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Guidelines for the recovery and recycling of plastics waste

塑料废弃物的回收和再利用指南

(ISO 15270:2008, Plastics - Guidelines for the recovery and recycling of plastics waste, MOD)

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Guidelines for the recovery and recycling of plastics waste

1 Scope

This document provides guidance on sources, recovery and recycling, recovery quality, material standards and product specifications in the process of plastic waste recovery and recycling, and provides various ways to recover and recycle plastic waste generated from pre-consumer and post-consumer sources.

This document applies to the management and application of plastic waste recovery and recycling.

NOTE: This document establishes general quality requirements to be considered at all steps of the recovery process and provides general recommendations for material standards, test standards and product specifications. The processing stages, requirements, recommendations and terminology presented in this document are of general applicability.

2 Normative references

The provisions of the following documents constitute the essential clauses of this document through normative references in this text. Among them, for referenced documents with dates, only the versions corresponding to the dates are applicable to this document; for referenced documents without dates, the latest versions (including all amendments) are applicable to this document.

GB/T 2035 Terms and definitions for plastics (GB/T 2035-2008, ISO 472:1999, IDT)

GB/T 16288 Marking of plastics products (GB/T 16288-2008, ISO 11469:2000, MOD)

3 Terms and definitions

The terms and definitions defined in GB/T 2035 and the following apply to this document.

3.1 waste

Any material or item that the owner discards or intends to discard or is required to discard.

3.9 mechanical recycling

The process of converting plastic waste into secondary raw materials or products without significantly changing the chemical structure of the material.

NOTE: Plastic secondary raw materials are synonymous with recyclate.

3.10 physical recycling

The process of separating one or more target polymers from other polymers, additives and other added materials (such as fibers, fillers, colorants and contaminants) through a series of purification steps to obtain a recovered polymer that is largely unaffected by the process and can be reused in plastic formulations.

NOTE 1: This process may also enable other valuable components of the plastic to be recovered.

NOTE 2: Currently, most physical recycling methods are solvent-based methods.

3.11 chemical recycling

Through cracking, gasification or depolymerization reaction, coke oven treatment (excluding energy recovery and incineration) and other technologies, the chemical structure of plastic waste is changed to generate new monomers or raw materials.

NOTE: It is formerly known as "feedstock recycling".

3.12 biological recycling

organic recycling

The biodegradable plastic waste is treated aerobically (composting) or anaerobically (digestion) using microorganisms under controlled conditions to produce stable residual organic matter, carbon dioxide and water under aerobic conditions, or stable residual organic matter, methane, carbon dioxide and water under anaerobic conditions.

NOTE: It includes industrial processes involving living microorganisms and can convert biowaste into valuable products.

3.13 recovered material

Plastic materials that are separated, transferred or removed from solid waste for recycling or to replace raw materials.

NOTE: See ISO 14021.

3.14 recyclate

Plastic materials that are generated from the recycling of plastic waste.

3.22 agglomerate

The phenomenon of particles sticking together after being shredded and/or granulated.

3.23 baling

The process in which plastic waste is compacted and secured as a bundle to facilitate handling, storage and transportation.

3.24 lot

A determined quantity of some commodity produced or manufactured under assumed uniform conditions.

3.25 homogenizing

The process of improving the uniformity of a certain component and/or property of a plastic material throughout the material.

3.26 micronizing

The process of shredding plastic material into a fine powder.

3.27 purge material

Material resulting from the passing of polymer through plastics processing equipment for the purpose of cleaning the equipment.

NOTE: If one polymer is changed to another, or the color or grade of the polymer is changed, purge material is required.

3.28 depolymerization

The chemical reverse reaction of a polymer into its monomers or a polymer of lower relative molecular mass.

NOTE: It includes hydrolysis, glycolysis, formic acid hydrolysis, etc.

