# TECHNICAL REPORT

# ISO/TR 16218

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# Packaging and the environment — Processes for chemical recovery

*Emballage et environnement — Processus de valorisation chimique*



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# Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 16218 was prepared by Technical Committee ISO/TC 122, *Packaging*, Subcommittee SC 4, *Packaging and Environment*.

# Introduction

Resource use optimization, resource savings, environmental impacts' minimization are among priorities in a perspective of sustainable development. These priorities apply also to the packaging sector. Since many years, this latter has developed initiatives in these directions, working on the packaging design aspects as well as on the organization of the logistic chain, on setting up recovery and recycling schemes or on the development of used packaging recovery or recycling technologies.

For various reasons, including the diversity of national or regional contexts, some confusion arose from the fact that neither legislations nor communication messages from the concerned stakeholders could rely on clear and unanimously agreed upon definitions of the terms used and of the respective benefits of the various recovery/recycling options.

ISO/TC 122/SC 4 is developing standards on the optimization of the packaging system (ISO 18602), on reuse (ISO 18603), on material recycling (ISO 18604), on energy recovery (ISO 18605) and on organic recycling (ISO 18606). ISO 18601 will define the general requirements for the use of these ISO standards in the field of packaging and the environment.

This Technical Report is an attempt to clarify some ideas relating to the concept of "Chemical Recovery", to put it in the perspective of the other recovery options and to help local stakeholders to identify the locally most appropriate treatment option, on the basis of a common understanding of the terms and of the basic requirements specific to each recovery technology. In this Technical Report, the methodologies of chemical recovery of used packaging are described.

# Packaging and the environment — Processes for chemical recovery

## 1 Scope

Several processes for chemical recovery of used packaging are considered to be material recycling. The focus of this Technical Report is for used packaging, although the processes described are not specific for used packaging and can be used for recovery of other materials of same type. Processes for chemical recovery of used packaging are applicable for plastic packaging or biomass-based packaging, which might be interpreted in two different ways:

— processes to recover valuable chemical substances by chemical treatment of used packaging, for example, to recover monomers of polyethylene terephthalate (PET) by hydrolysis, glycolysis or methanolysis, to recover oil by catalytic reaction or pyrolysis, to recover valuable gases such as hydrogen by gasification, to recover coke, oil and gasses by cokefaction;

— processes to directly substitute used packaging for natural resources without chemical pretreatment, for example, flakes of used plastic packaging may use in blast furnace in the place of coke as a reducing agent.

Examples and key characteristics of chemical recovery processes are given in Annexes A to E.

NOTE For the purpose of this Technical Report; "Chemical recovery" means the production of chemicals, identical to or differing from, the starting raw materials that were used for the production of the packaging materials, or the direct substitution of natural resources by using used packaging. These recovered chemicals can be used as such, or as reactants in further chemical syntheses; directly '*in situ*' or in another production process.



## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 21067, *Packaging — Vocabulary*

ISO 18601, *Packaging and the environment — General requirements for the use of ISO standards in the field of packaging and the environment*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21067, ISO 18601, and the following apply.

**3.1**
**monomer recovery**
processes to recover monomers such as by decomposition of used packaging

Note 1 to entry: The industrial processes are established to recover monomers to produce polyethylene terephthalate (PET) such as dimethyl-terephthalate (DMT), bis-hydroxyethyl-terephthalate (BHET) and ethylene glycol (EG) by chemical decomposition of PET. The processes to recover monomers from the following polymers are at the development stage for polymers such as; polycarbonate (PC), polyamide (PA), polystyrene (PS) and poly lactic acid (PLA) polymer.

**3.2**
**oil recovery**
processes to recover oil from used packaging such as by decomposition with or without catalyst

**3.3**
**gas recovery**
processes to recover gases useful for chemical industries as their raw materials (hydrogen and carbon mono-oxide) such as by carbonization and partial burning of used packaging

**3.4**
**reduction agent in blast furnaces**
product providing carbon and hydrogen to replace coke with used packaging in blast furnaces for steel production

Note 1 to entry: In the conventional steel production processes, coke is used as a reduction agent.

