Importance of UV radiation for the production of non methane hydrocarbons and carbon monoxide by phytoplankton

Sophie Tran (1), Ilka Peeken (2,3,4), Bernard Bonsang (1), Valérie Gros (1), Roland Sarda-Esteve (1)

(1) Laboratoire des Sciences du Climat et de l'Environnement, CNRS-CEA-UVSQ, Gif-sur-Yvette, France. **(2)** Leibniz Institute of Marine Sciences, Kiel, Germany. **(3)** Center for Marine Environmental Sciences, Bremen, Germany. **(4)** Alfred Wegener Institute for Polar- and Marine Research, Bermerhaven, Germany.

Corresponding author : sophie.tran@lsce.ipsl.fr

Abstract

Over the ocean some non methane hydrocarbons (NMHC) are known to be directly produced by living algae whereas carbon monoxide (CO) is supposed to be produced only by photolytic destruction of dissolved organic carbon (DOC) involving chromophoric dissolved organic matter (CDOM). In order to determine more precisely the impact of PAR and UV radiations on the production of NMHC and CO, different phytoplankton species have been grown in laboratory and successively exposed to PAR, PAR+UVA and PAR+UVA+UVB radiations.

The results confirm that isoprene production occurs mainly under PAR, corresponding to a direct production by active growing phytoplankton, while the production of other NMHC appears strongly enhanced by UV radiation, in agreement with the hypothesis of a production depending on the UV photodegradation of CDOM. Isobutene and CO emissions seem to combine these two mechanisms.

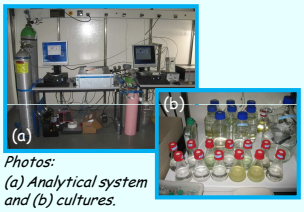
Observed production rates are normalized to chlorophyll and used to evaluate the global significance of the role of these various production pathways.

Methods

Reproduction of a diurnal cycle, with a **dark period** followed by a **period of irradiation**.

Instrumentation

	NMHCs	CO
Analyser	Gas chromatography coupled with a flame ionization detector (GC-FID)	Gas chromatography coupled with a mercuric oxide reduction gas detector (GC-RGD)
selected compounds	ethene, propene, isobutene, isoprene	carbon monoxide
sampling frequency	30 min	10 min
detection limit	< 40 pptv	< 1 ppbv



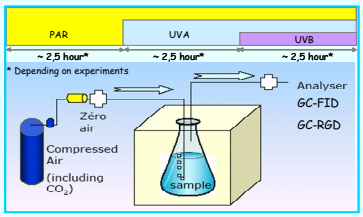
Photos: (a) Analytical system and (b) cultures.

Experimental conditions

	Range (nm)	NMHCs	CO	units
PAR	400 - 700	**282**	**283**	$\mu E.m^{-2}.s^{-1}$
UVA	315 - 400	**8.33**	**8.41**	$W.m^{-2}$
UVB	280 - 315	**0.63**	**0.64**	$W.m^{-2}$

(PAR = Photosynthetically Active Radiation)

Temperature controlled at 20°C



Cultures chosen for this study:

Algae group	Species	Habitat
Coccolithophorids	Emiliania huxleyi	Oceanic, Coastal
	Calcidiscus leptoporus	Oceanic, Coastal
diatoms	Thalassiosira rotula	Coastal
	Cosinodiscus wailesii	Coastal, Oceanic
cyanobacteria	Anabaena torulosa	Coastal / freshwater

Normalisation to chlorophyll-a:

$$[A]_{(\mu g\ A/\mu g\ Chla/h)} = \frac{k \times ([A]^{sample}_{(pptv)} - [A]^{bkg\ average}_{(pptv)}) \times M_{(A)} \times F}{[Chla_{per\ sample}]_{(\mu g/L)}}$$

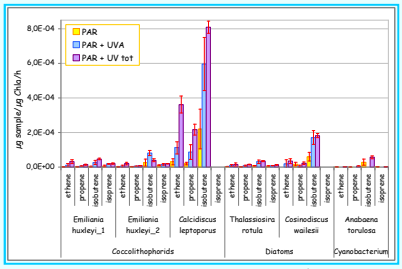
- $[A]$, production rate of A in µg A/µg Chla/h
- $[A]^{sample}$, concentration of the compound A in the sample in pptv
- $[A]^{bkg\ average}$, average of values without light in pptv
- $[Chla_{per\ sample}]$, quantity of chlorophyll-a for each sample in µg Chla/L
- M(A) , molar mass of the compound A (g/mol)
- F, flow rate (mL/min)
- k, unit conversion factor

During these experiments, a **control** was also performed by using a filtered algae sample (only for CO measurements and the species *Emiliania huxleyi* for NMHCs measurements).