3.29 biodegradation

A process in which material degradation is caused by biological activities, especially the action of enzymes, so that the materials are gradually digested by microorganisms or certain organisms as a nutrient source, resulting in a decrease in their relative molecular mass, weight loss, a decrease in physical properties, etc., and ultimately being decomposed into simpler compounds, mineralized inorganic salts of the contained elements, and inanimate objects.

[Source: GB/T 41010-2021, 3.1]

3.30 environmental aspect

Elements of an organization's activities, products or services that interact or can interact with their environment.

NOTE 1: An environmental aspect may produce one or more environmental impacts. Significant environmental impact aspects are environmental aspects that have or can produce one or more significant environmental impacts.

NOTE 2: Significant environmental aspects are determined by the organization using one or more criteria.

[Source: GB/T 24001-2016, 3.2.2]

3.31 environmental impact

Adverse or beneficial changes in the environment that are caused wholly or in part by the organization's environmental aspects.

[Source: GB/T 24001-2016, 3.2.4]

4 Sources

4.1 Overview

Recovered plastic materials come from a variety of sources, but do not include hazardous plastic waste such as medical waste, pharmaceutical waste, pesticide packaging waste, and plastic waste containing (or exposed to) radioactive or biologically toxic materials.

4.2 Pre-consumer sources of materials

4.2.1 Resin (plastic raw material) production

Rejected materials generated during the production process of resin (plastic raw material) manufacturers.

4.2.2 Plastic processing

Materials produced during the processing of plastic raw materials into plastic products, including:

-- purge materials and waste from the processing;

-- scrapped products, parts and semi-finished products;

-- samples or rejected products and other unused clean products.

5.2 Material recovery

5.2.1 Overview

There are four different ways to recover plastic waste materials: mechanical recycling, physical recycling, chemical recycling, and biological recycling. Plastic waste should be recovered and labeled according to material type.

5.2.2 Separation and sorting

In all material recovery processes, plastics are usually required to be separated and sorted, which can be separated and sorted manually or automatically by appropriate identification methods. The more accurate and effective the identification, sorting and separation methods are, the better the quality of the recovered products obtained. Therefore, for product production or application, the design of disassembly, separation and sorting should be considered. Depending on the specific situation, compaction processes such as rolling and baling, or volume reduction processes such as shredding and tearing can be used to ensure simpler operation. Plastic products marked in accordance with GB/T 16288 shall be sorted according to the product markings.

It is not advisable to use manual sorting methods for the separation and sorting of plastic waste, which may cause workplace environmental problems (such as chemical or microbiological problems). Ergonomic problems caused by repetitive work and patterned movements also pose risks. If manual sorting cannot be avoided, the workplace needs to be designed to minimize the problem.

NOTE 1: Pre-consumer materials are usually sorted by plastic type to facilitate their reuse in the production process. The recycling of post-consumer materials is often more complicated due to accidental mixing with other plastic waste or aging of the polymer.

NOTE 2: Some post-consumer materials may contain the same base plastics, but some of these base plastics have different material properties, such as high-density polyethylene bottles with different melt flow rates, densities or colors. These may result in products with unique and controllable physical properties in the next recycling step. In some cases, it is not practical or commercial to achieve the desired degree of separation and purification of recyclates, so that products containing recyclate components are only used in less demanding situations, such as certain mixed materials. Standards for recyclate properties are an effective tool for evaluating whether they meet market requirements.

NOTE 3: In some cases, reinforced plastics may be recovered by chemical recycling without the need to separate the polymer matrix from the reinforcing fiber material.

Most plastic products contain other polymers or additives for various reasons, such as antioxidants, colorants, and in some cases, fillers, glass fibers, or carbon fibers for reinforcement.

When the effective separation at this stage fails to achieve the performance required of

the recyclate, appropriate preparation should be made in the next regeneration step, such as further sorting, homogenization, and micronization.

5.2.3 Mechanical recycling

5.2.3.1 Operation steps

Mechanical recycling usually includes the following operations, some of which may be carried out simultaneously, which are part of the preparation and production process of recyclates:

For plastics: collection → identification → sorting → shredding → washing → drying → separating → agglomerating → extruding/blending → pelletizing.

