A study on available technologies to treat asbestos

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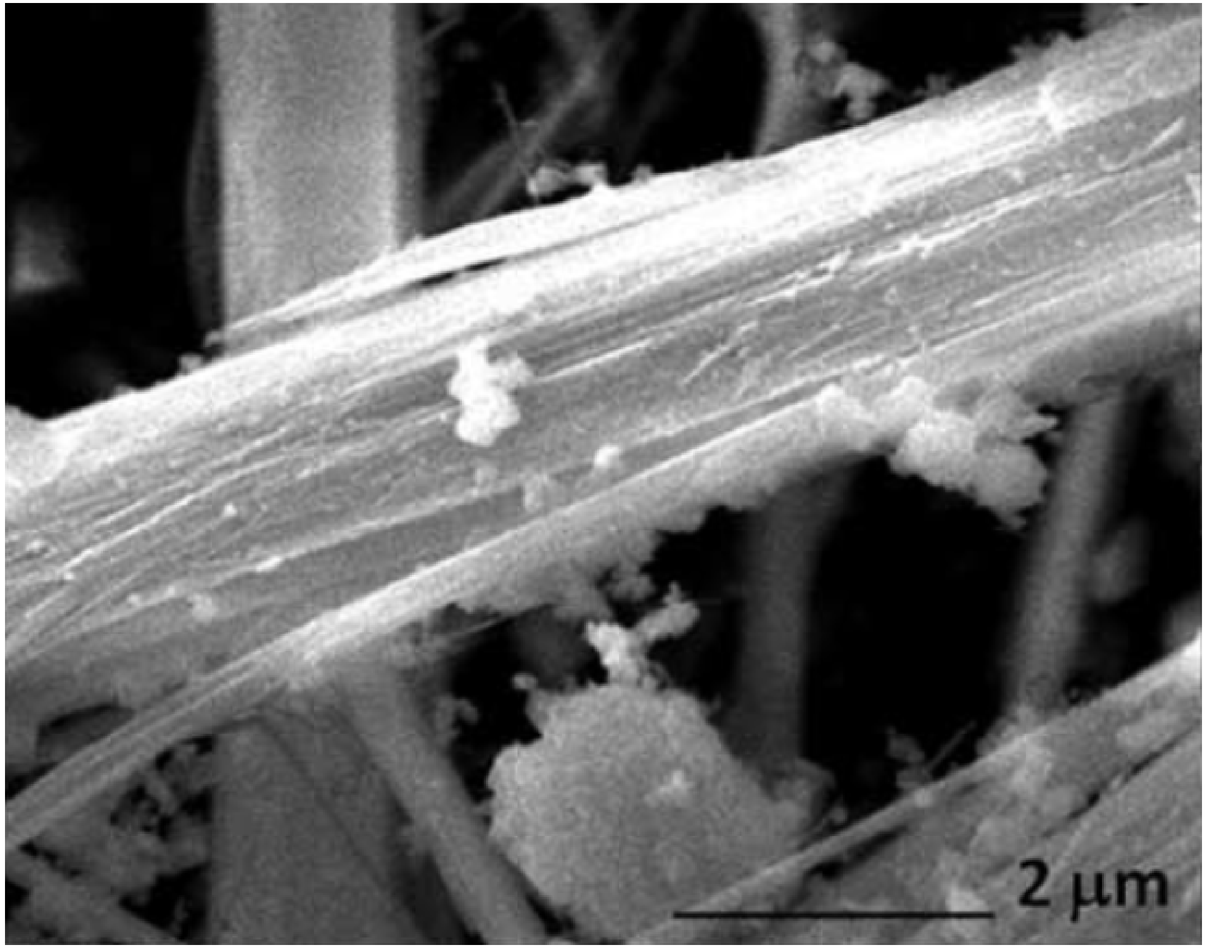
Summary

Asbestos
EU Raccomandations
Inertization
Technical solutions
Conclusions

What is the asbestos?



Giacobbe at al., 2010

ASBESTOS: is a group of minerals composed by a natural mineral fibres

The fibrous-asbestiform crystal habit and chemical-physical surface reactivity, may induce fatal lung diseases.

European Parliament resolution

According to current legislation, ACW (Asbestos Containing Waste) must be removed and properly managed in accordance with safety regulations.

