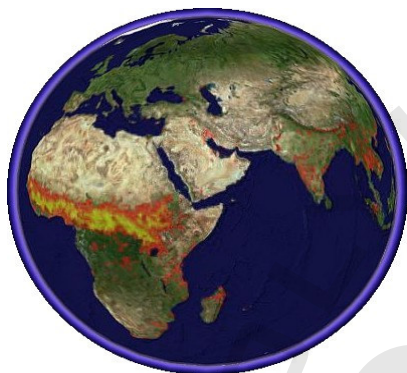
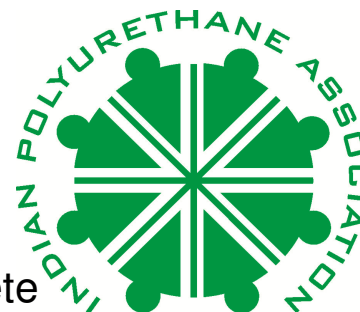


Alternative Blowing Agent Options for HCFC 141b

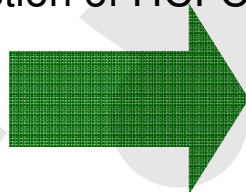
Foam Sector

Environmental Regulations: HCFC Phase Out

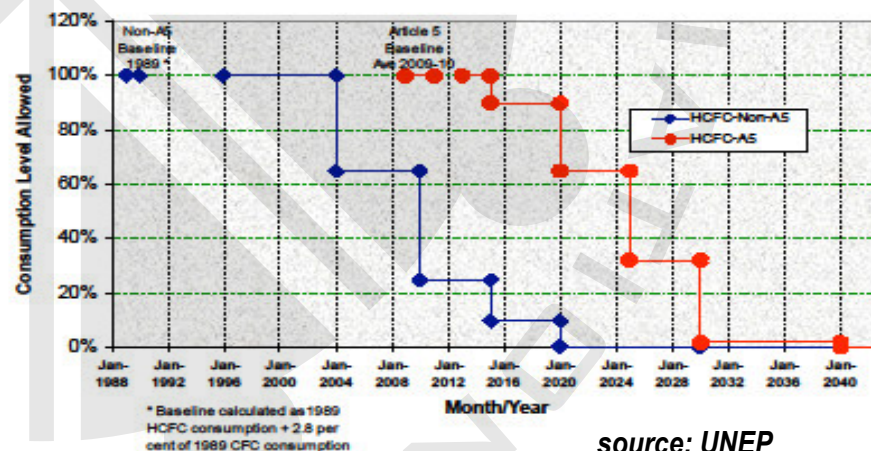


- The Montreal Protocol on Substances that Deplete the Ozone Layer stands as one of the most successful examples of international cooperation to tackle a major global environmental threat
- Developed and developing Countries have agreed a phase out program for ODS, including HCFC
- **141b** is a HCFC used as blowing agent in polymeric foams including polyurethane

- In Europe HCFCs are banned since 2004
- In North America EPA has forced HCFC-141b phase out in 2003
- In 2007 Parties have decided to accelerate the phase-out of consumption and production of HCFC

