

## LEARN ABOUT TFA

# For a while range of information about Trifluoroacetic acid/acetate as a breakdown product of some HFCs and some HFOs

Created: May 2019

### [What is TFA](#)

### [Naturally Occurring TFA](#)

### [Where is TFA Found](#)

### [TFA and Organisms](#)

### [TFA from HFCs and HFOs](#)

### [Effect of TFA from HFCs and HFOs](#)

### [TFA from other sources](#)

## Important Conclusions from the [2018 Scientific Assessment of Ozone Depletion](#)

**There is increased confidence that trifluoroacetic acid (TFA) produced from degradation of HFCs, HCFCs, and HFOs will not harm the environment over the next few decades.** This assessment is based on the current estimates of future use of [hydrofluorocarbons, HCFCs, and HFOs](#). It is noteworthy that HFCs and HCFCs have atmospheric lifetimes long enough to globally distribute any TFA emissions, while HFOs have atmospheric lifetimes so short that TFA emissions are deposited near the point of emission. Periodic re-evaluation is prudent, given the uncertainties in the sources and sinks of TFA and because of its persistence in the environment.

Page ES.50

The large body of published field measurements, toxicological studies, modelling studies, and environmental assessments point to a clear conclusion: **The current and estimated future concentrations of TFA and its salts resulting from degradation of HCFCs, HFCs, and HFOs do not pose any known significant risk to human or ecosystem health.**

Page 6.14

## Important Conclusions from the [2018 Environmental Effects Assessment](#)

Estimates of production of TFA in China, the USA, and Europe, from the degradation of HFO-1234yf from its application in automobile air conditioners, and assuming no dilution, would be several orders of magnitude less than the chronic “no observable effect concentration” (NOEC) of 10,000,000 ng L<sup>-1</sup> for TFA-Na salt from an aquatic microcosms study.

**Overall, there is no new evidence that contradicts the conclusion of our previous Assessments that exposure to current and projected concentrations of salts of TFA in surface waters present a minimal risk to the health of humans and the environment.** A recent review of this topic reached a similar conclusion. [see [Norwegian Environment Agency, 2017, Study on Environmental and Health Effects of HFO Refrigerants](#), Norwegian Environment Agency Report No. No. M-917|2017, Oslo, Norway, p. 349] Executive Summary page 16

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### TFA in European river water

A recent comprehensive study investigated the quantities of trifluoroacetate (TFA) found in major rivers across Germany. Following this study, it had been claimed that HFO-1234yf has possible negative consequences to produce drinking water. However, **currently HFO-1234yf is at most an insignificant contributor to the quantities of TFA found**. Furthermore, based on a recent study on *Future emissions and atmospheric fate of HFC-1234yf from mobile air conditioners in Europe*, the projected growth in use of HFO-1234yf and resulting emissions of TFA is expected to have only a small contribution to the quantities of TFA found in German rivers. This is consistent with the conclusions from the [2018 Environmental Effects Assessment](#)

Further information is available [here](#).

### Atmospheric Breakdown: Molar yields of TFA from HFCs, HFOs and HCFCs

Designation	Formula	TFA molar yield
HFC-134a	CF <sub>3</sub> CFH <sub>2</sub>	21%
HFC-227ea	CF <sub>3</sub> CHF <sub>2</sub> CF <sub>3</sub>	100%
HFC-236fa	CF <sub>3</sub> CH <sub>2</sub> CF <sub>3</sub>	<10%
HFC-245fa	CF <sub>3</sub> CH <sub>2</sub> CHF <sub>2</sub>	<10%
HFC-365mfc	CH <sub>3</sub> CF <sub>2</sub> CH <sub>2</sub> CF <sub>3</sub>	<10%
HFO-1234yf	CF <sub>3</sub> CF=CH <sub>2</sub>	100%
HFO-1234ze(E)	Trans- CF <sub>3</sub> CH=CFH	0%
HCFO-1233zd(E)	Trans-CHCl=CHCF <sub>3</sub>	0% experimental, max 2% theoretical
HCFC-123	CF <sub>3</sub> CCl <sub>2</sub> H	60%
HCFC-124	CF <sub>3</sub> CFClH	100%

Other atmospheric breakdown products include naturally occurring HCOOH (formic acid) HF, HCl, CO<sub>2</sub>. The TFA yields have been determined using models and/or laboratory experiments

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### More Resources

[INFOGRAPHIC on TFA](#)

HFOs and TFA: See the [VIDEO](#).

UNEP Ozone Secretariat, Ecological Issues on the feasibility of managing HFCs: Focus on TFA Inter-sessional informal meeting, 12-13 June 2015 Informal Brief on Ecological Issues on HFCs June 2015 see [EFCTC Learn about TFA from HFCs HFOs.pdf](#)

[IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Global Climate System Chapter 2](#)

World Meteorological Organization (2010): Global Ozone Research and Monitoring Project—Report No. 52. Chapter 1

Available at: [https://www.wmo.int/pages/prog/arep/gaw/ozone\\_2010/documents/Ozone-Assessment-2010-complete.pdf](https://www.wmo.int/pages/prog/arep/gaw/ozone_2010/documents/Ozone-Assessment-2010-complete.pdf)

Environmental Risk Assessment of Trifluoroacetic Acid, Jean Charles Boutonnet et al; [Human and Ecological Risk Assessment](#) 5(1):59-124 · February 1999, available at [https://www.researchgate.net/publication/254217782\\_Environmental\\_Risk\\_Assessment\\_of\\_Trifluoroacetic\\_Acid](https://www.researchgate.net/publication/254217782_Environmental_Risk_Assessment_of_Trifluoroacetic_Acid)

