# CONVERTING WASTES INTO A POLYMER FOR ENERGY AND CONSTRUCTION USE. THE "OXIDE-DESTRUCTION PROCESS"

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**ABSTRACT**

Considering the widespread problems regarding waste management, and the large percentage of wastes that is currently incinerated (about 80%), a dramatic change in strategy is needed to improve recycling and reduce the need to resort to dumps and incinerators. The "oxide-destruction process" consists of a strongly oxidant reaction in solution, initiated by an oxidant mixture based on a patented formula and a reagent that completely de-polymerises wastes. This reaction frees the -OH groups commonly present in waste substances such as fatty acids, sugars, etc., which in reaction with the -NCO groups of the reactant mixture give place to a polymerisation reaction forming a new polymer with an elastic structure and open cells, named "Polyxane". The latter is a sterile and stable substance, as determined by chemical and physical analyses. Finally, the wet fraction of wastes is changed by the "oxide-destruction processing" into combustible "bio-mass" with high calorific power, which provides considerable energy recovery. The Polyxane is a material similar to Polyurethane, but the latter is made from a base of a polyol and an isocyanate as reagents, whereas the former is made from a base of wastes and isotrimer mixture as reagents. A technology which can contribute to reach this goal was specified by the Committee of Enquiry on Waste Cycle, who in the final report at point 1.2.9 stated that "oxide-destruction processing" is a well-grounded alternative to "thermal-destruction processing" for waste disposal and waste areas reclamation. Secondly, it can avoid the high costs of separate waste management. The oxide-destruction process and its main product "Polyxane" are independent of the physico-chemical state of the waste material, and even of the different mixtures of materials. Thus it is possible to use all waste fractions that are classified as non-recyclable with normal technologies. All industrial production and post-use wastes, such as solid urban wastes, plastics, mud coming from water treatment plants, and animal flours, are suitable raw materials for "Polyxane"."Polyxane" can be used in different ways and in many areas, such as for insulating prefabricated elements, for insulating perforated concrete, as panels for thermo-acoustic insulation, as subsoil strata for cultivation, public and private green areas, for enhancing the geological drainage of sandy or clay soils, for the reclamation of abandoned quarries, as landscaping material, for phyto-depuration and so on. In conclusion, oxide-destruction is a very helpful and versatile solution to many waste problems.

## 1. INTRODUCTION

The process named "oxide-destruction" is a waste-transforming method, which transforms wastes (such as solid urban and hospital waste) into sterile and stable polymers. The research supported by "EcoEnergy Ricerche", had the purpose of zero-pollution: no smoke or liquid emissions, no remainders, no wastes of any type. The oxide-destruction uses all parts of the wastes and is a quick manufacturing process: final transformation into inert and stable materials is obtained in about 10 minutes. The process is quick enough to allow a plant to dispose of a great deal of urban solide wastes, up to 150 tons a day. Moreover, it allows a correct and safe disposal of slaughtering remainders at risk of B.S.E., as stated in the Italian law 49/2001 - art. 1 - subsection 3. The treated remainders do not need previous selection or washing. The process is so simple that can easily be adapted to small or large plants, both mobile and fixed, industrial and domestic. As an example, it is possible to apply plants in tourist settlements, ecological site factories, slaughterhouses, hospitals, small or large towns, etc. Furthermore, the oxide-destruction process allows reclamation of temporary or unauthorized waste areas with mobile plants. It also allows the treatment of polluted sites because waste is immediately transformed into a very stable product, without any problems and spending only limited amounts of water, electric energy and fuel.

## 2. PHASES OF PROCESS

The process phases are as follows:

### 2.1 Mechanical treatment for volumetric reduction

a) wastes unloaded by vehicles or picked up by buckets in temporary waste areas, are fed to a hopper linked to conveyor belts of various carrying capacities;
b) fractions of higher density (pebbles, pieces of metal etc.) are automatically separated;
c) waste is measured in a grinding device (both fixed and mobile) in order to obtain the best dose of oxide for the process.

### 2.2 Chemical treatment

Ground waste is loaded in a continuous reactor made up by two cones, one cylinder section and a continuous mixing device.

Oxidation. The ground material in the first section of the reactor is mixed with the oxidant mixture named "oxitrimer": this is the first stage of the process, which is completed in 50 seconds. The oxidant action of the oxitrimer breaks down the physico-chemical structure of wastes, obtaining primarily a depolymerised material and some free active alcoholic fractions. Oxidation in this process is so quick as to limit the addition of heavy metals incorporated in insoluble oxides and hydroxides. Furthermore, the oxidant action is important in order to sterilise mud (also from the point of view of the bacterial action, because it destroys many pathogenic germs and parasites coming mainly from urban wastes, such as cholera, dysentery, typhus, tuberculosis, etc.).