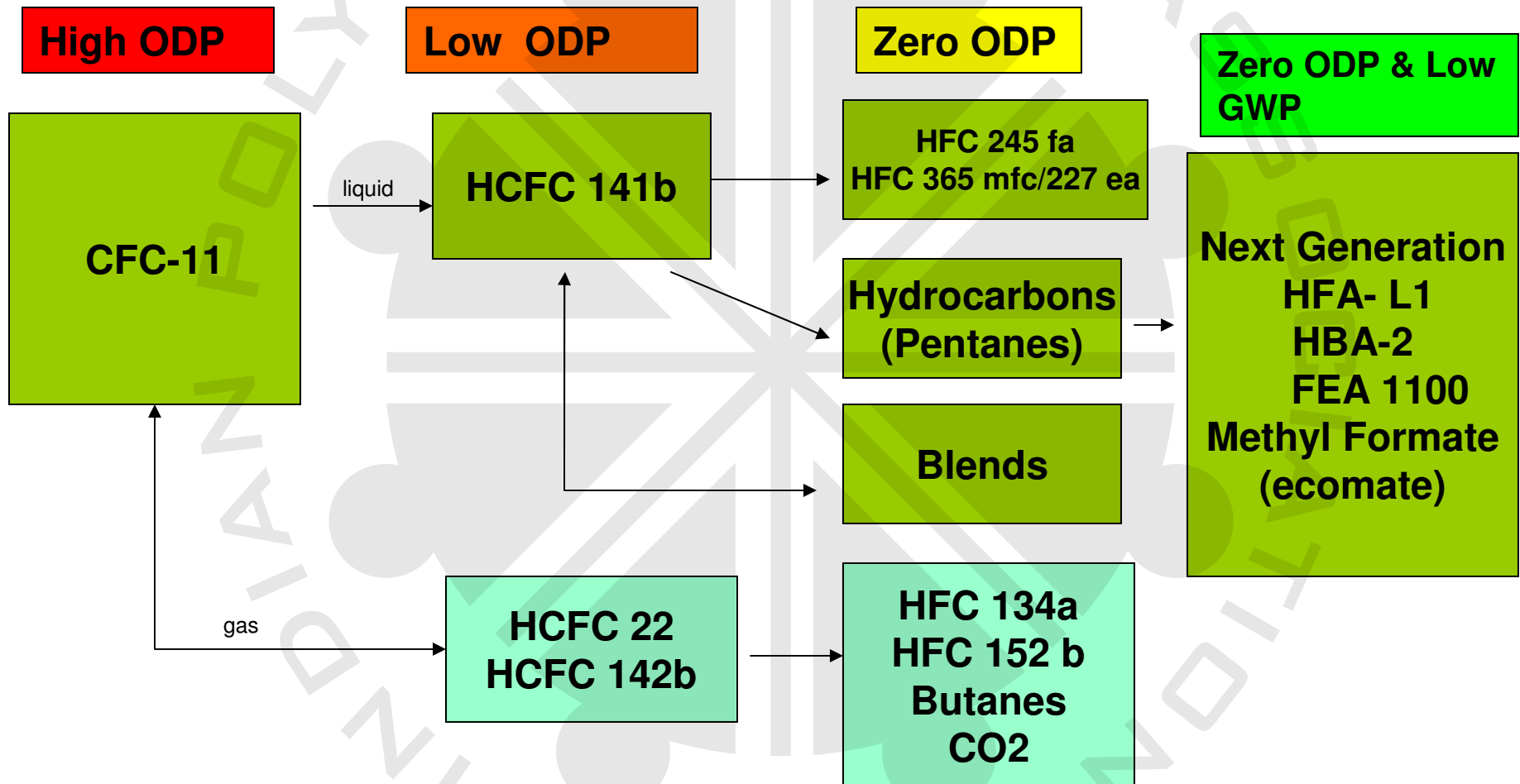


HCFCs (Annex C/I) Consumption Reduction Schedule



source: UNEP

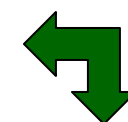
Blowing Agent Evolution



Blowing Agent Properties Comparison



| Compound | MW | Physical State | Boiling Point (°C) | Lambda 25°C (mW/mK) | Flash Point (°C) | LFL/UFL* | ODP | GWP |
|-------------------|-----|----------------|--------------------|---------------------|------------------|----------|------------|----------|
| HCFC-141b | 117 | liquid | 33 | 10 | None | 7.4/15.5 | 0.11 | 630 |
| HFC-134a | 102 | gas | -27 | | None | None | 0 | 1300 |
| HFC-245fa | 134 | liquid | 15 | 13 | None | None | 0 | 820 |
| HFC-365mfc | 148 | liquid | 40 | 12 | - 24 | 3.4/13 | 0 | 840 |
| n-Pentane | 72 | liquid | 36 | 15 | - 49 | 1.5 | 0 | 11 |
| Iso-Pentane | 72 | liquid | 28 | 14 | - 51 | 1.4 | 0 | 11 |
| Cyclo-Pentane | 70 | liquid | 49 | 13 | - 7 | 1.5 | 0 | 11 |
| Carbondioxide | 44 | gas | - 78 | 16.3 | None | None | 0 | 1.0 |
| Methylal | 76 | liquid | 42.3 | | - 18 | 2.2/19.9 | 0 | Very low |
| Methyl Formate | 60 | liquid | 31.5 | 10.7 | - 19 | 5/20 | 0 | Very low |
| FEA-1100(Du Pont) | na | liquid | 33 | 10.7 | None | na | 0 | Very low |
| HBA-2 (Honeywell) | na | liquid | na | na | None | na | Negligible | Very low |
| AFA-L1 (Arkema) | na | liquid | na | 10 | None | None | Negligible | Very low |