Atmospheric chemistry of cis-CF<sub>3</sub>CH=CHF: Kinetics of reactions with OH radicals and O<sub>3</sub> and products of OH radical initiated oxidation; E.J.K. Nilsson, O.J. Nielsen, M.S. Johnson, M.D. Hurley, T.J. Wallington; *Chemical Physics Letters* 473 (2009) 233–237

### Papers on use of HFO-1234yf and its degradation products

Stephan Henne, Dudley E. Shallcross, Stefan Reimann, Ping Xiao, Dominik Brunner, Simon O’Doherty, and Brigitte Buchmann, Future Emissions and Atmospheric Fate of HFC-1234yf from Mobile Air Conditioners in Europe, *Environ. Sci. Technol.*, 2012, 46 (3), pp 1650–1658 DOI: 10.1021/es2034608.

Kajihara, H., Inoue, K., Yoshida, K., Nagaosa, R. 2010. Estimation of environmental concentrations and deposition fluxes of R-1234yf and its decomposition products emitted from air conditioning equipment to atmosphere. Proc. 2010 Int. Symposium on Next-Generation Air Conditioning and Refrigeration Technology, paper no NS24, Tokyo, Japan

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Luecken, D. J., Waterland, R. L., Taddonio, N., Hutzell, W. T., Rugh, J. P., Andersen, S. O., 2010. Ozone and TFA Impacts in North America from Degradation of 2,3,3,3-Tetrafluoropropene (HFO-1234yf), A Potential Greenhouse Gas Replacement. *Environmental Science and Technology*, 44(1): 44,343–348

Papasavva, S., Luecken, D. J., Waterland, R. L., Taddonio, K. N., Andersen, S. O., 2009. Estimated 2017 Refrigerant Emissions of 2,3,3,3-tetrafluoropropene (HFC-1234yf) in the United States Resulting from Automobile Air Conditioning. *Environmental Science and*

*Technology*, 43(24):9252–9259

### Transport of sea spray inland

Unexpected Contributions of Sea Spray and Lake Spray Aerosol to Inland Particulate Matter, Nathaniel W. May, Matthew J. Gunsch, Nicole E. Olson, Amy L. Bondy, Rachel M. Kirpes, Steven B. Bertman, Swarup China, Alexander Laskin, Philip K. Hopke, Andrew P. Ault, and Kerri A. Pratt; *Environ. Sci. Technol. Lett.*, **2018**, 5 (7), pp 405–412 DOI: 10.1021/acs.estlett.8b00254

Sea spray aerosol (SSA) and lake spray aerosol (LSA) from wave breaking contribute to particulate matter (PM) in coastal regions near oceans and freshwater lakes, respectively. The paper shows that SSA and LSA episodically contribute to atmospheric aerosol populations at a rural site in northern Michigan >700 and >25 km from the nearest seawater and Great Lakes sources, respectively.

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#### What is TFA

TFA (trifluoroacetic acid and its salts). TFA is very stable in the environment as the trifluoroacetate ion ( $\text{CF}_3\text{COO}^-$ ) which will be combined with counter-ions such as sodium, in seawater, or calcium or ammonium ( $\text{NH}_4^+$ ) inland, to form neutral salts. "TFA" is used as shorthand for trifluoroacetic acid and its salts.

#### Naturally Occurring TFA

Over 200 million tonnes are present in the oceans, both coastal and deep-ocean seawater, having apparently accumulated over many million years from chemical reactions in or around sub-sea volcanic vents. More than 95% of TFA found in the oceans is naturally formed. The concentration in the oceans is small (about  $\sim 200 \text{ ng L}^{-1}$  or  $\sim 2 \times 10^{-10} \text{ g of TFA /g of sea water}$ ).

#### Where is TFA Found

TFA is found in the oceans. It was also found in samples of fog, rain, river and lake water analysed during the 1990s. TFA is also found in soil samples, including in an archived soil sample from 1865. Generally, soil retention of TFA is poor and the TFA will ultimately enter the aqueous environment.

#### TFA and Organisms

The salts of TFA are inert and not of toxicological or environmental concern in the small concentrations ( $\sim 200 \text{ ng L}^{-1}$ ) that are present in the ocean. The current and estimated future concentrations of TFA and its salts resulting from degradation of HCFCs, HFCs, and HFOs do not pose any known significant risk to human or ecosystem health.

#### TFA from HFCs and HFOs

TFA is produced as a breakdown product of some HFCs, including HFC-134a, and from HFO -1234yf. No TFA is formed from HFO-1234ze(E). No TFA was found experimentally for the breakdown of HCFO1233zd(E), but recent modelling suggests up to 2% could theoretically be formed. Some HCFCs (HCFC-123 and -124) also breakdown to produce TFA. A table of TFA yields is here above

#### Effect of TFA from HFCs and HFOs

For an upper range scenario of global HFC use by 2050 it was estimated that the total additional contribution of TFA to the oceans would be less 7.5% of the TFA present at the start of the millennium. With the 2016 Kigali Amendment to the Montreal Protocol, the TFA due to global HFC use, and hence TFA formation as a breakdown product, is projected to be lower but partially offset by increased use of HFOs.

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### TFA from other sources

TFA is produced as a breakdown product of several other chemicals and is produced synthetically by the chemical industry.

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