

HFO

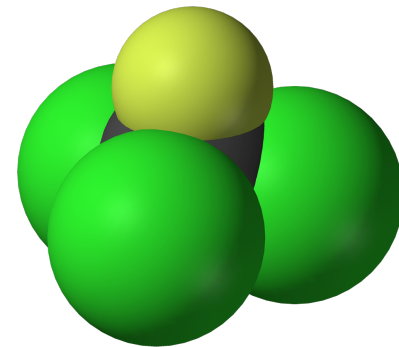
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GWP
ODP

GWP: Greenhouse warming potential

- ▶ Amount of heat trapped by 1 kg of a greenhouse gas, relative to the amount of heat trapped by 1 kg of CO₂.
- ▶ Measured over a period of 100 years, specified because some gases decay faster in the atmosphere than others.

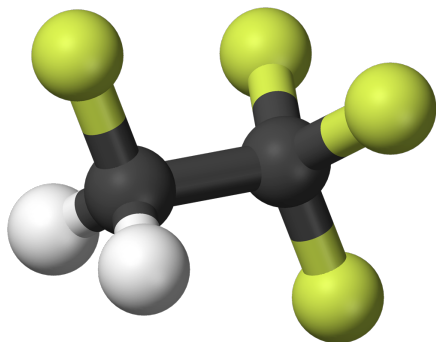
ODP: Ozone depletion potential

- ▶ Amount of ozone lost by 1 kg of gas, relative to the amount of ozone lost by 1 kg of R11 ($\text{Cl}_3\text{F C}$).
- ▶ UV from the Sun breaks up Cl-C bonds.
- ▶ Probably best known with Cl compounds, but also occurs with I and Br.
- ▶ F-C bonds are too strong.

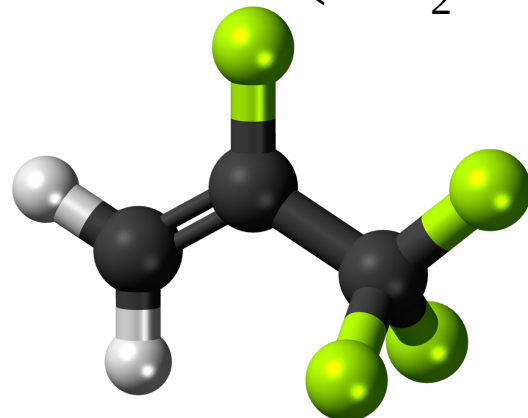


HFO

- ▶ HFO stands for hydrofluoroolefin.
- ▶ They are HFCs which have a double C=C bond.
- ▶ This makes them more reactive and gives them a shorter lifetime.
- ▶ They are slated to replace R134a ($\text{CH}_2\text{F}-\text{CF}_3$):



1,1,1,2-tetrafluoroethane



2,3,3,3-tetrafluoropropene

Good and bad properties of HFOs

- ▶ HFO-1234yf $\text{CH}_2=\text{CF}-\text{CF}_3$
 - ▶ air conditioning in cars, to replace R134a
- ▶ HFO-1234ze(E), 1234ze(Z) isomers $\text{CHF}=\text{CH}-\text{CF}_3$
- ▶ HFO-1233zd(E) isomers $\text{HClC}=\text{CH}-\text{CF}_3$
 - ▶ chillers
- ▶ HFO-1336mzz $\text{CF}_3-\text{CH}=\text{CH}-\text{CF}_3$
 - ▶ heat pumps

- ▶ Good:
 - ▶ low GWP: < 1 ,
 - ▶ short atmospheric lifetime: 10-20 days,
 - ▶ ODP ~ 0 in those made only with fluorine (no Cl, I, Br).
- ▶ Bad:
 - ▶ concern about flammability,
 - ▶ produces HF when burning,
 - ▶ atmospheric decay to trifluoroacetic acid (phytotoxic, aquatic life).