**3.5**
**raw material for coke manufacturing**
product to partially replace coal with used packaging for raw material of coke furnaces to produce coke

## 4 Inventory of relevant existing documents

Various options of chemical recovery are also addressed in some standardization documents, for example

— ISO 15270:2008, Plastics — Guidelines for the recovery and recycling of plastics waste

— ISO 18601, Packaging and the environment — General requirements for the use of ISO standards in the field of packaging and the environment

— ISO 18604, Packaging and the environment — Material recycling

— ISO 21067, Packaging — Vocabulary

## 5 Identification of further packaging-specific needs related to chemical recovery

The prime objective of this Technical Report is specific for used packaging. In order to meet the needs of the market, the used packaging fraction ending up in a chemical recovery process is in many cases used in combination with other material fractions of the same type. Therefore the processes described in this Technical Report are in practise not restricted to used packaging.

Each recovery option has its own specifications, e.g. number of materials, maximum levels of contamination, etc. Certain materials may be incompatible with some chemical recovery processes. In cases of significant amount of such materials being included, pre-treatment to remove these should be introduced to avoid those problems.

## 6 Suitability for chemical recovery process

Chemical recovery is included as material recycling as an option. If used packaging, i.e. source material, is collected in mono-material route, the used packaging is feasible for mechanical recycling. In the case of PET bottles, however, chemical recovery by monomer recovery is also feasible to obtain high grade PET resin. In the case of expanded polystyrene (PS), some parts of source material can be recycled by mechanical recycling, and the other parts, i.e. contaminated material, are generally used as source of chemical recovery. If used packaging, i.e. source material, is collected in commingled material route, such material can be used as sources of chemical recovery other than monomer recovery. These recovery options possess wide acceptability of source material, commingled or contaminated, if only it does not impede the operation of facilities.

An example of assessment checklist is given in Annex F.

NOTE Plastic materials are most suitable for these processes. However, if there is no obstacle on the operation of facilities, biomass-based materials such as wood, paper and fibre can be incorporated into the process.

# Annex A
(informative)

# Examples of monomer recovery of PET

## A.1 Material

Any PET product, including bottles, film, fibre and fabrics, can be used for the monomer recovery of PET. Used PET bottles are a candidate of starting material for the process. Used PET bottles are sorted before processing.

## A.2 Decomposition processes

In industrial processes, PET bottles are shredded, washed, and dried to produce PET flakes as shown in Figure A.1 and prior to being decomposed in a second step. The contaminants are usually removed at the flaking operation.

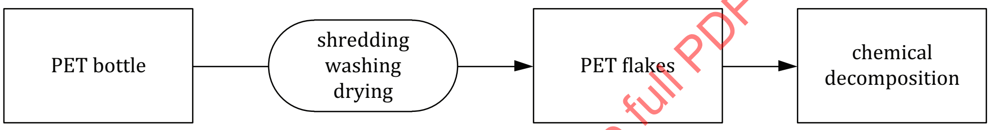


**Figure A.1 — Pre-treatment (flake production)**

Two decomposition processes have been established, namely glycolysis and methanolysis, as shown in Figure A.2 and Figure A.3, respectively.

