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NEW ADVANCES IN AEROSOL DEFLUXERS TO REPLACE HCFC-141B

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INTRODUCTION

A decades worth of changing global environmental regulations has profoundly changed aerosol defluxing and cleaning methods. One product that has played a significant part in the transition away from ozone depleting CFCs is [HCFC-141b](#). However, because it is itself an ozone depleting substance, production of HCFC-141b will cease as of January 1, 2003. This pending phase out of HCFC-141b has significantly increased interest in replacement chemistries for aerosol defluxers and cleaners.

REGULATORY BACKGROUND

In the United States, the Clean Air Act (CAA) mandates that the manufacture and use of HCFC-141b be regulated by the United States Environmental Protection Agency (US EPA).

In brief, CAA regulations that are specific to HCFC-141b are as follows:

- Section 612 (known as "SNAP" because of the title "Significant New Applications Program") bans the use of HCFC-141b in cleaning equipment (i.e., vapor degreasers) but permits its use in essential aerosol applications.
- Section 610(d) of the CAA bans all aerosol uses of HCFC-141b as "nonessential" with the exception of eight exempt product categories. The exempt aerosol products include lubricants and cleaners for electronics, lubricants and cleaners for aircraft, mold release agents, document preservation sprays and certain wasp and hornet sprays. It is this provision that permits the use of HCFC-141b as an aerosol defluxer in the US.

LIST OF SNAP-APPROVED ALTERNATIVES

Section 612 of the CAA (the SNAP regulations) mandates that the EPA evaluate and approve all substances prior to their use as replacements for ozone-depleting CFCs. The

SNAP classification "Aerosol Solvents" is one of many review categories established by the EPA.

A material must be formally listed on the SNAP Aerosol Solvents list (or pending in the EPA SNAP review process) to be legally acceptable for aerosol use.* Some materials are SNAP-accepted with "conditions or restrictions" which should be considered prior to use.

The SNAP list of "acceptable" aerosol solvents is as follows:

| Material | Commercially Available? | Conditions or Restrictions? |
|---------------------------------------|--------------------------------|------------------------------------|
| Alcohols, Ethers, Esters and Keytones | Yes | Minimal |
| HCFC-225ca/cb | Yes | Minimal** |
| HFC-43-10mee | Yes | Minimal |
| Monochloro-tolulenes | Yes | Significant |
| Perfluorocarbons | Yes | Significant |
| Perfluoropolyethers | Yes | Significant |
| HFE-7100/7200 | Yes | None |
| Petroleum Hydrocarbons | Yes | None |
| Chlorinated Solvents | Yes | Significant |
| Trans-1,2-dichloroethylene | Yes | None |
| Terpenes | Yes | None |
| HCFCs | No | Significant |
| Water | Yes | None |
| HFC-365mfc | Yes | Minimal |

| | | |
|--|-----------|---------|
| HFC-245fa | 2003-2004 | Minimal |
| <p>* NOTE: The actual text of SNAP "Conditions and Restrictions" typically involves usage details relating to safety or environmental information. For full text content, see Section 612 at www.epa.gov/ozone/title6/snap</p> <p>** NOTE: Although SNAP places minimal Conditions or Restrictions on the aerosol use of HFC225ca/cb, it is a regulated substance in the CAA as a Class II Ozone Depleting Substance (ODS) and is mandated for phase-out by 2015.</p> | | |

Within the past 12 months, SNAP has approved two new substitutes for use in aerosol applications: HFC365mfc and HFC-245fa.

The HFC-365mfc is of significance because it is commercially available, low in cost by contemporary standards, has an excellent toxicity profile and has minimal regulatory restrictions specific to aerosol applications. The SNAP approval of HFC-365mfc has opened up new opportunities for formulators intent on blending aerosol defluxers and cleaners.

Although the SNAP approval of HFC-245fa shows promise for aerosol applications, it is not expected to be commercially available until late 2003 or early 2004. As such it has not been included in this review.

FORMULATING GOALS

For busy manufacturing engineers, evaluating and approving aerosol defluxers and cleaners for use in production is a time consuming and expensive undertaking. A practical approach to solvent alternative selection should limit consideration only to commercially available materials that have long-term market viability. Materials subject to existing or pending federal regulatory action that could put long-term availability in jeopardy and should be avoided.