Lifetime, GWP, ODP

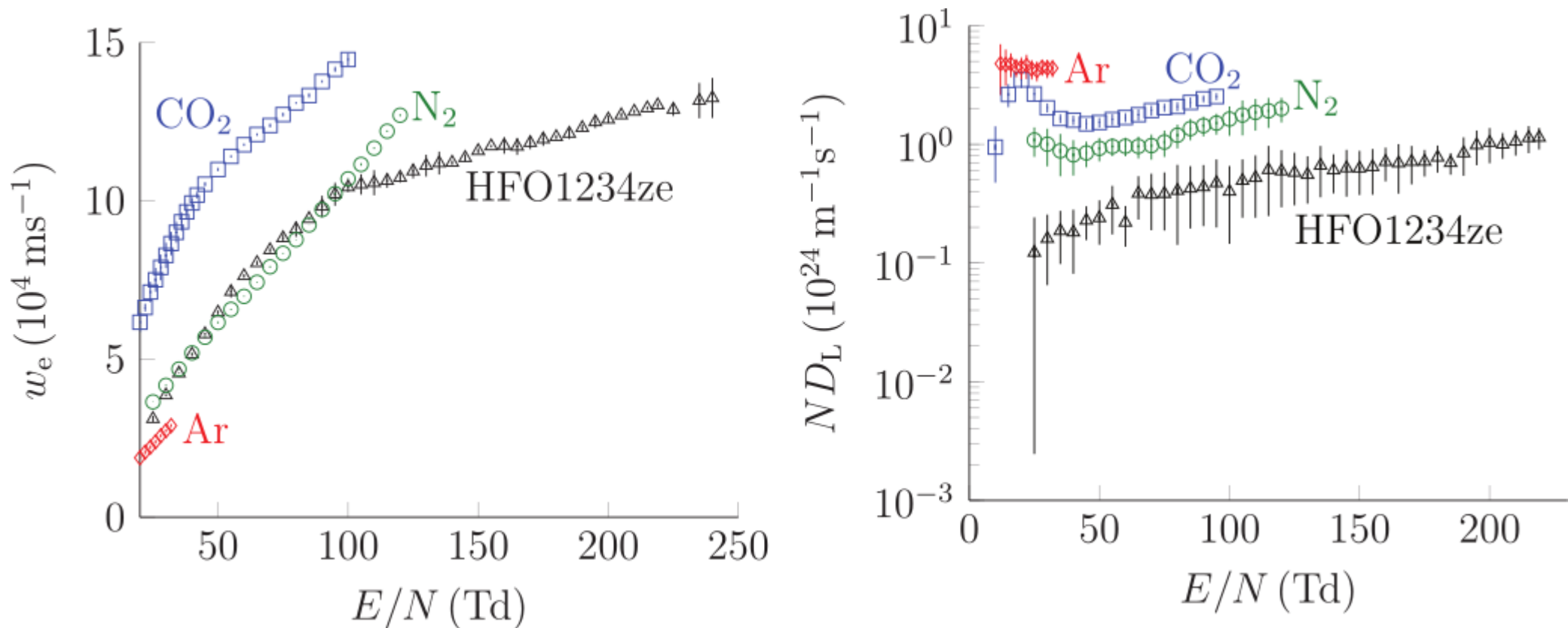
► Properties of some common compounds:

Gas	Lifetime [years]	GWP [100 years]	ODP
CO ₂	10-100	reference	0
CCl ₃ F (R11)	45	4660	reference
CH ₄	12.4	28	
CH ₂ F-CF ₃ (R134a)	13.4	1300	0
CHF ₂ -CHF ₂ (R134)	9.7	1120	0
CH ₃ -CF ₃ (R143a)	47.1	4800	0
CHF ₂ -CF ₃ (R125)	28.2	3170	0
CF ₄	50000	6630	0
C ₂ F ₆	10000	11100	0
C ₃ F ₈	2600	8900	0
SF ₆	3200	23500	0 ?
CF ₃ Br (Halon 1301)	65	6290	16
1234yf	10.5 days	<1	0
(Z) 1234ze	10 days	<1	0
(E) 1234ze	16.4 days	<1	0

[from IPCC WG1/AR5]

Literature

- ▶ A. Chachereau et al. 2016 Plasma Sources Sci. Technol. **25** 045005



Literature

- ▶ L. Benussi et al., A study of HFO-1234ze (1,3,3,3-Tetrafluoropropene) as an eco-friendly replacement in RPC detectors, INFN-14-14/LNF 11 nov 2014.

