Interreg Sudoe KET4F-Gas

www.KET4F-Gas.eu

EnviEstudos, S.A.

Reduction of the Environmental Impact of Fluorinated Gases in the Sudoe Space using Key Enabling Technologies

KET4F-Gas

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Research and Innovation

Cooperation depends on you

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What should be done with F-gases?

REDUCE

REUSE

RECYCLE

RECLAIM

KET4F-Gas tools and solutions

1. Tool for the selection of Key Enabling Technologies

- Learning
- Decision-making
- Saving time
- Trust

2. KET4F-gas technologies

- 2 prototypes
- Separation of R-410A
- Efficient recovery of R-32

1. Tool for the selection of Key Enabling Technologies

- Allows the **classification of waste** according to the European method (EWL – European Waste List)
- Allows a better understanding of the **impact of fluorinated gases**
- Informs about the **best solutions available for F-gases treatment** using Key Enabling Technologies (KETs).

http://www.ket4f-gas.eu/?page_id=1537

Classification of waste

- Chapters from 01 to 20
- Each chapter gathers different types of waste related to a **specific area of waste-generating activity**, namely industrial, urban, agricultural and hospital, or simply related to production processes.

Residue Classification

00 Waste Classification

Select a waste source

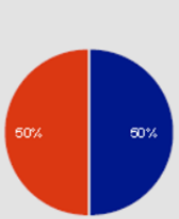
- 01 - Wastes resulting from exploration, mining, quarrying, physical and chemical treatment of minerals
- 02 - Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing
- 03 - Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard
- 04 - Wastes from the leather, fur and textile industries
- 05 - Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal
- 06 - Wastes from inorganic chemical processes
- 07 - Wastes from organic chemical processes
- 08 - Wastes from the manufacture, formulation, supply and use (MFSU) of coatings (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks
- 09 - Wastes from the photographic industry
- 10 - Wastes from thermal processes
- 11 - Wastes from chemical surface treatment and coating of metals and other materials; non-ferrous hydro-metallurgy
- 12 - Wastes from shaping and physical and mechanical surface treatment of metals and plastics
- 17 - Construction and demolition wastes (including excavated soil from contaminated sites)
- 18 - Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)
- 19 - Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use
- 20 - Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions
- N - None of the above

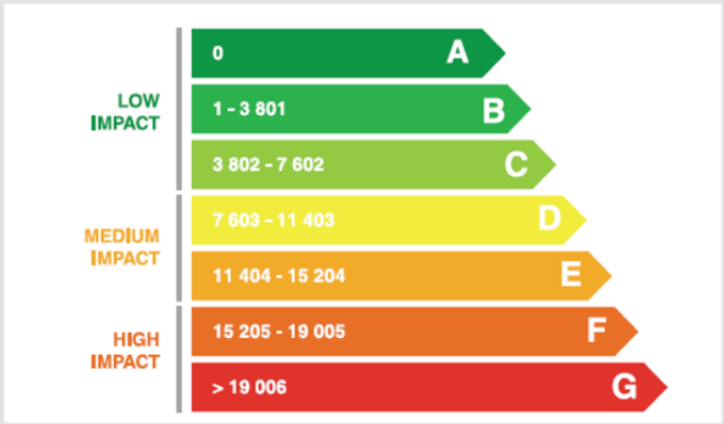
Selection of treatment technologies

- Identify the F-gas (chemical/commercial name) you want to know more about.

- Information:
  - Chemical composition/gases mixture
  - Global Warming Impact
  - Impact level
  - Treatment technologies
  - Mixtures of fluorinated gases where it can be found

Fluorinated Gas	R-410A
Chemical composition / Gases mixture	R-125 (50%); R-32 (50%);
Global Warming Impact (GWP)	2087,500
Impact level	The selected gas is at the point B of the impact scale





Selection of technologies treatment

Treatment technologies	Advanced Materials Advanced Materials - Alternative Solvents; Advanced Materials - Solid Porous Matrices; Advanced Materials - MOFs; Advanced Manufacturing Technologies Advanced Manufacturing Technologies - Membranes; Nanotechnology Nanotechnology - Nanoparticles Suspension;