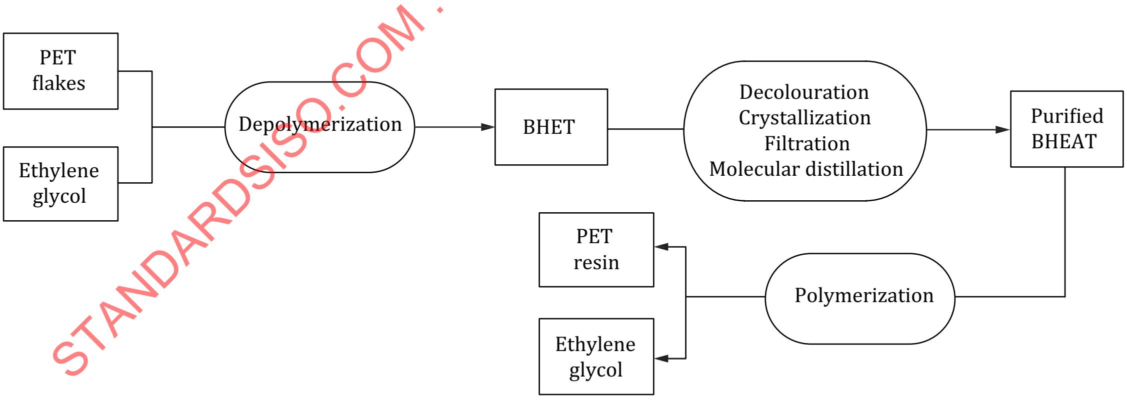


**Figure A.2 — Glycolysis process**

In glycolysis, the mixture of PET flakes and ethylene glycol is heated up to decompose PET. Bis-hydroxyethyl-terephthalate (BHET) is recovered by this process. The recovered BHET is de-coloured, crystallized, filtered, and then molecular distilled to obtain pure BHET. The pure BHET is directly employed to polymerize PET resin. Ethylene glycol is recovered from the polymerization process.

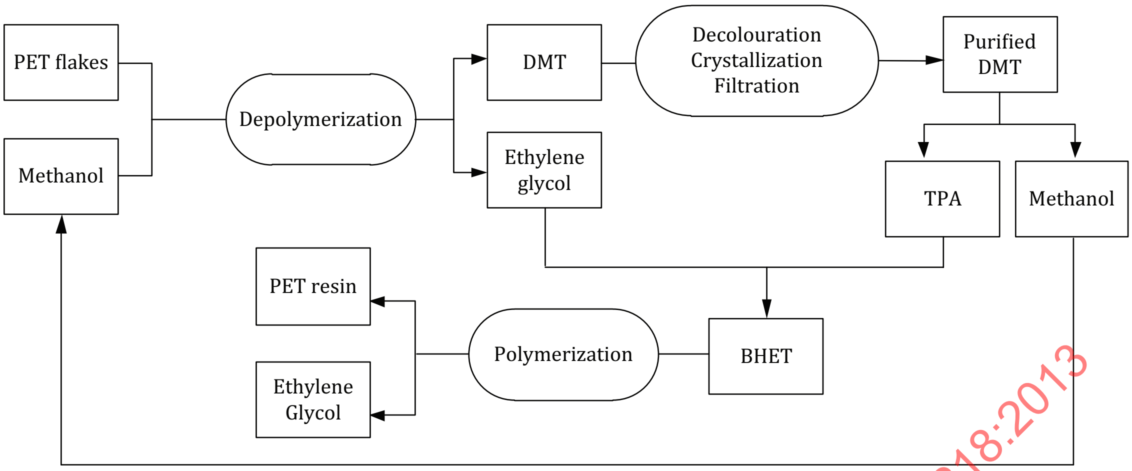


**Figure A.3 — Methanolysis process**

In methanolysis, the mixture of PET flakes and methanol is heated up to decompose PET. Di-methyl-terephthalate (DMT) is recovered by this process. The recovered DMT is de-coloured, crystallized, filtered to obtain pure DMT. The pure DMT is converted into pure terephthalic acid (TPA) and methanol. This TPA is converted into BHET by addition of ethylene glycol, which is employed to polymerize PET resin. Ethylene glycol is recovered from the polymerization process.

# Annex B
(informative)

# An example of oil recovery

## B.1 Material

Any organic materials including plastics and biomass-based materials can be used for oil recovery. Used packaging is a candidate of starting material for the process, if only it is collected/sorted. Commingled and slightly contaminated used packaging can apply for this process.

NOTE Plastic materials are most suitable for this process. However, if there is no obstacle on the operation of the de-HCl extruder, biomass-based materials such as wood, paper and fibre are incorporated into the process.