Considering cost, cleaning performance, safety and workplace acceptance, HCFC-141b is the existing standard by which aerosol defluxers are measured.* New aerosol defluxing formulas should offer as many of following physical characteristics as possible:

- [Not flammable](#)
- [Clean oils, grease, rosin fluxes and general contaminants](#)
- Not [hygroscopic](#)
- [Fast evaporation](#) without residues
- Safe on [most materials of construction](#)

- Blends well with other solvents
- Acceptable [toxicity ratings](#)
- [Low odor](#)
- [Compatible with vapor degreasers](#)

Any new formula must also have an Ozone Depletion Potential (ODP) of zero and be within acceptable limits regarding Global Warming and VOC regulations.

OTHER CONSIDERATIONS

New aerosol solvent formulas replacing HCFC-141b must (at a minimum) meet the following prerequisites:

- [Shipping Classification](#): In a non-aerosol package, the formula must ship worldwide as a non-hazardous, non-regulated material.* As an aerosol the formula must be able to ship worldwide as a "Nonflammable Aerosol."
- Worker Safety: [Low solvent toxicity](#), [low flammability](#) and simplified regulatory compliance (i.e. OSHA, NFPA, VOC content, etc.) are prime formulation considerations.
- Physical Aspects: [Low odor](#), [fast drying time](#), and ease of use (i.e., no rinse required) are physical characteristics that assure user acceptance.
- [Affordability](#): Most new solvent blends typically show an increase in cost when compared to HCFC-141b. A number of aerosol companies have developed [attachments for their containers](#) that allow users to dispense solvent through a brush attachment that enhances cleaning by combining the solvency of the cleaner with the action of the brush. In many applications that combination will significantly reduce solvent usage and costs.

THE NEW FORMULAS

Working in compliance with the previously mentioned considerations, several new formulations have emerged that rival HCFC-141b performance. They are: Vertrel® C, Vertrel® CT and Vertrel® CHD from DuPont, and HFE-71D90 from 3M. Details regarding formula ingredients for each product are listed below:

| Ingredients | HFC-365mfc | HFC-43-10 | HFE-7100 | Trans-1,2-dichloroethylene |
|-------------|------------|-----------|----------|----------------------------|
| Vertrel® C | Yes | Yes | No | No |
| | | | | |

| | | | | |
|--------------|-----|-----|-----|-----|
| Vertrel® CT | Yes | Yes | No | Yes |
| HFE-7100 | No | No | Yes | Yes |
| Vertrel® CHD | No | Yes | No | Yes |

AEROSOL CRITERIA: HCFC-141b IS THE BENCHMARK

The above four new formulas represent state-of-the-art advances in aerosol blends that are SNAP-approved, have performance profiles very similar to HCFC-141b, and are reasonably low in cost. Individual profiles are listed below, with HCFC-141b included as reference.

| Ingredients | HCFC-141b | Vertrel® C | Vertrel® CT | HFE-7100 | Vertrel® CHD |
|-----------------------------|-----------|------------|-------------|------------|--------------|
| Percent Volatile | 100% | 100% | 100% | 100% | 100% |
| Boiling Point | 30°C | 44°C | 36.8°C | 42.6° C | 41°C |
| Surface Tension (Dyne/Cm) | 19.3 | 15 | 18.8 | 21.1 | 19.4 |
| Water Solubility | Slight | Slight | Slight | Slight | Slight |
| k _b Factor | 56 | 14 | 21 | n/a | 110 |
| Vapor Pressure (mm/Hg) | 569 | 366 | 496 | 405 | 201 |
| Density | 1.24 | 1-41 | 1.33 | 1.26 | 1.26 |
| Vapor Degreasing Compatible | Yes | Yes | Yes | No | No |

Although each of these new formulas would be considered fast drying, note that the boiling points of the new formulas range between 19% and 32% higher (and vapor pressures similarly lower) than those of HCFC-141b. In most aerosol defluxing and cleaning applications this is a physical advantage. A common complaint of aerosol HCFC-141 b users is that [it can dry too fast](#), resulting in excess solvent usage. A cleaner that dries marginally slower than HCFC-141b will remain on the cleaning site longer and do more cleaning. The net result is less solvent is used to perform individual cleaning task, keeping costs down.

Other physical similarities such as surface tension, k_b , water solubility, density, and even vapor degreaser compatibility demonstrate that these advanced formulas have much in common with HCFC-141b.

These quantified characteristics suggest that most users would find these new formulas as good, if not better, than HCFC-141b in aerosol [defluxing](#) and cleaning applications.