The KEF-Gas platform is **simple**, **accessible to everyone and free of charge.**

The benefits from the platform include:

- **Learning**
- **Helps on decision-making**
- **Saving time**
- **Trust**

2. KET4F-Gas prototypes

Two prototypes based on two different advanced **separation processes:**

- ✓ **Adsorption column**
- ✓ **Membrane technology**

R-410A (near-azeotropic system of **pure F-gases R-32 and R-125)** is one of the most used refrigerants in residential and commercial air conditioners

Efficient recovery of R-32 from the high-GWP refrigerant blend R-410A, for reutilization purposes in novel environmentally-friendly refrigerant mixtures with low-GWP.

2. KET4F-Gas prototypes

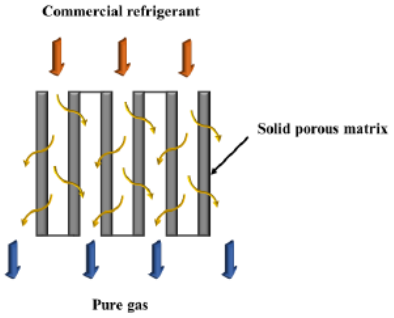
Main characteristics:

- ✓ Low energy requirements
- ✓ Easy to apply due to small amount of space required, to their modularity and scalability
- ✓ Low maintenance
- ✓ Long lifetime
- ✓ **High separation performance and high R-32 purity** (>99%) when both prototypes are **used in series**

2. Technology example: Advanced Materials - Solid Porous Matrices

Interreg Sudoe KET4F-Gas	**Advanced Materials**

Technology	**Solid Porous Matrices**
How it works	Solid porous matrices, such as activated carbons and zeolites, have large pore volume, allowing to capture and store large amounts of gases. Several adsorbents have specificity to one gas, allowing the separation of gas mixtures in its components.
Applied to	R-410A (50% R-32 + 50% R-125)
Advantages	Solid porous matrices have large volume pore and superficial area. Moreover, they have low cost and are available in a wide range of specifications, allowing the adsorption of different gases.



Applications

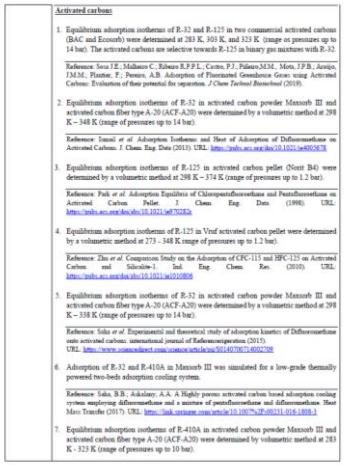
Zeolites

1. Equilibrium adsorption isotherms of R-125 in zeolite 13X and in a pore-size modified zeolite 5A were determined by a volumetric method at 293 K, 313 K, and 333 K (range of pressures up to 10 bar).

   Reference: Liu *et al.* Adsorption Separation of R134a, R125, and R143a Fluorocarbon Mixtures Using 13X and Surface Modified 5A Zeolites. ALChE (2017).
   URL: https://aiche.onlinelibrary.wiley.com/doi/full/10.1002/aic.15955

2. Equilibrium adsorption isotherms of R-32 and R-125 in zeolite 4A were determined at 293 K, 323 K and 353 K (range of pressures up to 3 bar). Zeolite 4A can be used to separated binary gas mixtures of R-32 and R-125 into their pure components.

   Reference: Liu *et al.* Adsorption Separation of R-22, R-32and R-125 Fluorocarbons using 4A Molecular Sieve Zeolite. Chemistry Select (2016).
   URL: https://onlinelibrary.wiley.com/doi/abs/10.1002/slct.201600689



Activated carbon:

1. Equilibrium adsorption isotherms of R-32 and R-125 in two commercial activated carbons (BAC and Ecosorb) were determined at 283 K, 303 K, and 323 K (range of pressures up to 14 bar). The activated carbons are selective towards R-125 in binary gas mixtures with R-32.