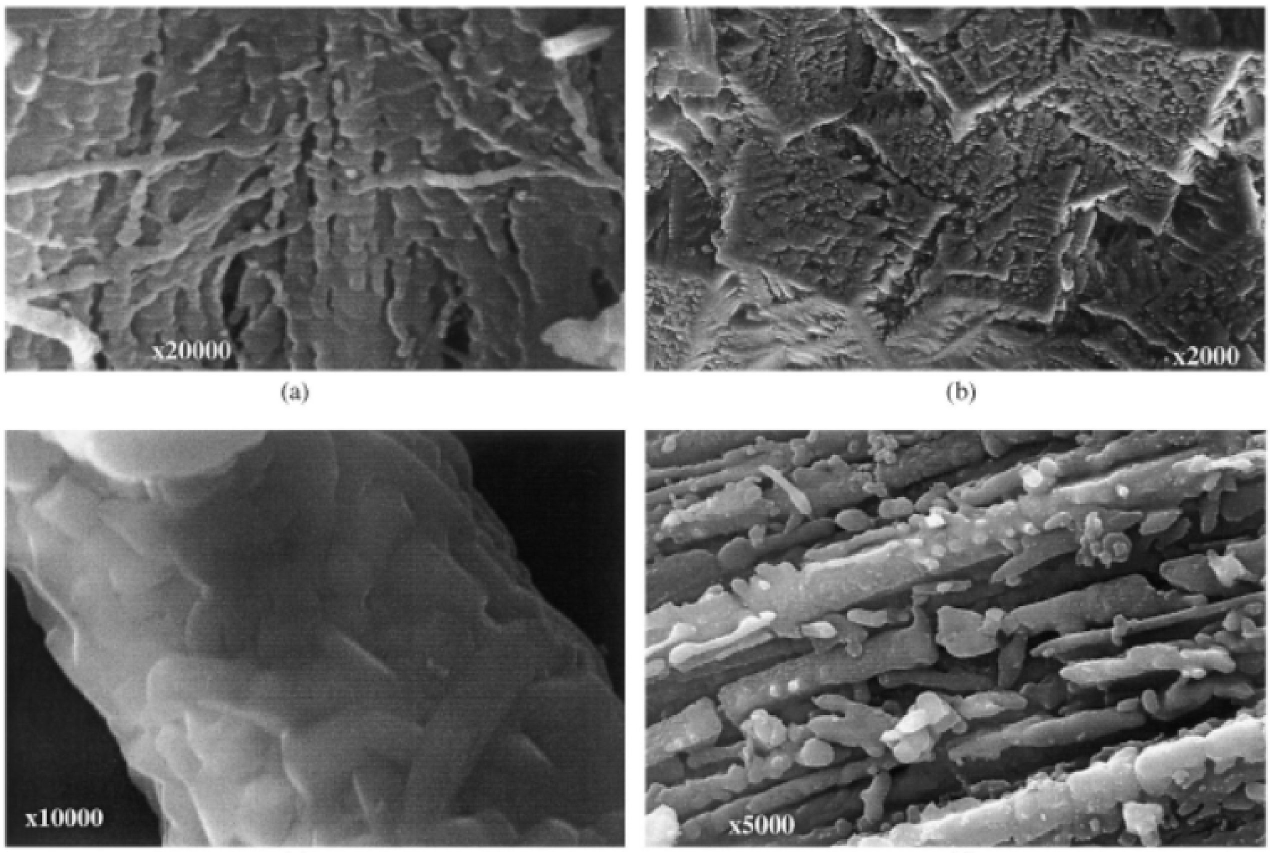
The European Parliament resolution 2012/2065 (INI) of 14 March 2013 ("asbestos related occupational health threats and prospects for abolishing all existing asbestos") states that:

"whereas delivering asbestos waste to **landfills** would **not appear to be the safest way of definitively eliminating the release of asbestos fibres** into the environment (particularly into air and groundwater) and whereas therefore **it would be far preferable to opt for asbestos inertization plants**".

"creating landfills for asbestos waste is only a temporary solution to the problem, which in this way is left to be dealt with by future generations"

What's the solution?

Inertization: The treatments aim to completely modify the crystallochemical structure of asbestos therefore eliminate the danger.



Gualtieri et. Al, 2000

What's the solution?

