Energetic Valorisation of Hazardous Wastes from Wood Industry

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Abstract: The aim of this work is to energetically valorise a hazardous waste: the sanding powder generated during the paint and varnish removal in the wood industry. The waste was treated with two different clays to obtain inert products with a Specific Caloric Power higher than 2500 cal/g to be used as fuel in the manufacture of clinker or in the pottery industry. Products were mixtures of clay and waste obtained using different amounts of clays from 5 to 40 % w/w. The waste was stabilized by adsorption of its organic molecules over the surface of the clays. This fact was confirmed by FTIR measurements.

Key-Words: sepiolite, attapulgite, hazardous waste, energy production, wood industry

1. Introduction

The European Catalogue of Waste Products assigns organic wastes to a group of hazardous by-products. Wood Industry generates an important number of organic hazardous wastes derived from the preparation and refinishing processes. Among them, the sanding powder generated during the paint and varnish removal is a hazardous waste that actually is send to landfill. This powder is included in the European Catalogue of Waste Products as 080117* (wastes from paint or vanish removal containing organic solvent or other dangerous substances) and it is necessary its stabilization/solidification previously to be disposed in the landfill.

Traditional use of cements in the stabilization/solidification is limited in the case of the organic wastes due to the negative effects produced by the organics compounds on the cement hydration process [1]. To overcome this drawback, alternative processes have been developed to pre-treat the organic waste and adapt it to the cement stabilization process [2]. The use of organophilic clays and clays modified by organic complexes in the stabilization of organic contaminants in aqueous or organic solution has been the objective of different studies [3, 4]. Such treatments allow to obtain monolithic solids, which are highly resistant to both compression (mechanical resistance) and, in particular, leaching of the contaminants (chemical resistance).

Lopez et al. [5] described a process designed to stabilize and physically-chemically render inert organic wastes products from different industrial processes. The method proposed is based on the use, under defined conditions, of a high specific surface phyllosilicate (sepiolite) to produce inert materials. The main differences of the proposed method with respect to previous stabilization processes include: non use of cement, possibility of treating any type of organic residue whether a liquid or a paste, and the chance to energetically recover the final product. Fifteen hazardous wastes generated by several industries were studied: wastes from the paint manufacturing process; wastes from the liquid detergent manufacture (surfactants); expired raw materials used in the cosmetic industry, sludge produced after cleaning tanks containing chlorinated hydrocarbons; dyes and paints and their mixture.

In the present paper, the application of the method proposed by Lopez et al. was used for the energetic valorisation of the sanding powder generated during the paint and varnish removal in the wood industry [5]. The effect of the clay used in the stabilization process is evaluated as well as the characteristics of the products obtained.

2. Materials and methods

The hazardous waste used in the present study was the sanding powder generated during the paint and varnish removal in the production of wood doors in an industry placed in Castilla-La Mancha (Spain). Table 1 shows the physico-chemical characteristics of this waste.

Table 1. Physico-chemical characteristics of the sanding powder

Parameter	Value	Units
Ash	18,66	%
Moisture content	1,29	%
Ignition Point	> 100	ºC
SCP	5132	kcal/kg
F	0,12	%
Cl	0,04	%
Br	< 0,01	%
S	0,12	%
METALS		
As	n.d.	ppm
Cd	n.d.	ppm
Co	0,8	ppm
Cu	21,4	ppm
Cr	0,4	ppm
Fe	291	ppm
Hg	n.d.	ppm
Mn	0,7	ppm
Ni	10,4	ppm
Pb	n.d.	ppm
Sb	n.d.	ppm
Sn	n.d.	ppm
Ti	n.d.	ppm
Tl	n.d.	ppm
V	n.d.	ppm
Zn	742	ppm

n.d. no detected

Two different clays from TOLSA S.A. (Spain) were used as additives to stabilize the waste: attapulgite ($(MgAl)_5(SiAl)_8O_{20}(OH)_2 \cdot 8H_2O$) and sepiolite ($Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$). Table 2 shows their physico-chemical properties.