Present options

Potential future options



June 2010

Blowing Agent Technologies For Rigid PU Foam

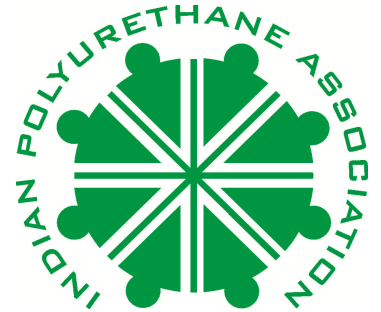


Two different class of blowing agents available today to replace HCFC-141b

- **Zero ODP substances** (HFC-134a; HFC-365/227; HFC-245fa)
- **Zero ODP and Low GWP substances** (water, formic acid, HCs, methylal, methyl formate)

| <i>Processing Cautions</i> | | Zero ODP | | | Zero ODP Low GWP | | | | |
|---|-----------|--------------------|--------------------|-----------|------------------|-------------|------|----------|----------------|
| <i>Blowing Agent Flash Point</i> | | NO | NO | NO | NO | NO | YES | YES | YES |
| <i>Potential Metal Corrosion</i> | | NO | NO | NO | NO | YES | NO | NO | YES |
| <i>Important Foam Properties</i> | HCFC 141b | HFC-134a low level | HFC-134a - 365/227 | HFC-245fa | Water | Formic Acid | HC | Methylal | Methyl Formate |
| <i>Applied Density</i> | REF | -- | - | + | --- | -- | =/+ | --- | --- |
| <i>Compressive Strenght</i> | REF | + | =/+ | + | ++ | ++ | =/- | ++ | ++ |
| <i>Foam K-factor</i> | REF | --- | -- | =/ + | ---- | ---- | - | ---- | ---- |
| <i>Skin Hardness (Wood Imitation)</i> | REF | -- | + | - | --- | n.a. | n.a. | n.a. | n.a. |
| <i>Demolding Time</i> | REF | -- | - | - | --- | --- | + | --- | --- |
| <i>Max Operating Temperature (Pipe)</i> | REF | n.a. | n.a. | = | ++ | n.a. | = | n.a. | n.a. |
| <i>Aesthetics</i> | REF | + | = | + | = | ++ | n.a. | n.a. | n.a. |
| <i>Change/Additional process equipment requirements</i> | REF | Likely | Yes | Likely | No | Yes | Yes | Likely | Likely |

An Important Note:



The general properties reported in the previous slide can be considered as a guideline for selecting the right blowing agent. However, each application is unique and the knowledge on the physical properties will help to decide the right choice.

For example, for those applications driven by thermal insulation, fully water blown solution will not be the most effective one

Semirigid Integral Skin



Applications:

- steering wheel
- furniture (armrest, headrest, seat)

Key requirements:

- Skin formation
- Aesthetics
- Good Abrasion resistance

Blowing agent options:

Zero ODP : HFC 134a and HFC 245 fa/365 mfc-227

Zero ODP/Low GWP

Present : Water, Hydrocarbon

Future : Methyl Formate ,FEA 1100,HBA2 and AFA –L1



Domestic Appliance



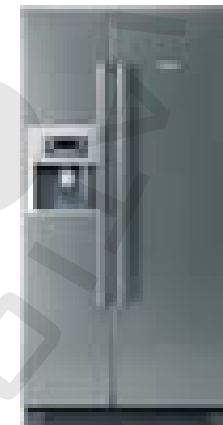
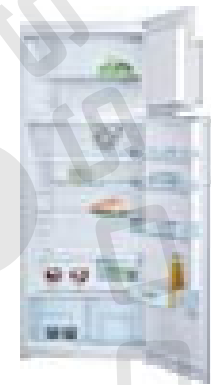
- **Key requirements:**
 - Foam insulation properties (K-factor)
 - Fast productivity