All the intertization processes can be classified into the following three macro-categories:

Thermal treatment – consist of the modification of the crystal-chemical structure, through the use of heat up to or above 1200 °C

Three stages:

- *loss of adsorbed water,*
- *removal of structural OH groups*
- *crystallization of amorphous materials*

Chemical treatment– consist to use strong basic or acid solutions to convert asbestos into harmless compounds

Mechanochemical treatment – fibres are degraded by mechanical milling

Inertization: Thermal treatment

This category is very articulated and incorporate the **most important industrial experiences**.

The common **critical issues** for all thermal treatments are:

- **the high energy required** to heat a thermally inert material such as asbestos.
- **formation of atmospheric pollutants** during the heating phases (vinyl-asbestos can lead to the formation of persistent organic pollutants such as dioxins and polychlorinated biphenyls)

The **main advantages** connected to thermal treatment are:

- **incorporation of large amounts of heavy metal ions** inside an inorganic amorphous network;
- the **final** process **product is inert**
- flexibility to **treat wastes** of **various type;**
- a **reduced amount of waste** is obtained.
- **consolidated** technology;

Inertization: Thermal treatment

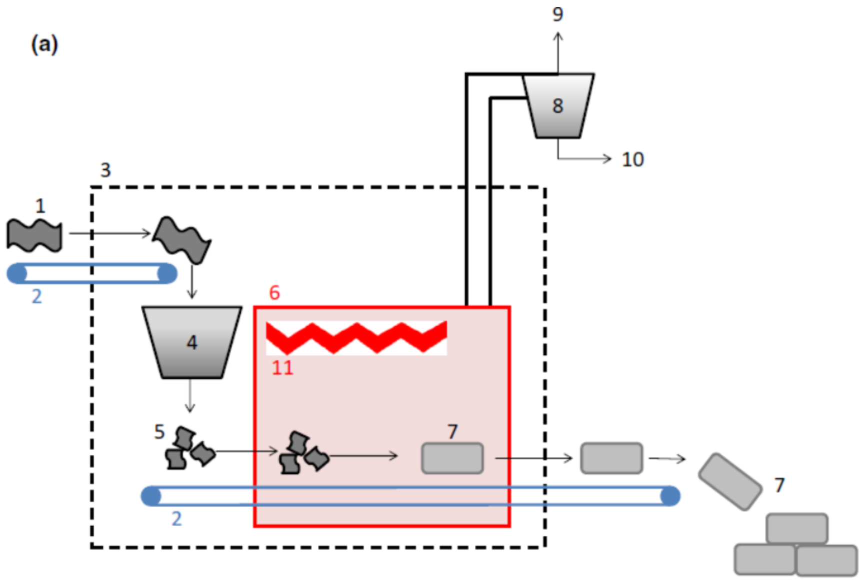
Simple Vitrification - simplest thermal treatment at temperatures generally above 1000 °C to obtain an inert silica material. The resulting is the production of an inert glass material.

Vitrification with controlled recrystallization – the only difference to simple vetrification is that a heating rate control system is applied. Is it possible to obtain products with good mechanical properties which can be used in building or civil works

INERTIAM Process – First operative plant which uses a plasma torch

KRY-AS Process – The cooking cycle uses a "tunnel" continuous industrial gas oven

