TRANSITIONING TO LOW-GWP **ALTERNATIVES IN NON-MEDICAL AEROSOLS**

Background

This fact sheet provides current information on low-Global Warming Potential (GWP) alternatives for non-medical commercial aerosols (i.e., excluding metered-dose inhalers (MDIs)) that have historically relied on ozone depleting substances controlled under the *Montreal Protocol on Substances that Deplete the Ozone Layer*.[1] Aerosols use liquefied or compressed gas to propel active ingredients in liquid, paste, or powder form in precise spray patterns with controlled droplet sizes and amounts. Typical aerosol products use a propellant that is a gas at atmospheric pressure, but is a pressurized liquid in the can. Some aerosols also contain a solvent. In some cleaning applications, the propellant disperses the solvent; in other applications, the solvent product and propellant solution are evenly mixed to improve shelf-life and product performance, such as by preventing dripping and ensuring uniform film thickness for spray paints. Non-medical commercial aerosols can be broken down into the following two product categories:

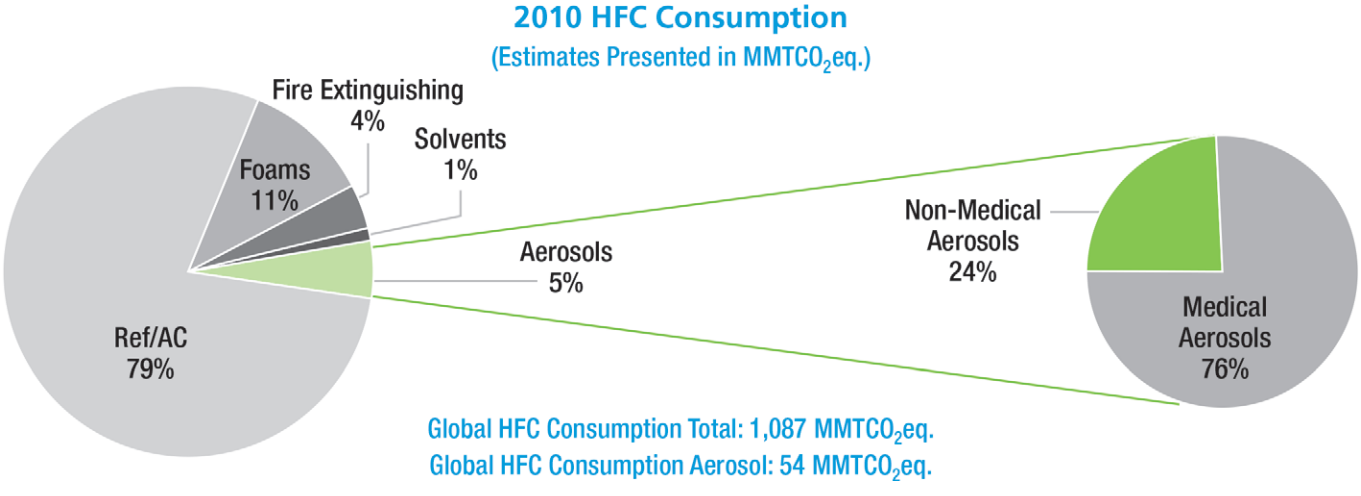
Consumer Aerosols

- Tire inflators/sealants
- Safety signal horns
- Animal repellants
- Personal care products (e.g., cosmetic aerosols, hairspray, deodorants, wound care sprays,[2] taping base[3])
- Food dispensing products
- Freeze sprays (e.g., food freezing, animal waste freezing, cold sprays[4])
- Spray paint
- Novelty aerosols (e.g., artificial snow, plastic string, noise makers, cork poppers)
- Miscellaneous consumer aerosols (e.g., household cleaning products, brake cleaners,[5] eyeglass and keyboard dusters, room fresheners, spray adhesives)

Technical Aerosols

- Dusters[6] (e.g., for photographic negatives, semiconductor chip manufacture, specimens for observation under electron microscope)
- Cleaners (e.g., electronic contact cleaners,[7] flux remover[8])
- Pesticides (e.g., wasp and hornet sprays, aircraft insecticides)
- Miscellaneous technical aerosols (e.g., document preservation sprays, freeze sprays[9])

Although a large portion of the aerosol market has avoided HFC propellants and solvents by transitioning directly to low-GWP options and "not-in-kind" (NIK) alternatives, in 2010, global HFC consumption from aerosols was estimated at 54 million metric tons of carbon dioxide equivalent ($MMTCO_2eq.$). Twenty-four percent of this amount was from the non-medical commercial end-uses described above. Developed countries accounted for nearly all of the global HFCs used in commercial aerosols.



