

Short Communication

POTENTIAL ALTERNATIVES TO CHLOROFLUOROCARBONS AND THEIR RISKS

Anoop Kumar Mishra and *Siddhartha Shukla

Research Scholar, *Professor

Department of Environmental Sciences

Dr. R. M. L. Avadh University, Faizabad-224001 UP, India

E-mail: dr_siddharthashukla@yahoo.com

Abstract: Chlorofluorocarbons (CFCs) are well known for the depletion of stratospheric ozone layer. As a substitute of this, Hydro-Chlorofluorocarbons (HCFCs) and Hydro-Fluorocarbons (HFCs) were suggested as ozone friendly alternatives in Montreal protocol (1987). But researches done on these alternatives revealed that some Hydro-Chlorofluorocarbons Such as HCFC-123, HCFC-124 and Hydro-Fluorocarbons such as HFC-134a are expected to produce Trifluoro-acetate (TFA). This TFA is resistant to abiotic degradation process and is expected to distribute from air to cloud water, whence it will return to the earth surface via precipitation. At the surface it is getting accumulated in seasonal wet lands and is affecting their role as habitat for many rare and endangered plant and animal species and also in their use by migratory and wintering fowl for foraging and resting during winter and early spring.

Keywords: Chlorofluorocarbons, Hydro chlorofluorocarbons, Hydro fluorocarbons, Trifluoroacetate, Seasonal wetlands and ozone friendly substitute.

The chlorofluorocarbons (CFCs) came into advent in 1930, as miraculous refrigerants, having so many admirable qualities such as they were inexpensive, non-inflammable, less poisonous and chemically inert. Owing to these qualities, CFCs got a variety of uses as propellants for aerosol sprays, cleaning solvents and fire extinguisher etc (**James, 1999; Midgley & Henne, 1930**). The idea of use of CFCs as safe refrigerant soon became fake, when scientist could know that the chlorine released from these depletes the ozone layer of the stratosphere (**Molina & Rowland, 1974**). This report forced the scientists to worry about CFCs. In this chain various ozone friendly alternatives to CFCs as refrigerant were proposed (**Calm, 2002**).

Ozone friendly alternatives to chlorofluorocarbons as refrigerant			
Hydrocarbons (Butane & Propane)	Ammonia	Hydro chlorofluorocarbons (HCFCs)	Hydro fluorocarbons (HFCs)
Highly inflammable Less efficient than CFCs Greater contribution to Green House Effect	Highly corrosive Danger to human health if escapes. Less efficient than CFCs. Greater contribution to Green House Effect.	Efficient refrigeration. No toxic effect. Destroys Ozone but to a lesser extent than CFCs.	Efficient refrigeration. No toxic effect. Do not destroy Ozone, because chlorine molecule is absent.

Taking account of all the aspects of ozone friendly substitutes to CFCs the Montreal protocol was signed by 24 countries in October, 1987. Signatories to the Montreal protocol and subsequent amendments have agreed to –

- Phase out the use of CFCs in the next few decades.
- Hydro chlorofluorocarbons (HCFCs) and Hydro fluorocarbons (HFCs) have been proposed as CFCs alternatives.

The candidate replacement compounds included seven HCFCs and Five HFCs.

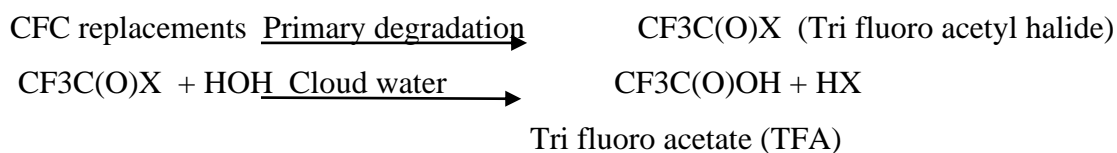
Candidate replacement compounds	
Hydro chlorofluorocarbons (HCFCs)	Hydro fluorocarbons (HFCs)
HCFC-22	HFC-32
*HCFC-123	HFC-125
*HCFC-124	*HFC-134a
HCFC-141b	HFC-143a
HCFC-142b	HFC-52a
HCFC-225ca	
HCFC-225cb	

{Compound marked produce Tri fluoro acetate (TFA) in the atmosphere}

There was a general scientific consensus that these CFCs-substitutes are environmentally preferable and do not take part in the ozone layer perturbation, and that's why these have been hopefully and aggressively pursued as logical successors to CFCs.