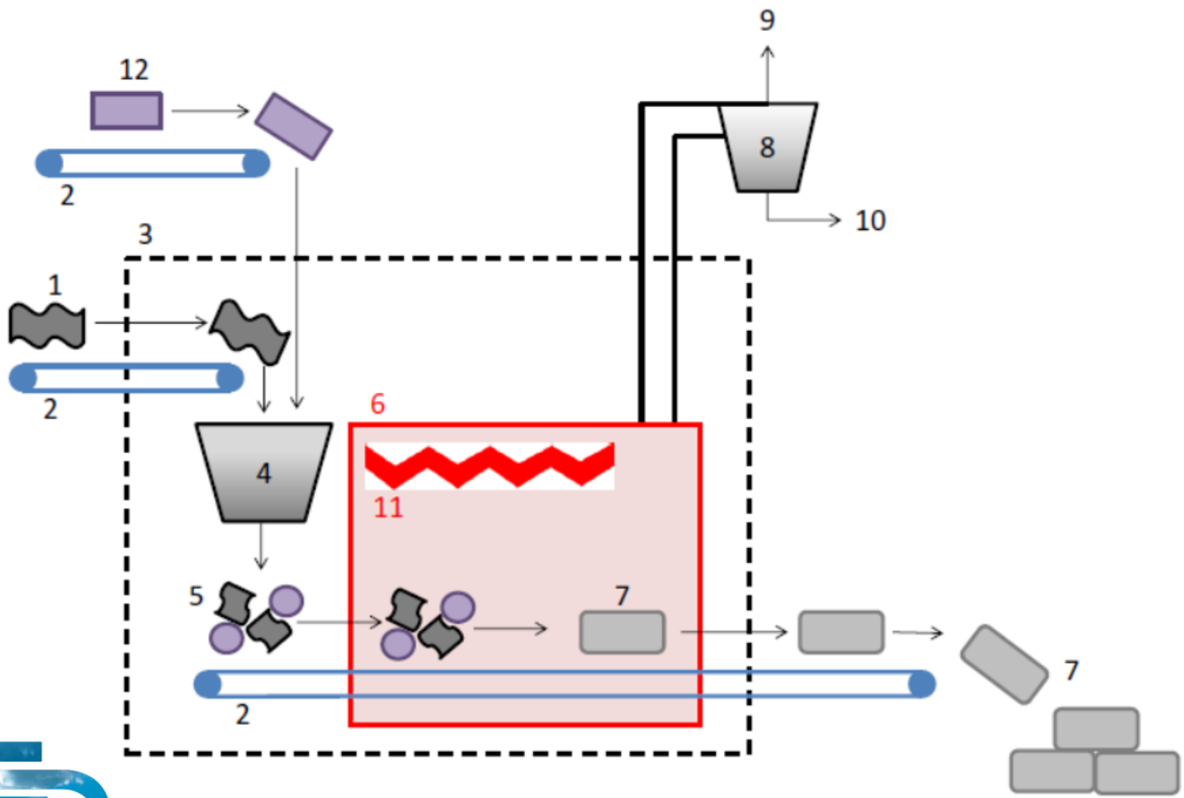
There are real industrial applications



Inertization: Thermal treatment

Thermal treatment with other inorganic materials in addition to the controlled Recrystallization. it is possible to use inorganic materials such as clay

At present technology is at a pilot plant leve



CORDIAM Process–

ACW is weted, mixed with clay, milled and then roasted in the oven.

VETRIFIX Process – The ACW is milled and mixed with glassy granules and glass scraps. After is added a low-melting agent and then inserted in electric oven.

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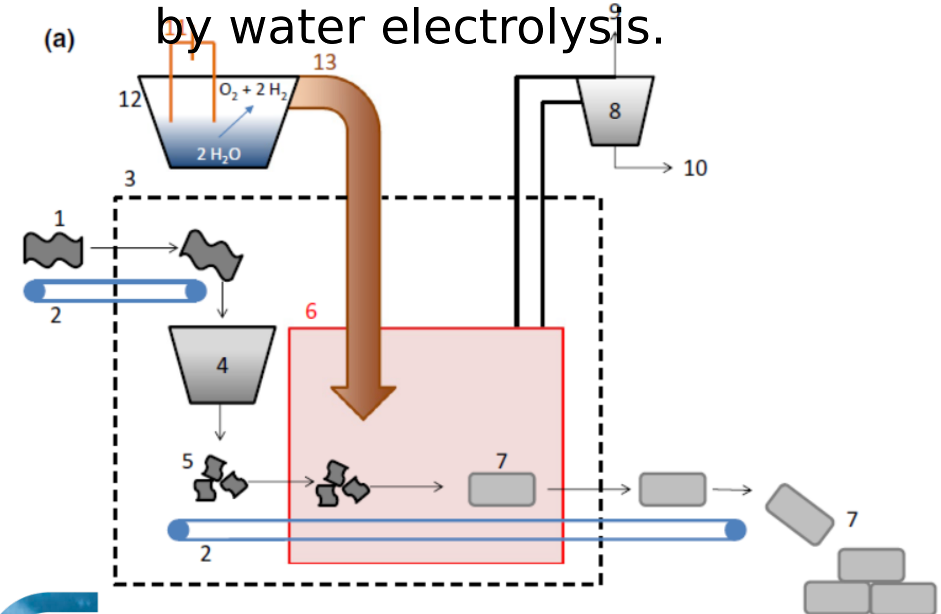
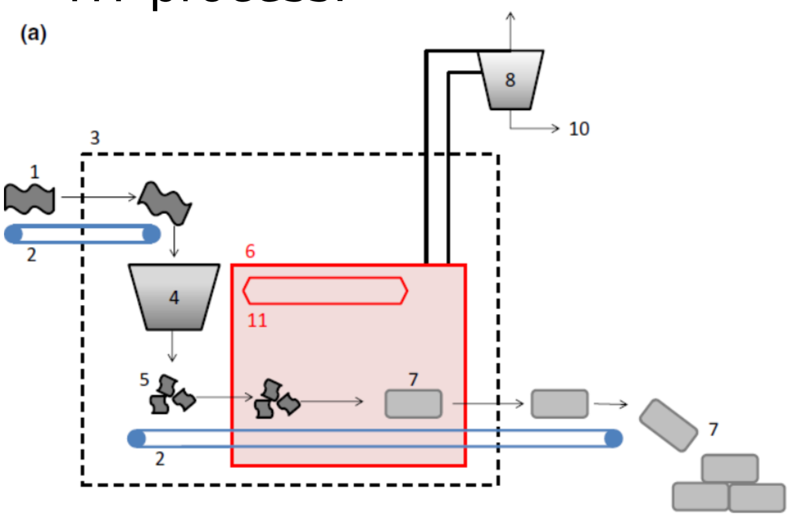
Inertization: Thermal treatment