Polymerisation. In the second section of the reactor wastes are mixed with a reagent named "isotrimer", which causes polymerisation to form expanded polyxane, which is very similar to existing polyurethanes. The material still in the polymerisation phase is placed inside large metal cases, the shape of which determine the final appearance of the polymerised material.

In summary, in the oxide-destruction process, stabilisation, disinfection and residual humidity evaporation lead to long lasting sterility and stability.

Note: as the polyurethane is formed by a reaction between a polyol and an isocyanate, the polyxane is obtained by the reaction between wastes and isotrimer.

## 3. BASIC THEORY OF MOLECULAR DEMOLITION

### 3.1 Molecular demolition performed by natural organisms

The microbe-killing activity of phagocytic cells is mainly connected to the ability of these cells to produce molecules such as super-oxide ion ($O_2^-$), hydrogen peroxide ($H_2O_2$) and hypochlorite ion ($HOCl^-$) which disrupt the bacterial membrane, leading to microbe death.

This metabolic process is known as "respiratory burst".
An essential role in obtaining super-oxide ion is played by the enzyme known as nicotine-amide-adenine-dinucleotide-phosphate-oxydase (NADPH-oxydase). This enzyme is necessary to the electron transportation which, in the metabolic activation of phagocytic cells, reduces molecular oxygen ($O_2$) to super-oxide ion ($O_2^-$). It is made up of four protein sub-units: two molecules, p22 and gp91phox, are located in the cell membrane. Both are known as cytochrome complex b558; two molecules, p47 and p67, are located in the cell cytoplasm.
Cell activation gets the passage of these molecules from the cytoplasm to the membrane and their assembly to form an enzyme complex able to carry out the whole oxydasic activity.

### 3.2 Molecular demolition for quick waste disposal via the "oxide-destruction process"

The oxide-destruction process perfectly imitates natural microbe-killing oxidant reaction. It is made of two phases:

#### 3.2.1 Oxidant phase.

In this phase the oxidant mixture named oxitrimer demolishes the protein molecules and the other substances present. The demolition produces -OH and $-CH_2$ groups.
During the reaction, energy is obtained as heat, which makes the water present evaporate.
Oxidation transforms some alcoholic groups, i.e primary $-CH_2OH$ and secondary >CH-OH of cellulose, in aldehydes (-CH=O), ketones (>C=O) and carboxylic acids (-COOH), and breaks hexatomic rings.
The carboxilic groups react with pre-existent alcoholic groups obtaining esters. Oxygen produces new links forming new polymers.
The strong attack of the isotrimer causes the death of micro-organisms by damaging the bacterial membrane.

#### 3.2.2 Depolymerisation phase.

Depolymerisation accomplishes the complete demolition of all pre-existent structures, such as prions, proteins, viruses, bacteria and micro-organisms, as well as the sterilisation of the pre-existing materials.

## 4. MOLECULAR DEMOLITION OF BIOLOGICAL POLYMERS

In living organisms four main types of organic polymers are found:

- carbohydrates (formed by sugars),
- proteins (formed by amino acids),
- lipids (non polar molecules such as grease and wax), and
- nucleotides (complex molecules playing a key role in energetic exchanges which may combine in order to form the big molecules known as nucleic acids).

Here we will describe in more detail the molecular demolition of proteins and lipids.

### 4.1 Molecular demolition of proteins

In the oxide-destruction reaction, hydrogen peroxide, a component of oxitrimer, is decomposed: $2H_2O_2 \rightarrow 2 H_2 + 2O_2$.
Free oxygen reacts with animal proteins leading to acidic hydrolysis and demolition of amino acids. The amino acids, because of molecular demolition, lose –OH and $-CH_2$ groups and with acetic acid form, among other products, acetic amide ($CH_3$-CO-$NH_2$), an essential catalyst in the final polymerisation process, which forms the end sterile product.

In quick succession all depolymerisations follow, so as to demolish the pre-existent physico-chemical structure and prepare the substrate for subsequent polymerisation. Water is evaporated in the exothermal process of depolymerisation and polymerisation.
In summery, depolymerisation accomplishes the oxidant molecular demolition of proteins, obtaining the separation of amino acids. The oxidant action of oxitrimer in connection with amino acids produces ammonia, $CO_2$ and urea; the glucids produce $CO_2$ and ethanol.

### 4.2 Molecular demolition of lipids

A molecule of fat is constituted by three molecules of fatty acids and one of glycerol.
The depolimerisation hydrolises the esther bond of the lipid, freeing the glycerol and the fatty acids.
Oxygen released by oxitrimer reacts with the fatty acids (both saturated and insaturated), and transforms them into glyceraldehyde ($CH_2$-OH-CH-OH-CHO) and in glyceric acid ($CH_2$-OH-CH-OH-$CO_2$H).