HFC Alternatives and Market Trends

Historically, CFC-12 was used as a propellant and CFCs (e.g., CFC-11 and -113) and methyl chloroform were often used as solvents in aerosols. In response to the CFC phaseout, these were replaced with a variety of alternatives, including HCFCs, hydrocarbons (HCs), oxygenated organic compounds, and NIK alternatives. HCFCs included primarily HCFC-22 for propellants and both HCFC-141b and HCFC-225ca/cb for solvents.[10] HCFC propellants have in turn been replaced with high-GWP HFCs—including HFC-134a—as well as a variety of low-GWP substitutes, such as HCs, compressed gases, NIK alternatives, and HFC-152a. Likewise, HCFC solvents have been replaced by HFC-43-10mee, HFC-365mfc, HFC-245fa, *trans*-1,2-dichloroethylene, HCs, oxygenated organic compounds, and hydrofluoroethers (HFEs). Other low-GWP fluorinated compounds are also in use or under development, including HFOs.[11] These alternatives are described further below.

HCs

- Propane, butane, and isobutane blends used for propellants
- Hexane, heptane, and other HCs used as solvents
- Used in technical and some consumer aerosols
- Plant modifications needed to address flammability/safety concerns
- Local use restrictions may apply due to concerns over volatile organic compound (VOC) emissions, in particular in the United States

Oxygenated Organic Compounds

- Dimethyl ether (DME) used for propellants
- Esters, ethers, alcohols, and ketones used as solvents
- Used in technical and consumer aerosols
- Plant modifications needed to address flammability/safety concerns
- Local use restrictions may apply due to concerns over VOC emissions, in particular in the United States

NIK

- Finger/trigger pumps, powder formulations, sticks, rollers, brushes, bag-in-can/piston-can systems, wipes, sand-blasting, brushing, and abrasion used in place of propellants and solvents in technical and consumer aerosols
- Mixing balls and dip tubes also used in place of high-GWP solvents in technical aerosols; propellants still required

Europe's Experience

Europe is the world's largest producer of aerosols, with 5.5 billion units produced in 2011 representing nearly 46% of global production. Of these, 5.1 billion were produced in the European Union (EU). Shortly after the signing of the Montreal Protocol, the EU aerosol industry transitioned from CFCs to HCFCs for the majority of non-medical aerosols in 1989, and then transitioned away from HCFC propellants to HFCs (primarily HFC-134a), HCs, and NIK devices by 1995. In 2002, the European industry voluntarily began the transition away from HFCs through the Code of Practice on HFC Use in Aerosols of the European Aerosol Federation, which specified that HFC propellants only be used when no other safe, practical, economic, or environmentally acceptable alternatives exist. This transition was later boosted by EU regulation (Regulation (EC) No. 842/2006), which banned HFC use in novelty aerosol products as of July 2009.

Chemical	GWP	ODP[a]
Propellant		
CFC-12	10,900	1
HCFC-22	1,810	0.055
HFC-134a	1,430	0
N_2O	298	0.017
HFC-152a	124	0
HFO-1234ze(E)	6	0
Butane	4	0
Propane	3.3	0
Isobutane	3	0
CO_2	1	0
DME	1	0
Solvent		
CFC-113	6,130	0.8
CFC-11	4,750	1
HFC-43-10mee	1,640	0
HFC-245fa	1,030	0
HFC-365mfc	794	0
HCFC-141b	725	0.11
HCFC-225cb	595	0.033
HFE-449s1 (HFE-7100)	297	0
Methyl chloroform	146	0.1
HCFC-225ca	122	0.025
HFE-569sf2 (HFE-7200)	59	0
Oxygenated Organic Compounds	<20	0
-1233zd(E) (HBA-2)	4.7-7	~0
Hexane	3	0
Heptane	3	0

[a]ODP = ozone depletion potential

Compressed Gases

- Includes CO_2, air, nitrous oxide (N_2O), and nitrogen
- Used as propellants in some technical and consumer applications (e.g., dusters)
- N_2O commonly used in food dispensing aerosols