- **Treatment with Oxyhydrogen** – provides the use of a stoichiometric gas mixture of 1:2 oxygen and hydrogen (oxyhydrogen) produced by water electrolysis.



Microwave air plasma treatment uses microwave as energy.
There is no significant use of this technique on an industrial scale, with the exception of ATON HT process.



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Inertization: Chemical treatment

Chemical treatment consists in treatment of the compounds included in asbestos structure with chemical additives (strong basic or acid) which are added to lower the melting temperature or enhance mineralogical decomposition.

The common **critical issues** for all chemical treatments are:

- the long treatment time
- the need of waste liquid treatment
- the costs associated with the consumption of reagents and the subsequent disposal of wastewater.

The **main advantages** connected to chemical treatment are:

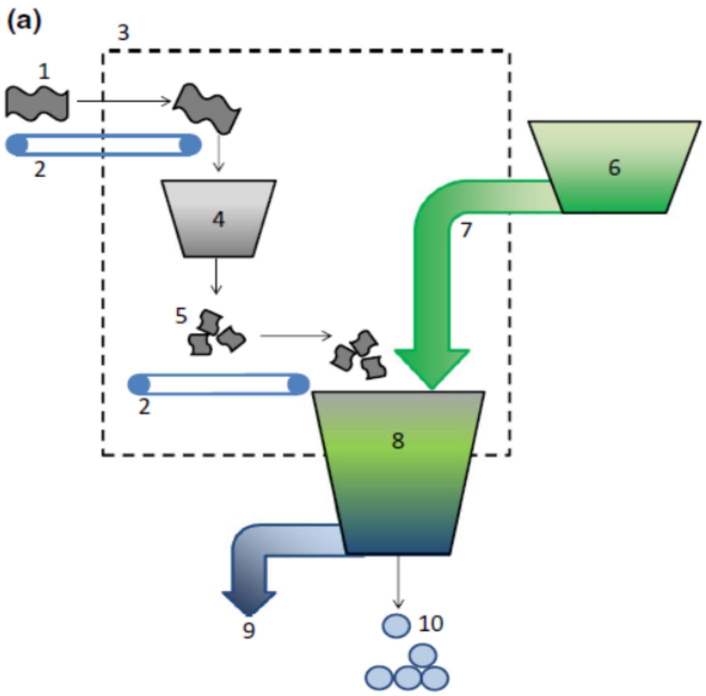
- the reduced energy cost
- room temperature process

Inertization: Chemical treatment

- **Classic chemical treatment**

- Use high pH (alkaline conditions) ,asbestos is converted into magnesium hydroxide and sodium silicate
- Use acid solutions, strong acidic solutions can hydrolyse the Si–O bond, creating free silanol moieties(R3Si–OH).
- Use Hydrofluoric acid to form gaseous silicon fluoride (SiF4)

There aren't real industrial applications



Inertization: Chemical treatment

- **Hydrothermal treatment (supercritical water)**

This treatments eliminates the problem of the handling of corrosive/hazardous reagents because this approach allows to operate at neutral pH.
It uses supercritical water at 250 MPa and 650 °C.

The main issues related to the process are:

- particularly high pressures;
- filtration of the obtained water,
- need (in some specific applications) to add 6% of hydrogen peroxide.