Inert end-products were obtained by mixing the initial waste product with the selected clay. Mixing was performed in a MAP MLH 06 horizontal laboratory mixer of 5 L capacity at a mixing speed of 300 r.p.m. Mixing time was fixed at 15 minutes. Several assays involving proportions of clay and waste material from 0.05 to 0.4 kg clay per kg mixture were performed. All physical and chemical tests were performed according to standard procedures.

Once the final products were obtained, they were characterized in the same way that parent ones. Additionally, Fourier Transform Infra-Red Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM) were also performed on representative samples of the end products of the waste treatment processes.

To assay the mechanical properties of the products obtained, briquettes made from the end-products were performed.

Table 2. Physico-chemical properties of clays

Parameter	Sepiolite	Attapulgite
Moisture (%)	9 ± 3	18
Bulk Density (g/L)	600 ± 40	750
pH	8,7	9,5
Water Absorption (%)	140	90
Specific Gravity (g/cm^3)	2,3	2,2
Surface Area BET, N_2 (m^2/g)	240	300

3. Results and discussion

Table 3 shows some of the physico-chemical properties of the final product samples, which are easily to handle solids in the powder form. The final products have amounts of clays between 5 to 40 % w/w affecting its SCP that decreased in the same proportions. At the same time, the moisture of the products and their ash content increased with the amount of clay added. Ignition point was higher than 100 ºC for all the samples

Table 3. Physico-Chemical properties of the final product samples

	SCP (cal/g)	Moisture (%)	Ash (%)
Sanding powder	5132,0	1,29	18,7
Clay/Waste (%w/w)			
SE 5/95	4671,4	2,18	23,2
SE 10/90	4230,1	2,84	30,1
SE 20/80	3546,2	3,65	39,3
SE 30/70	3219,6	4,35	45,0
SE 40/60	2542,0	5,22	54,3
AT 5/95	4788,5	1,54	16,8
AT 10/90	4665,1	2,15	20,4
AT 20/80	3737,8	3,23	27,3
AT 30/70	3648,2	4,95	34,9
AT 40/60	3024,3	6,22	42,2

SE: Sepiolite; AT: Attapulgite

It can be seen that the effect of the addition of sepiolite over the Specific Caloric Power of the waste was most important than that of the addition of attapulgite. This difference can be attribute to the different BET specific surface of the two clays

used. To confirm that, FTIR was used to study the structure of the products obtained.
Spectra obtained between 2500 and 4000 cm^{-1} show that the intensity of the band corresponding to the vibrational mode of Si-OH groups decreased as the waste content of the product increased. This indicates that the silanol groups and the waste molecules are linked by covalent bonds, reflecting an adsorption process on the external surface of the clay. Further, the band corresponding to the vibrational mode of the OH groups binding magnesium (3450 cm^{-1}) showed an increase in intensity and a slight shift towards the smaller wavelengths indicating the presence of hydrogen bonds between the waste and the bound water in the clay (14). The intensity of the band corresponding to the vibrational mode of Si-O bonds (1074 cm^{-1}) increased with the waste content of the mixture.
IR spectra from 1800 to 800 cm^{-1} allowed to observe that the band corresponding to the deformation vibration of H_2O (at 1600 cm^{-1}) separates into 3 bands (1620, 1645 and 1676 cm^{-1}) in the products. This also indicates an adsorption process via hydrogen bridges between the OH groups of the clay and the organic molecules in the waste.
These results suggest that the treatment of the waste with the clays involved the adsorption of organics molecules of the waste onto the external surface of the clay by means of hydrogen bonding in channels similar to those of zeolites. Moreover, after the treatment with the clays, the waste was stabilized. Thus, it can be considered as inert and not as hazardous.
Furthermore, all the products showed a SCP higher than 2500 cal/g. Then, it can be suggest the possibility of recovering the energy of the materials as fuels, i.e. in the manufacture of clinker [6] or in the pottery industry.

4. Conclusions

The process proposed allows the stabilization of a hazardous waste, the sanding powder generated during the paint and varnish removal in the wood industry, by rendering it inert. The method is based on the adsorption of organic molecules of the waste onto clays with high specific surface area and appropriate crystallochemical structure.
The products obtained have a SCP higher than 2500 cal/g and could be used as fuels in the cement and in the pottery industries.

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