   Reference: Sosa J.E.; Malheiro C.; Ribeiro R.P.P.L.; Castro, P.J.; Pilarro,M.M.; Moro, J.P.B.; Araújo, J.M.M.; Plantier, F.; Pereira, A.B. Adsorption of Fluorinated Greenhouse Gases using Activated Carbons: Evaluation of their potential for separation. *J Chem Technol Biotechnol* (2019).

2. Equilibrium adsorption isotherms of R-32 in activated carbon powder Maxsorb III and activated carbon fiber type A-20 (ACF-A20) were determined by a volumetric method at 298 K – 348 K (range of pressures up to 14 bar).

   Reference: Ismail *et al.* Adsorption Isotherms and Heat of Adsorption of Difluoromethane on Activated Carbons. J. Chem. Eng. Data (2013). URL: https://pubs.acs.org/doi/10.1021/je400567f

3. Equilibrium adsorption isotherms of R-125 in activated carbon pellet (Norit B4) were determined by a volumetric method at 298 K – 374 K (range of pressures up to 1.2 bar).

   Reference: Park *et al.* Adsorption Equilibria of Chloropentafluoroethane and Pentafluoroethane on Activated Carbon Pellet. J. Chem. Eng. Data. (1998). URL: https://pubs.acs.org/doi/abs/10.1021/je970282z

4. Equilibrium adsorption isotherms of R-125 in Vrsf activated carbon pellet were determined by a volumetric method at 273 - 348 K range of pressures up to 1.2 bar).

   Reference: Zhu *et al.* Comparison Study on the Adsorption of CFC-115 and HFC-125 on Activated Carbon and Silicalite-1. Ind. Eng. Chem. Res. (2010). URL: https://pubs.acs.org/doi/abs/10.1021/ie1010806

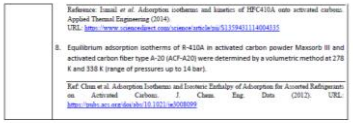
5. Equilibrium adsorption isotherms of R-32 in activated carbon powder Maxsorb III and activated carbon fiber type A-20 (ACF-A20) were determined by a volumetric method at 298 K – 338 K (range of pressures up to 14 bar).

   Reference: Saha *et al.* Experimental and theoretical study of adsorption kinetics of Difluoromethane onto activated carbon. international journal of Refrigeration (2015). URL: https://www.sciencedirect.com/science/article/pii/S0140700715002708

6. Adsorption of R-32 and R-410A in Maxsorb III was simulated for a low-grade thermally powered two-beds adsorption cooling system.

   Reference: Saha, B.B.; Askalany, A.A. A Highly porous activated carbon based adsorption cooling system employing difluoromethane and a mixture of pentafluoroethane and difluoromethane. Heat Mass Transfer (2017). URL: https://link.springer.com/article/10.1007%2Fs00231-016-1808-1

7. Equilibrium adsorption isotherms of R-410A in activated carbon powder Maxsorb III and activated carbon fiber type A-20 (ACF-A20) were determined by volumetric method at 283 K - 323 K (range of pressures up to 10 bar).



Reference: Ismail *et al.* Adsorption isotherms and kinetics of HFC410A onto activated carbons. Applied Thermal Engineering (2014).
URL: https://www.sciencedirect.com/science/article/pii/S1359431114004335

8. Equilibrium adsorption isotherms of R-410A in activated carbon powder Maxsorb III and activated carbon fiber type A-20 (ACF-A20) were determined by a volumetric method at 278 K and 338 K (range of pressures up to 14 bar).

Ref: Claus et al. Adsorption Isotherms and Isosteric Enthalpy of Adsorption for Assorted Refrigerants on Activated Carbons. J. Chem. Eng. Data (2012). URL: https://pubs.acs.org/doi/abs/10.1021/je5008099

For additional information, visit the webpage http://www.ket4f-gas.eu/ or contact mmb@fct.unl.pt, jmmda@fct.unl.pt

Other KET4F-Gas tools

- ✓ **Good practices handbook for industry and waste managers: EN, PT, FR, ES**

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