HFEs

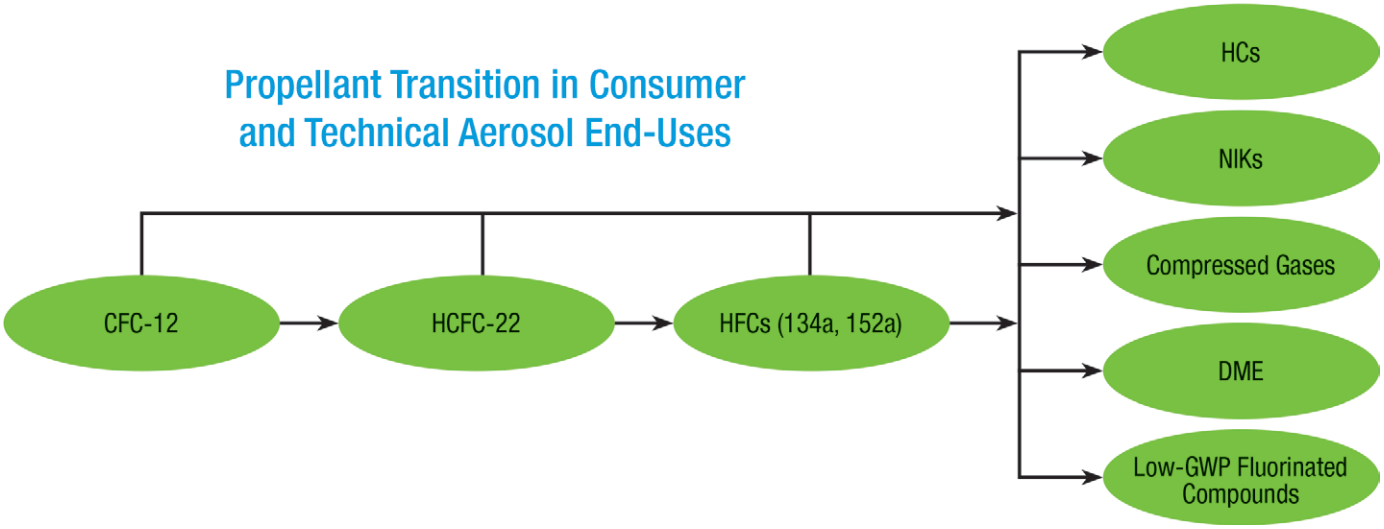
- Used as solvents in technical aerosols
- No flammability
- May be mixed with other, more flammable compounds with higher solvency, such as *trans*-dichloroethylene