At present, technology is at a prototype level

- **Treatment with reducing agents**

The process requires the addition of a reducing agent such as a metal in its elementary state.
Criticalities of these processes are linked to the onset of reaction.
The advantage of this approach is that oxidation–reduction reactions are preferred and once started they proceed spontaneously.

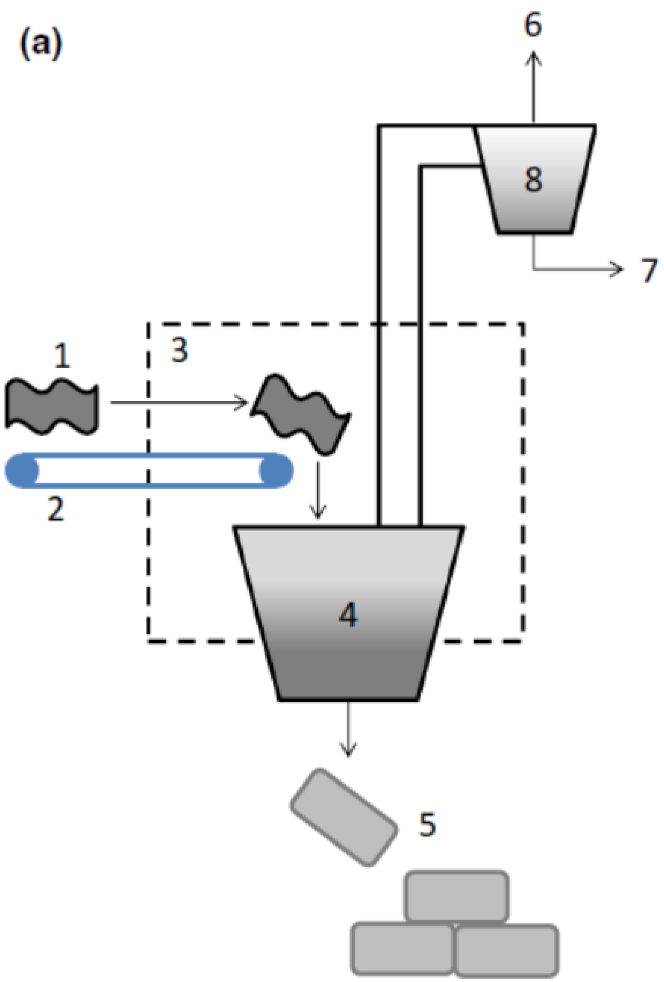
Inertization: Mechanochemical treatment

Mechanochemical treatment

The mechanochemical treatments rely on the mechanical energy transmitted to the ACW by crushing machines the task of destroying the crystal lattices and the molecular bonds present in asbestos.

High-energy milling or ultramilling processes have been successfully proposed and used at the real and laboratory scale to handle the ACW.

The results are obtained from progressive amorphization by the release of the hydroxyl ions needed to maintain the crystalline structure: with this regard, the process is called “cold vitrification”.



Comparison of the different treatments

Parameters	Thermic	Chemical	Mechanochemical
Process temperature (°C)	1000-1800	<600	<100
Energy consumption	high	low	medium
Waste products	high quantities of waste gasseous	high quantities of waste water	no waste
Reuse	Application for road surface or cement	Application in cement or glass industry	Application in civil engineering applications in building materials
Atmospheric emissions	high	low	low
Wastewater	low quantities	high quantities of wastewater	**none**

Conclusion

The **level of some technologies is able to tackle the problem of asbestos-containing materials**.

Indeed a number of applications is available for thermal degradation of asbestos.

Each technology presents advantages and disadvantage and can **be selected on the base of the specific process needs.**

The possibility to obtain a reusable byproduct is the most important technical point in order to reach the economic feasibility of a plant.