- **Blowing Agent Options :**

Zero ODP :HFC 245 fa

Zero ODP /Low GWP:
Present :Cyclo Pentane

Future : FEA 1100,HBA2 and AFA –L1



Commercial Appliance



- Application:
 - supermarket counters
 - horizontal freezer
 - Visi-coolers
 - food service equipment
- Blowing agent options:
 - Zero ODP
 - HFC 134a low level, HFC 245 f and HFC 134a/HFC 365 mfc/227ea
 - Zero ODP/Low GWP :
 - Present : Water, formic acid , Hydrocarbon, Methyl formate
 - Future : FEA 1100, HBA2 and AFA –L1



Source: Hiltmann 2008

Supermarket



visi-coolers



Food service

Thermoware:(Picnic coolers & Jars)



Key requirement:

- Fast productivity
- Low cost

Blowing Agent Options

Zero ODP

HFC-134 low level, HFC-134a/FA, HFC-245fa and HFC 134a/365/227

Zero ODP/Low GWP

Present : Water, Hydrocarbon

Future : Methyl Formate, FEA 1100, HBA2 and AFA -L1





Discontinuous Panel

- **Application**
 - Cold store
 - Building Panel
 - Telecom Shelter
- **Key requirements**
 - Low k-value
 - Faster Productivity
 - FR

Blowing Agent options:

Zero ODP- HCFC 134 a, HCFC 134a/FA, HCFC 134a/HFC 365
mfc/227 ea

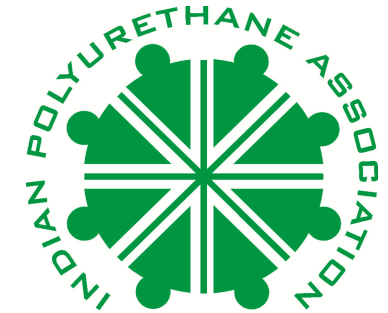
Zero ODP- Low GWP

Present – Water , Water/FA , HC, Methyl Formate

Future - FEA 1100, HBA2 and AFA –L1



Continuous Panel



Application

- Building panel
- Cold room
- Telecom Shelter

Key requirements:

- Faster Production
- FR

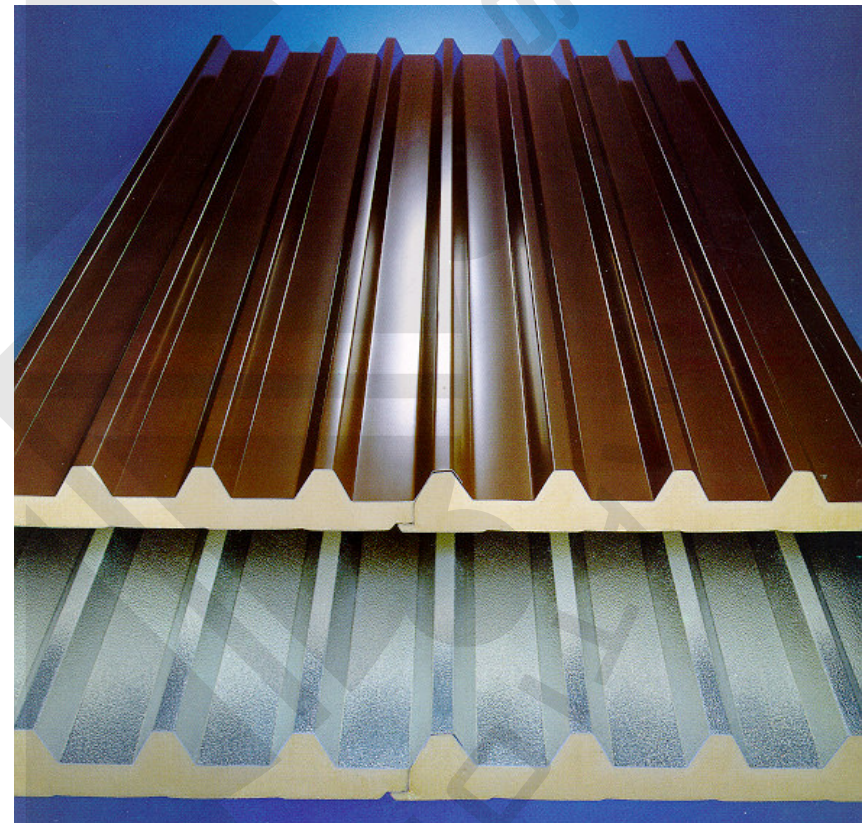
Blowing Agent options :