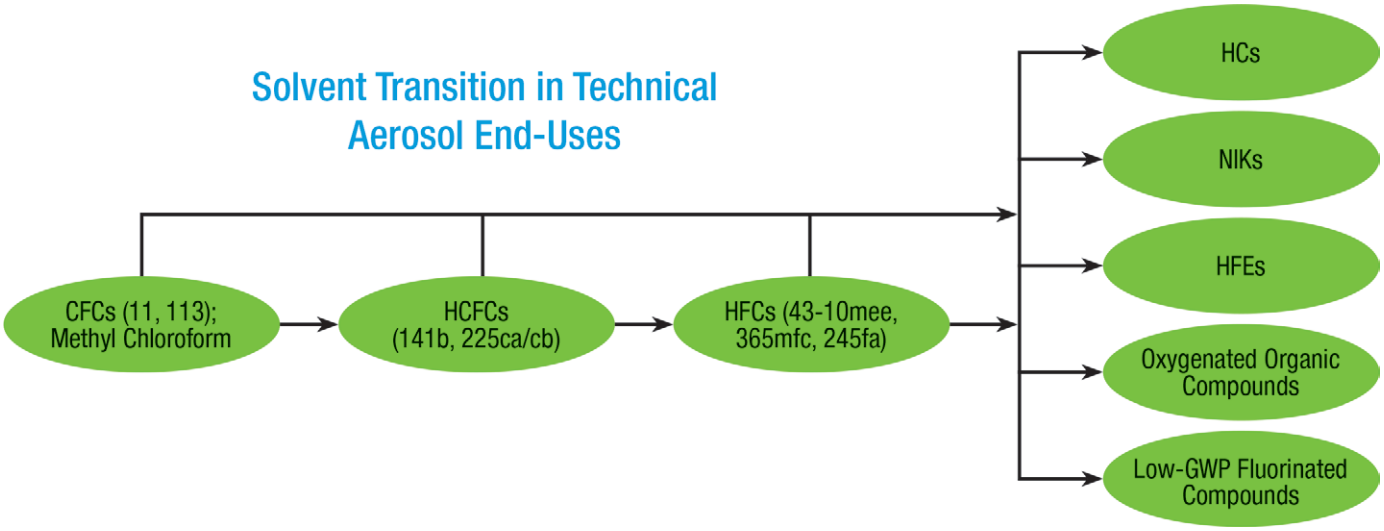
HFC-152a

- Although an HFC, the GWP is 91% lower than HFC-134a
- Used as a propellant in technical and consumer aerosols, particularly where VOCs are of concern, such as in the United States
- Moderate flammability

Low-GWP Fluorinated Compounds

- HFO-1234ze(E) used as a propellant in technical and consumer aerosols
- Other low-GWP fluorinated compounds are becoming available as propellants and solvents (e.g., -1233zd(E)[12] used as solvent)
- Depending on solvency of the fluorinated compound, it may be mixed with other, more flammable compounds with higher solvency
- Some exhibit low flammability, others non-flammable
- Few facility modifications required to transition from HCFCs or HFCs





Challenges to Market Entry and Potential Solutions

Alternative	Challenges to Market Entry	Potential Solutions
HCs, Oxygenated Organic Compounds (Propellant and Solvent)	• Highly Flammable • VOC Regulation and Air Quality Impacts	• Engineering Controls • Standards and Safety Regulations • Training and Education
NIK (Propellant and Solvent)	• Lower Performance for Some Applications	• Engineering Design
Compressed Gases (Propellant)	• Fewer Blasts per Can Compared to HFCs	• Engineering Design
HFEs (Solvent)	• Lower Performance for Some Applications	• Mixing with Other, More Aggressive Solvents
HFC-152a (Propellant)	• Moderate Flammability	• Engineering Controls • Standards and Safety Regulations • Training and Education
Low-GWP Fluorinated Compounds (Propellant and Solvent)	• Some Are Still Entering World Markets	• Field Testing

Future Outlook

Much of the aerosol sector has avoided the use of HFCs, transitioning from CFCs or HCFCs directly to low-GWP alternative chemicals and NIK solutions. Together, the suite of known alternative chemicals and NIK options can significantly reduce the remaining HFC consumption in both the near and long terms, while simultaneously helping to complete the HCFC phaseout. Although more work remains to fully adopt these alternatives, the industries currently using HCFCs and HFCs have proven through the ODS phaseout that they can move quickly to protect the environment.

[1] Although MDIs are also transitioning away from CFC propellants to HFC propellants, critical use exemptions allow the limited use of CFCs for safety and technical reasons.

[2] Wound care sprays include germicides and spray-on bandages.

[3] Taping base is used on injuries to help secure tape, underwrap, and elastic wraps.

[4] Topical coolants and freeze sprays are used by medical trainers and athletes. After application, the spray evaporates from the skin, lowering the surface temperature to alleviate pain.

[5] Brake cleaners remove oil, dirt, and other debris from vehicle braking systems. Brake cleaners previously used methyl chloroform and successfully avoided use of high-GWP HFCs by transitioning directly to perchloroethylene or carbon dioxide as a solvent/propellant.

[6] Duster sprays are compressed gases used to blow off dust or dirt, particularly from computers and electronic equipment.

[7] Electronic contact cleaners are used to dissolve and remove oil, grease, flux, condensation, and other contaminants quickly from delicate electronic circuitry and instrumentation.

[8] Flux removers are used to clean excess flux and solder residue from circuit boards and electrical components.

[9] Among other uses, freeze sprays are used to test electrical conductivity of components on circuit boards, and freeze and remove warts.

[10] In the United States, the use of HCFC aerosols was banned for nonessential products in 1994. Only a few types of products were allowed.

[11] HFOs (hydrofluoro-olefins) are unsaturated HFCs.

[12] -1233zd(E), an unsaturated compound, is also referred to as trans-1-chloro-3,3,3-trifluoroprop-1-ene and by trade names such as HBA-2.

U.S. Environmental Protection Agency
EPA 430-F-13-013 • www.epa.gov • April 2013
Printed on recycled paper

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