ttp://www.filieraamianto.it/

Thank you for your attention

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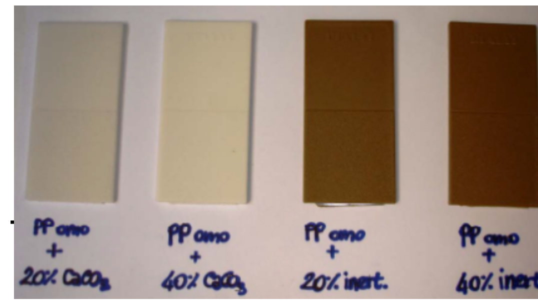
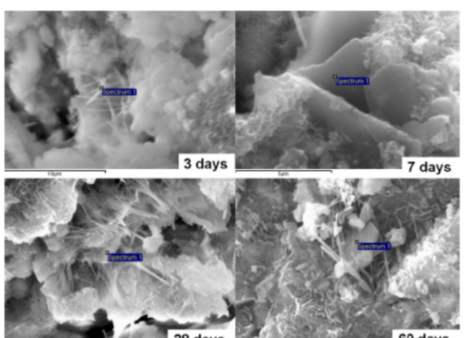
Recycling

the output material as second raw material studied by Gualtieri et. al (2011a, 2011b, 2012) Viani et al (2013, 2014) are:

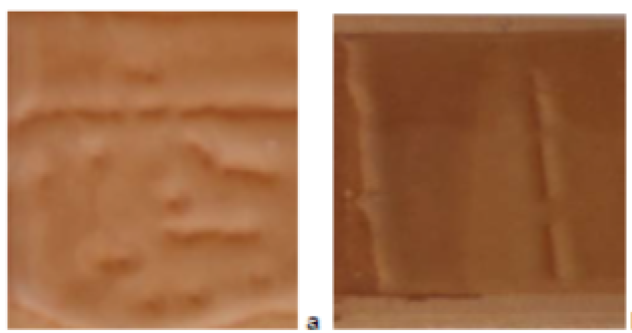
- Ceramic pigments industry;
- Production of ceramic and glass ceramic frits;
- Ceramic tile industry;
- Brick industry;
- Glass industry for the production of synthetic
- Production of cement materials;
- Geopolymer
- Plastic industry;



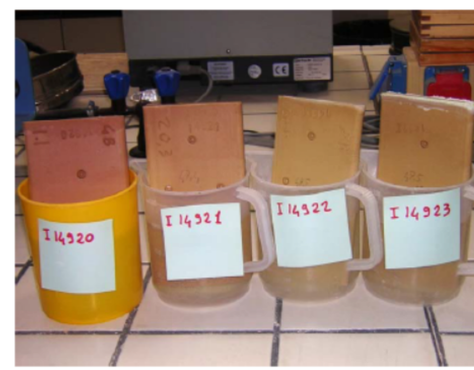
Polipropilenic compound



Concrete



Glaze



Brick

Recycling

Table 4 Potential applications of byproducts obtained from asbestos inertization

Process group	Process	Use of final byproduct	References
Thermal (simple vitrification)	Cea	n.a	[19]
	Defi systemes	Inert materials used in construction industry	[20]
	Inertam	Railway roadbed	[21]
	Modyam aspireco	Forsterite for road substrate and concrete production	[22]
	Verultim	Inert materials used in construction industry	[23]
	Melting combined with MSW incinerator	n.a	[24]
Thermal (controlled recrystallization)	Kryas zetadi	Additive for concrete production	[25–28]
	Asbestex	Inert materials used in construction industry	[29]
Thermal (treatment with other inorganic materials)	Cordiam	n.a	[30]
	Vitrifix		[31]
	Enel	n.a	[32]
	Italcementi	Raw material for clinkers	[33]
Thermal (microwave)	Aton	Road substrate	[34]
Thermal (oxyhydrogen)	Oxyhydrogen	n.a	[7]
Chemical (strong basic solution)	Tresenerie	Flocculants	[50]
Chemical (strong acid)	Wasteless method	Phosphate fertilizers	[52, 53]
Chemical (fluoride)	ABCOV	Insulating and flame retardant material	[54–57]
Chemical (hydrothermal)	S-SYSTEM	Inert materials used in construction industry	[58]
	Chemical Center	Silicates for ceramic industry and magnesium solution for agriculture	[59]
Chemical (reducing agents)	Self-propagating reaction	n.a	[60]
Mechanochemical	High-energy milling	Powder for production of building materials	[65–67]

Recycling

Table 5 Examples of large-scale plant capacity for asbestos inertization

Process group	Process	Plant capacity	References
Thermal (simple vitrification)	Inertam	40 ton/day	[21]
	Asbestex	2.5 m^3/h	[29]
Thermal (treatment with other inorganic materials)	Cordiam	3.6 ton/day	[30]
	Vitrifix	5 ton/day	[31]
Chemical (basic solutions)	Solvas	2 ton/day	[62]