## 5. UTILISATION OF POLYMER

According to the author, it is possible use the final product in many ways, such as:

| | |
|---|---|
| reclamation of dismissed quarries | for acoustic insulation, both in civil and industrial applications |
| film enclosed in chalk panels | for thermal insulation, even in difficult situations, as the obtained material is fire-, weather-, mechanical stress resistant |
| disposal in waste areas of sterile and stable material | sea substratum for radication of algae, favoured by the open cell structure |
| sterile background for drainage | |

## 6. EXPERIMENTATION

On the 8th of March 2001 EcoEnergy made an experiment at the presence of the members of the "Parliament Panel on waste cycle and connected illicit activities" at the " Dipartimento di Chimica Organica e Biologica dell'Università di Messina" on samples of solid urban waste (SUW) and minced meat.

### 6.1 Microbiological analyses.

Table 1. Results of chemical-bacteriological analysis

| | Mesophils (CFU) | Humidity (%) |
|---|---|---|
| SUW | $2.1*10^{4}$ | 8.22 |
| Minced meat | $1.3*10^{3}$ | 9.85 |

CFU: colony forming units per g of material.

It is possible to infer that according to the microbial charge both samples can be considered practically sterile. The small bacterial charge is due to the outdoor conditions. Humidity (less than 10%) shows a large time stability.

### 6.2 Elementary analysis

Further analyses were carried out to check some characteristics of the final product.

Composition of samples was:

| | % |
|---|---|
| Carbon (C): | 65÷69 |
| Nitrogen (N): | 9.8÷11.3 |
| Hydrogen (H): | 5.4÷5.6 |
| other elements | not significant |

### 6.3 Thermal analysis

Material was found to be stable up to 200°C (STA system: Simultaneous Thermal Analyser)

### 6.4 Porosity

Four tests were carried out using a mercury porosimeter in order to evaluate material porosity, a distinguishing mark of rigid polyurethane used as insulating material. Results show pores with a cylindrical shape, uniformly distributed both from the point of view of pore dimension (2µm ÷ 90µm – mean 37µm) and from that of the number of pores per unit area. The percentage of pores per unit volume is 42÷51%, so the calculated density is about 1 $g/cm^3$.

### 6.5 Calorific power

Wheighed amounts of reagent were placed in a bomb-calorimeter, a steel container of fixed shape. Reaction is started and energy variation is determined by measuring the increase of temperature of the water surrounding the container (and of the other parts of the calorimetric bomb).

Material exhibits an average calorific value of 6000 cal/g (25000 J/g).

Table 2. Calorimetric analysis of polymer samples

| | |
|---|---|
| Sample weight | 0.4150 g |
| initial temperature | 22.04°C |
| final temperature | 23.04°C |
| non combusted residue | 0 g |
| calorific value | 6,207.23 cal/g |

A further test was carried out in a calorimetric bomb on two samples of meat after the initial treatment: oxidation and mixture with bio-mass. The material exhibited a calorific value of 2600 cal/g, and the non-combusted residue percentage was found to be 2 ÷ 3% of total mass.

Table 3. Calorimetric analysis on two intermediate samples

| | 1st sample | 2nd sample |
|---|---|---|
| Sample weight | 0.7734 g | 1.3105 g |
| initial temperature | 20.07°C | 20.79°C |
| final temperature | 20.8°C | 22.23°C |
| non combusted residue | 0.0225 g | 0.0249 g |
| calorific value | 2,504.3 cal/g | 2,885.38 cal/g |

## 7. PROCESS ECONOMIC ANALYSIS

Until now the process has been tested in a plant on a small scale, so the exact costs are to be determined on the first prototype on a real scale.

Suitable wastes for this process do not require particular treatments, and do not need preselection, washing or drying.

Wastes only need grinding and separation of coarse fractions and metallic parts, since the process works on the whole of existing materials, provided that they are broken in suitable dimensions.

About operating costs:

A) The process does not needs water, so the amount of water used is reduced to that necessary for periodic plant cleaning.
B) Also the electric consumption is small.
C) Added bio-mass (if necessary) has zero cost. On the contrary it is usually profitable.
D) Reagent cost is about Lit. 50/g (0.03 Euro/g) for both oxidant mixture and reagent.
E) Transportation costs are usually very small due to the possibility of placing the plant inside the waste area. Furthermore, revenues are to be considered if the product is sold.

## 8. CONCLUSIONS

This new recycling process opens up a very interesting view on ecological problems, insulating materials and environmental costs.

An important aspect about costs is also the possibility of providing an alternative to differential waste collecting. It is well known that the New York Mayor has stopped this kind of waste collecting because of the high costs. In Italy 1 kg of plastics collected with this method costs about 0.35 Euro, whereas 1 kg of undifferentiated waste processed into expanded polixane only costs 0.05 ÷ 0.07 Euro, and commercial polixane can put on the market at 1,000 ÷ 3,000 Lit/kg (1.50 ÷ 2.00 Euro/kg) depending on its density.