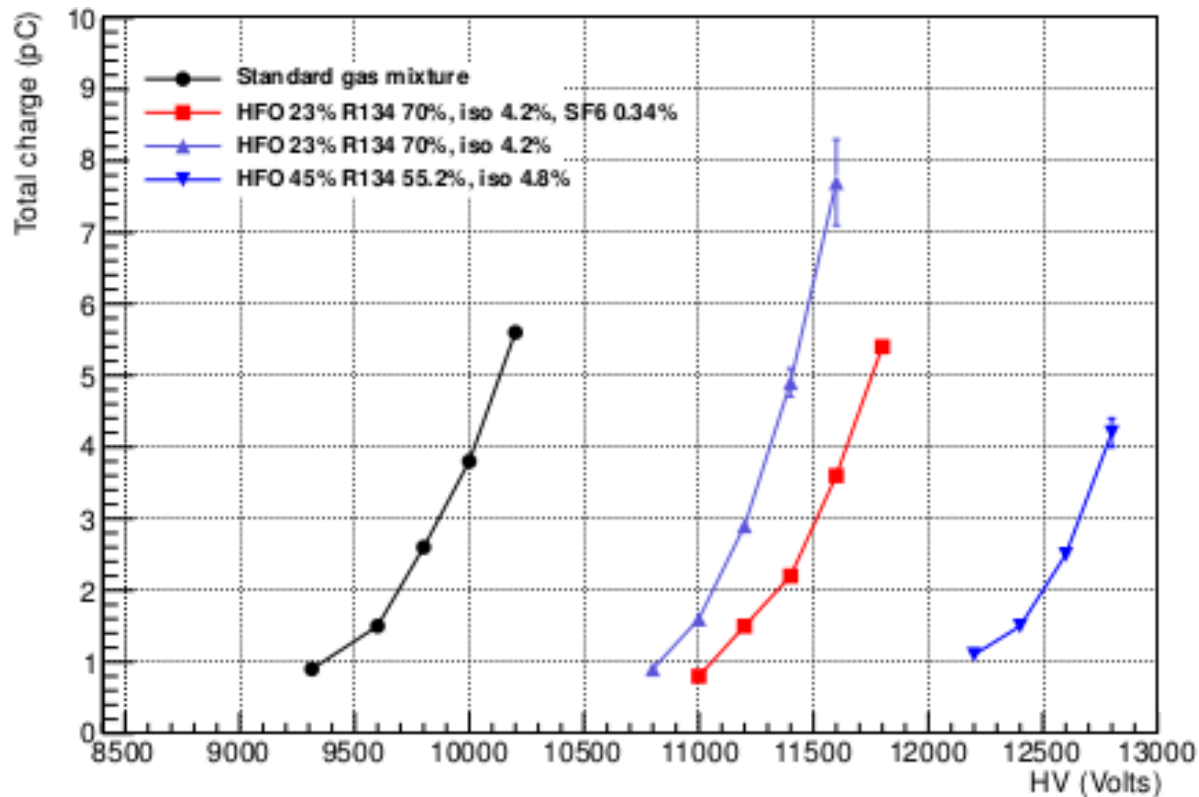


Figure 13: Integrated induced charge vs effective HV for different mixtures composed by isobutane, R134a, HFO1234ze with and without SF_6

Interest

- ▶ Which compounds are likely to be used in HEP in the foreseeable future ?
- ▶ For applications: RPCs, presumably – any other use ?