced_Rep4	the concentration of acrylate produced in an experiment, calculated as the acrylate concentration of "Light_Exposed_Sample_Replicate_4" at the end of an irradiation minus the average concentration in the dark controls ("Average_Dark_Control")	Nanomolar (nM)
Average_1	Average of replicate samples	Nanomolar (nM)
Std_Dev_1	Standard deviation (n=4)	Nanomolar (nM)
Acrylate_Production_Rate_Hourly_Rep1	The hourly rate of acrylate production determined by dividing the amount of acrylate produced ("Acrylate_Produced_Rep1") by the time of sunlight exposure ("Sunlight_Exposure_Time")	Nanomolar per hour (nM h-1)

Acrylate_Production_Rate_Hourly_Rep2	The hourly rate of acrylate production determined by dividing the amount of acrylate produced ("Acrylate_Produced_Rep2") by the time of sunlight exposure ("Sunlight_Exposure_Time")	Nanomolar per hour (nM h-1)
Acrylate_Production_Rate_Hourly_Rep3	The hourly rate of acrylate production determined by dividing the amount of acrylate produced ("Acrylate_Produced_Rep3") by the time of sunlight exposure ("Sunlight_Exposure_Time")	Nanomolar per hour (nM h-1)
Acrylate_Production_Rate_Hourly_Rep4	The hourly rate of acrylate production determined by dividing the amount of acrylate produced ("Acrylate_Produced_Rep4") by the time of sunlight exposure ("Sunlight_Exposure_Time")	Nanomolar per hour (nM h-1)
Average_2	Average of replicate samples	Nanomolar per hour (nM h-1)
Std_Dev_2	Standard deviation (n=4)	Nanomolar per hour (nM h-1)
photon_exposures_311_333_nm	The sunlight photon exposures for each sunlight-exposure experiment between 311 and 333 nm were determined using nitrate	Micromole quanta per square centimeter (µmol quanta cm-2)
photon_exposures_330_380_nm	The sunlight photon exposures for each sunlight-exposure experiment between 330 and 380 nm were determined using nitrite actinometry	Micromole quanta per square centimeter (µmol quanta cm-2)
Acrylate_Production_Rate_Photon_Based_Rep1	The photon-based rate of acrylate production is equal to 1000 times the amount of acrylate produced ("Acrylate_Produced_Rep1") divided by the nitrite photon exposure (330-380 nm)	Picomolar per micromole quanta per square centimeter (pM (µmol quanta cm-2)-1)
Acrylate_Production_Rate_Photon_Based_Rep2	The photon-based rate of acrylate production is equal to 1000 times the amount of acrylate produced " (Acrylate_Produced_Rep2") divided by the nitrite photon exposure (330-380 nm)	Picomolar per micromole quanta per square centimeter (pM (µmol quanta cm-2)-1)

Acrylate_Production_Rate_Photon_Based_Rep3	The photon-based rate of acrylate production is equal to 1000 times the amount of acrylate produced ("Acrylate_Produced_Rep3") divided by the nitrite photon exposure (330-380 nm)	Picomolar per micromole quanta per square centimeter (pM (µmol quanta cm-2)-1)
Acrylate_Production_Rate_Photon_Based_Rep4	The photon-based rate of acrylate production is equal to 1000 times the amount of acrylate produced (Acrylate_Produced_Rep4") divided by the nitrite photon exposure (330-380 nm)	Picomolar per micromole quanta per square centimeter (pM (µmol quanta cm-2)-1)
Average_3	Average of replicate samples	Picomolar per micromole quanta per square centimeter (pM (µmol quanta cm-2)-1)
Std_Dev_3	Standard deviation (n=4)	Picomolar per micromole quanta per square centimeter (pM (µmol quanta cm-2)-1)

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Instruments

Dataset-specific Instrument Name	Shimadzu Prominence
Generic Instrument Name	High-Performance Liquid Chromatograph
Dataset-specific Description	Shimadzu Prominence high performance liquid chromatography (HPLC) system with a model SPD-20A/V UV-Vis absorbance detector set at 257 nm.
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	Niskin bottles
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Sea-surface water samples were collected in Niskin bottles during cruises in the Pacific Ocean, Atlantic Ocean, and the Gulf of Mexico
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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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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