## B.2 Process

Oil recovery is a process to recover high quality oil (hydro-carbon oil) from used packaging by treatment at high temperatures (under inert conditions) with or without catalysts. There are several processes running in Japan. A typical process is shown in Figure B.1.

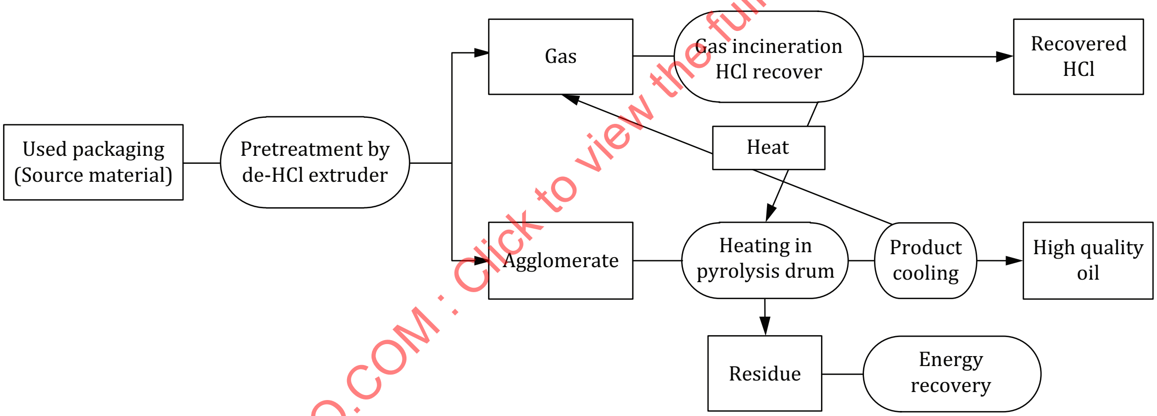


**Figure B.1 — A typical process of oil recovery system**



The used packaging is, at first, introduced into an extruder to remove chlorine. By incineration of the generated gas, HCl is recovered for recycling. The heat generated by incineration is utilized in the process. The plastic melt extruded from the extruder is introduced into a pyrolysis drum to decompose polymers. The products are cooled to obtain high quality oil, whereas gas components are merged with the gas generated from the extruder. The residue in the pyrolysis drum called char is utilized for energy recovery.

## B.3 Use

The recovered high quality oil can be used in the place of heavy oil, as either chemical feedstock or fuel.

NOTE 1 Note that the oil recovery process can be less efficient than other recovery processes. In the process, a portion of the used packaging is consumed to supply energy for the process. Thus, all of the used packaging is never recovered as oil. The priority of oil recovery is set lower than the priority for more efficient processes.

NOTE 2 The decomposed gas and oil are utilized as fuel or chemical raw material.

# Annex C
(informative)

# An example of gas recovery

## C.1 Material

Any organic materials including plastics and biomass-based materials can be used for gas recovery. Used packaging is a candidate of starting material for the process, if only it is collected/sorted. Commingled and slightly contaminated used packaging can apply for this process.

## C.2 Process

In industrial processes, hydrogen has been obtained by cracking natural gas or petroleum. By the gas recovery from used packaging, these resources are replaced by the used packaging. A typical process is shown in Figure C.1.