Zero ODP- HFC 134a ,HFC 134a/HFC 365
mfc/227 ea,HFC 245 fa

Zero ODP/Low GWP-

Present : Water, n-pentane,c-pentane

Future :FEA 1100,HBA2 and AFA –L1



Water Heaters



Key requirements:

- Faster production
- Low Energy Consumption

Blowing Agent options :

Zero ODP- 134 a , HFC 134 fa/ HFC365-227 ea,HFC 245 fa

Zero ODP/Low GWP

- Present – water, Hydrocarbon
- Future - Methyl Formate,FEA 1100,HBA2 and AFA –L1



Pipe Insulation



Key requirements:

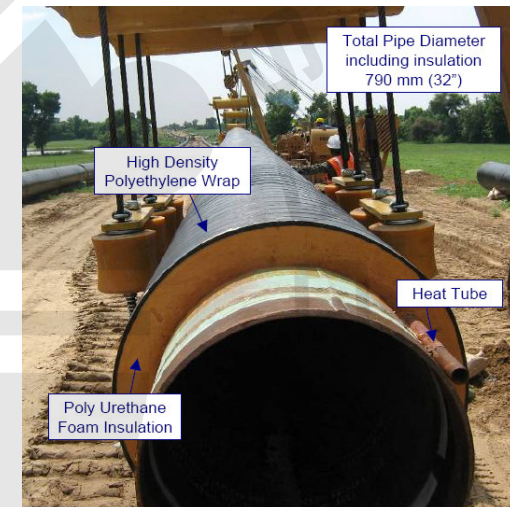
- Good mechanical properties
- Max operating temperature
- Thermal insulation

Blowing Agent Options :

Zero ODP – HFC 245 fa

Zero ODP/ LOW GWP

- Present** – Hydrocarbon , water blown
- **Future** - FEA 1100,HBA2 and AFA –L1



General Insulation-Spray



Applications include

- Walls, crawl spaces, enclosed attics, roof decks

Key requirements

- Good Foam mechanical properties
- Good Foam insulation properties
- Low Moisture vapor resistance
- Low Flame spread
- Low Smoke generation

Blowing agent options :

Zero ODP – HCF 134 a, HCF 134 a/HFC 365 mfc & 245 Fa

Zero ODP/Low GWP

Present - Water

Future - FEA 1100, HBA2 and AFA –L1



Potential Future Options: Hydrofluoroolefins (HFO's)



Few blowing agent suppliers are putting efforts in developing new zero ODP and low GWP molecules for foam application alternative to HFCs. Three molecules close to commercialization.

Arkema

AFA-L1

Honeywell

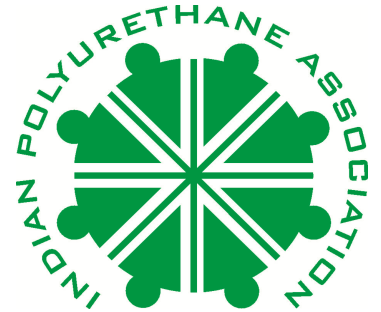
HBA-2

Du Pont

FEA-1100

- Developmental molecules
- Toxicity tests still ongoing
- Liquid, zero ODP & very low GWP blowing agents
- Non flammable
- Good solubility in polyol blends
- Thermal conductivity in line to HCFC141b and HFC 245fa
- K-value maintain with aging

Summary



- ✓ There are two class of blowing agent choice (Zero ODP & Zero ODP-Low GDP)
- ✓ The choice of blowing agent depends on the application and the physical property needs.
- ✓ It is advisable consult raw material suppliers for the right option



Disclaimer :

The information shared by Indian Polyurethane Association (IPUA) is generic in nature and has been compiled from public information or inputs that were made available by the members and/or manufacturers of raw materials/equipments. Please validate the information with your machine and chemical supplier before moving into the action phase.

Source of Information :

- Websites of Raw material and Machine Manufacturers
- Public Literature shared with IPUA by manufactures, machine suppliers and industry experts.



Thank you