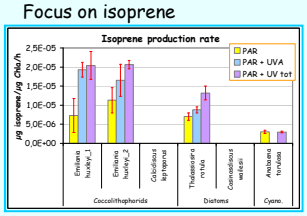
Results and discussion

Non Methane HydroCarbons

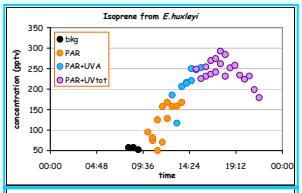
Summary of the production rate for each species:

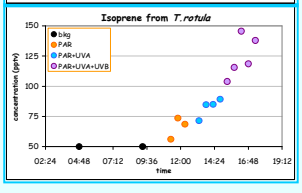


Focus on isoprene

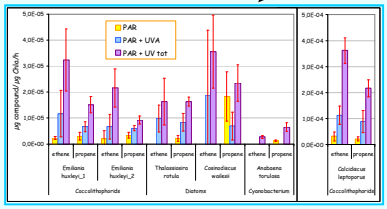


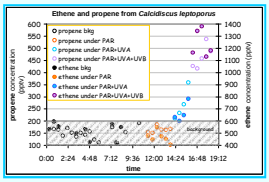
2 different cases:





Focus on ethene and propene





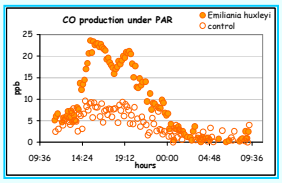
Evidence of the emission of ethene and propene under UV radiations.

PAR activates the emission of isoprene but the effect of UV radiation depends on the species.

The production of isoprene seems to be inhibited by UV radiations especially for *E.huxleyi* whereas it seems to be enhanced for *T.rotula*.

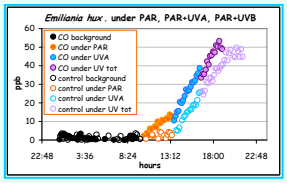
Carbon monoxide

CO under PAR



→ Under PAR, CO production in the sample > CO production in the control (Gros et al., 2009*)

CO under PAR and PAR+UV radiations



→ CO production increases under UV radiations, both in sample and control.

1) Evidence of direct production of CO by phytoplankton

2) Production rate enhanced by UV radiations (through photodegradation of DOC)

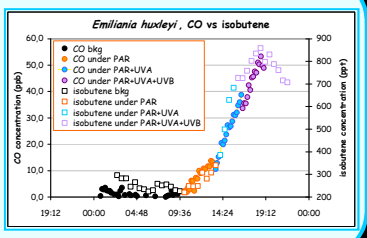
* Gros V., Peeken I., Bluhm K., Zoellner E., Sarda-Esteve R., Bonsang B., Carbon monoxide emissions by phytoplankton: Evidence from laboratory experiments, Env. Chem., vol.6, 2009.

Isobutene and CO

CO and isobutene have the same behaviour:

1) a direct production under PAR by phytoplankton,

2) a production enhanced by UV radiations, which involves the photodegradation of DOC.



Conclusion

1) The production of isoprene from living cells is initiated by PAR whereas the production of alkenes (e.g. ethene, propene, isobutene) is activated by UV radiations, in agreement with photolytic destruction processes involving CDOM (chromophoric dissolved organic matter) and DOC (dissolved organic carbon).

2) CO emissions, particularly studied for the coccolithophorid *Emiliania huxleyi* , result from two different processes: a direct production by living cells under PAR (minor contribution) and an indirect production due to the effect of UV radiations on CDOM (major contribution).

3) The emission of isobutene seems to result from the same processes as determined for CO.

Acknowledgements: K. Bluhm (IFM Geomar, Kiel, Germany), J. Williams (Max Planck Institute, Mainz, Germany), J. Stefels (Univ. of Gröningen, Haren, The Netherlands), and CEA, CNRS, EU (project OOMPH) for financial support.