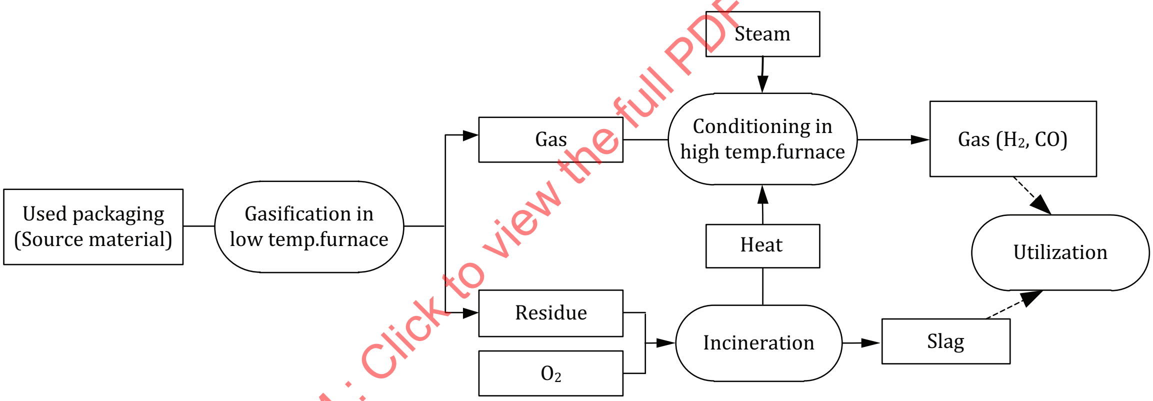


**Figure C.1 — A typical process of gas recovery system**

Used packaging is gasified in a low temperature furnace under inert condition. The char is burned using oxygen to supply energy for the process. The effluent gases are then treated with steam in a high temperature furnace to produce valuable gases (hydrogen, carbon mono-oxide, etc.) for the raw materials in chemical industries. The slag of the residue incineration is utilized to recover rare metals, etc.

## C.3 Use

The gases recovered are useful as a feedstock to manufacture ammonia and organic chemicals.

# Annex D
(informative)

# An example of reduction agent in blast furnaces

## D.1 Material

Any organic materials including plastics and biomass-based materials can be used for reduction agent in blast furnaces. Used packaging is a candidate of starting material for the process, if only it is collected/sorted. Commingled and slightly contaminated used packaging can apply for this process.

## D.2 Process

In the conventional steel production processes, coke is used as a reduction agent. The industrial processes are established to replace coke to used packaging. A typical process is shown in Figure D.1.

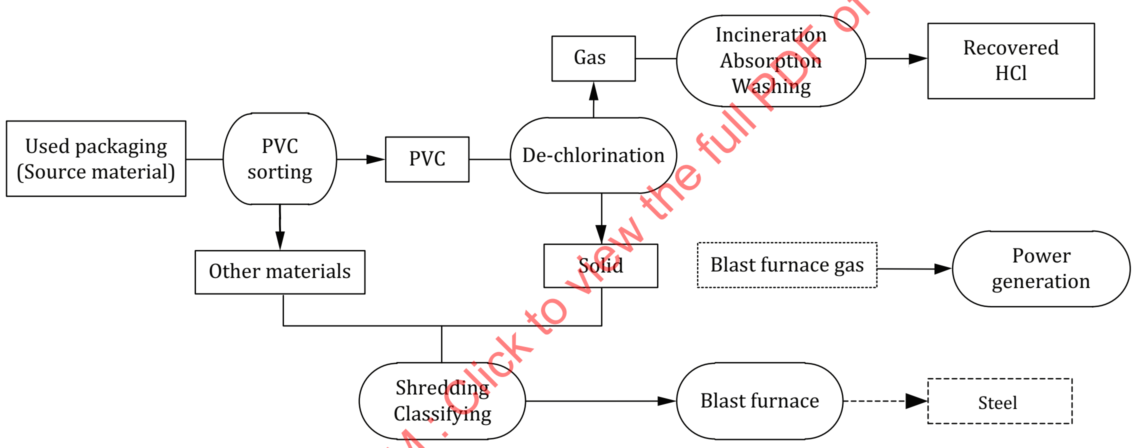


**Figure D.1 — A typical process to use used packaging as reduction agent in blast furnace**

The used packaging is sorted to remove PVC and other contaminants. PVC sorted is treated in a rotary kiln with coke to remove chlorine. The gases generated in the rotary kiln are incinerated to recover HCl. The solid (coke and char) is utilized as a reducing agent in blast furnaces. After sorting out PVC (other plastics), the used packaging is shredded and classified to use for reducing agent in blast furnaces for steel production. A part of the source materials introduced into blast furnaces is converted into blast furnace gas, which is utilized for power generation.