FLAMMABILITY CHARACTERISTICS

When [flammability characteristics](#) are compared, all four formulas are equal to or better than HCFC-141b. In fact, in non-aerosol packaging all of these formulas are officially classified for transportation purposes as "Non-Hazardous-Non-Regulated." None require special placarding or labeling.

In aerosol packaging, all are subject to various transportation regulations, depending on the mode of transport, because aerosols are pressurized canisters.

| Products | HCFC-141b | Vertrel® C | Vertrel® CT | HFE-7100 | Vertrel® CHD |
|--------------------------|-----------|------------|-------------|----------|--------------|
| Flash Point (Closed Cup) | None | None | None | None | None |
| Flame Extension | 2-4" | 0" | 0" | n/a | 0" |
| LEL | 7.6 | 5.5 | 6.5 | n/a | 4.3 |
| UEL | 17.7 | 9 | 11 | n/a | 13.5 |

ENVIRONMENTAL PROPERTIES

One big advantage of these new formulas is that they all enjoy relatively sound environmental profiles. All use ingredients that are US EPA SNAP-approved, none

deplete the ozone and all have atmospheric lifetimes that fall within acceptable contemporary standards. In some localities, ([Southern California](#), [Canada](#) and [Europe](#)) VOC regulations may present a challenge to some of these options, but at least one formula provides an avenue for complete VOC compliance.

| Products | HCFC-141b | Vertrel® C | Vertrel® CT | HFE-7100 | Vertrel® CHD |
|--|-----------|------------|-------------|----------|--------------|
| ODP | 0.1 | Zero | Zero | Zero | Zero |
| VOC | Exempt | Exempt | | | 10% Exempt |
| SNAP-Approved | Yes | Yes | Yes | Yes | Yes |
| Atmospheric life (years) | 9.3 | | | 4.1 | |

CLEANING PROPERTIES

Cleaning and solvent properties of these new formulations allow considerable flexibility in targeting specific aerosol defluxing and cleaning applications. The chart below gives a brief overview of which formulas are recommended in general defluxing, cleaning and miscellaneous industrial aerosol applications:

| Products | HCFC-141b | Vertrel® C | Vertrel® CT | HFE-7100 | Vertrel® CHD |
|----------------------------------|-----------|------------|-------------|----------|--------------|
| Defluxing | Yes | n/r | Yes | Yes | Yes |
| Contact Cleaning | Yes* | Yes* | Yes* | Yes* | Yes* |
| Carrying Agent | Yes* | Yes* | Yes* | Yes* | Yes* |
| Degreasing | Yes | n/r | Yes | Yes | Yes |

* NOTE: Denotes a formula that can be used in *some* general to heavy duty contact cleaning and carrying agent applications, but the aggressive nature of these formulas may preclude universal use as a precision Contact Cleaner or a Carrying Agent due to

materials compatibility issues.

CONCLUSION

These new formulas represent a sense of performance and environmental security to manufacturing engineers tasked with specifying aerosol defluxers and cleaners to replace HCFC-141b. None are a "temporary fix" with environmental or safety regulations pending that put their existence in jeopardy. In fact, all are long-term solutions with full, unreserved regulatory approvals that are the foundation from which long term manufacturing and maintenance procedures can be established. In addition, some of these formulas are suitable for vapor degreasing applications, which can assist in reducing manufacturing variables.

For many engineers who have worked first to find alternatives to CFC based defluxers, and now HCFC141 b based defluxers, these new formulas may represent the most significant advances of all.

REFERENCES

1. The United States Clean Air Act, Sections 612 and 610, www.epa.gov/ozone/title6/snap
2. "Cost Effective Replacements for HCFC-141b", Southern Aerosol Technical Association Fall 2001 Meeting, Joe Koch, 3M Specialty Materials.
3. "Hydrofluoroethers in Aerosol Formulations", Southern Aerosol Technical Association, September 1998, Ann Anich, 3M
4. Special thanks to Dr. Melodic Schweitzer, Abid Merchant and Dan Diguglieimo at the DuPont Fluorochemical Products Lab, Wilmington, DE

Related Information:

- For additional information about the ozone-safe DuPont HFC solvents, check out the [Vertrel® solvents web site](#).
- For other information about the Bromothane™ brand of nPB solvents, check out the [Bromothane™ web site](#).
- For additional help, use the [Solvent Selection Guide](#) in this Site to help determine the optimal recommendation.
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