However, a new risk of “potential accumulation of CFC degradation product in seasonal wetlands” has been reported in 1995 (**Tromp et.al., 1995; Cahill et. al., 2001**). Atmospheric degradation of several of these CFC replacements is expected to produce Trifluoroacetate (TFA). Most of the CFC replacements are halogenated ethane derivatives. Among these CFC substitutes three are important viz. HCFC-123, HCFC-124 and HFC-134a. The HFC-134a is expected to be one of the most important CFC replacements for refrigeration and air conditioning purposes between now and year 2025 (**Chang & Griddle, 1995; Bhatkar et. al., 2013**).

Since 1988, researches have been focused on tropospheric degradation pathway of the CFC replacements. Now it is evident from laboratory studies that these CFC replacements would first degrade to C₁ products like tri fluoro acetyl halides CF₃C(O)X, Where X is Cl or F. Further hydrolysis of these acetyl halides (i.e., interaction with OH radicals) in cloud water is expected to form Tri fluoro acetate (TFA-CF₃C(O)OH).



(Degradation pathway of CFC replacements)

A report of United Nation Environmental Program (UNEP) says that TFA is resistant to abiotic degradation processes such as photolysis & hydrolysis and is virtually unmetabolizable by most of the plants and animals. TFA is expected to distribute from air to cloud water, whence it will return to the earth surface via precipitation (**Finnian et.al., 2020**). Although its present concentration is about 0.160 µg/litre which is very much less than toxic threshold of the most sensitive species yet assessed. However, there are numerous water bodies characterized by little to no out flow and high evaporation rates (for eg., Agricultural evaporation ponds and seasonal wet lands including playa lakes, tundra ponds and vernal pools). This type of water bodies may have the potential to accumulate air and rain borne acids, including TFA. If these acids are not removed physically or chemically, their concentration might be elevated by several orders of magnitude above the global average concentration in rain water. The TFA concentration to be expected in the wet lands will depend on TFA source strength, enhancement factors and loss. There are variety of factors which are capable of enhancing, local source strength of TFA, for eg., the TFA concentration in precipitation of arid and semi arid regions may be 2-4 times greater than global means. The

atmospheric source strength of TFA may be further and substantially enhanced in urban areas because of high densities of source emitters. The enrichment of urban air with OH radical level as much as 10 times of zonal mean can lead to another order of magnitude increase by increasing the rate of TFA formation. In hydrologically and topographically closed wet lands such as playa lake, or partially closed wetlands such as vernal pools loss will be limited to minor seepage, aeolian losses and biodegradation (**Mark et.al., 2012**).

Therefore, TFA could accumulate in local surface waters in the absence of major biological or physical removal processes. TFA added as sodium salt (100 – 300 µg/litre) inhibits the growth of some species of alga, it has been observed that TFA get bioaccumulated in plant tissues and inhibits the early growth of sunflower, mungbeans and wheat at concentration down to 1mg/kg dry soil. TFA is highly mobile in xylem tissues and has been demonstrated to bioaccumulate by at least a factor of 30 in vascular plants. Thus the TFA concentration in wet lands would exponentially enhanced and would certainly affect the ecological importance of many of the ubiquitous wet lands, lies not only in their acting as habitat for many rare & endangered plant and animal species, but also in their use by migratory and wintering fowl for foraging and resting during winter and early spring.

Still, more information about degradation pathway of CFC-replacement and more sensitive analytical methods should be developed and published, making it easier for investigator worldwide to track current concentration of TFA in the environment, while concentration remains toxicological insignificant. Clearly a transition away from CFCs must be made. As some time happens, however, the solution to one problem is not without unintended risks. TFA is likely to be an extremely persistent and globally distributed compound but will it be universally benign when produced and released in kiloton quantities?

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