For reinforced plastics: collection → identification → sorting → shredding → washing → separating.

NOTE 1: In practical applications, flakes are often used directly as recyclates, and the last step of pelletization can usually be omitted.

NOTE 2: If the secondary raw materials obtained from the crushed plastic waste are used as aggregates for cement or mortar, the sequence of the operation units is as follows: collection → identification → sorting → shredding → product.

NOTE 3: When plastic waste can be sorted by type during the sorting operation, there is no need for separation operations after washing and drying operations.

Plastic waste for mechanical recycling is sold in bulk form as collected or in an added-value, sorted grade. Such commercial plastic waste may have a variety of forms and compositions, and information on the consistency and standard of its materials is essential. As a general rule, manufacturers and users of plastic materials and articles made from them should provide mechanical recyclers with material safety data sheets or other appropriate documents giving necessary data such as thermal stability, reactivity and recycled content.

5.2.3.2 Pre-treatment

Depending on the intended use of the recyclate and the characteristics of the waste, pre-treatment operations are used to remove as many contaminants as possible from the recovered materials and products to optimize their handling steps for transportation, processing and other downstream operations. For inhomogeneous plastic waste materials composed of similar grades or similar types of materials, material identification, sorting and separation steps are essential, such as household packaging waste or end-of-life electrical and electronic equipment in dedicated sorting centers. In any case, these pre-selection steps should be carried out before blending (commingling) with other wastes. In some cases, especially for post-consumer sources of material, the

necessary to adopt appropriate processes (such as solvent extraction) to remove other polymers, additives, fillers and contaminants.

5.2.5 Chemical recycling

In the petrochemical industry, some plastics can be converted into their basic monomer chemical components or corresponding hydrocarbons through various processes such as hydrolysis, pyrolysis, and gasification. These chemicals can be used as raw materials for polymerization reactions or in other chemical processes.

NOTE 1: The depolymerization has already been demonstrated, e.g., for PET obtained from post-consumer packaging sources such as collected commingled plastic bottles where the PET is sorted and subsequently depolymerized, generating monomer feedstock for polymerization and the subsequent manufacture of products such as bottles and fibers. Some acrylic polymers, such as methyl methacrylate monomer obtained by depolymerization can also be used as feedstock for commercial polymerization processes.

NOTE 2: Suitable plastic wastes and their derived hydrocarbons have been used as reducing agents in kilns and in metal smelting.

5.2.6 Biological recycling

Biodegradation is a viable option for the biological recycling of certain types of plastic waste. After the collection and separation of non-biodegradable contaminants, these plastics are subjected to aerobic or anaerobic decomposition. Separation of biodegradable contaminants, such as food or vegetable residues on plastics, is usually not necessary when the criteria for biodegradability, abiotic toxicity, and composition requirements are met. In the mechanical recycling process, they become contaminants if they thermally degrade and decompose at normal plastic operating temperatures.

5.3 Energy recovery

Energy recovery is a viable option, like other recovery methods. From a sustainability perspective, energy recovery is lower in priority than the reduction and reuse of plastics, as well as mechanical, physical, chemical and biological recycling, and higher than landfill. In municipal solid waste incineration systems that meet gas emission, radiation and dust regulatory requirements, direct combustion or co-combustion of plastic waste is a typical application of energy recovery.

NOTE: Since most plastic waste is hydrocarbon in nature, its inherent calorific value is high. Therefore, the final application of recovered plastic as fuel is very effective, as long as factors such as combustion by-products are fully considered. This recovery method has been successfully applied in industrial processing and steam generation systems, thermal power generation, and lime, cement and metal mineral smelters. If the plastic waste is a mixture of multiple polymers or is severely colored and cannot be recycled as a material, energy recovery is the last option and is better than simple incineration or landfill.

necessary to ensure compliance with occupational health and safety requirements.

6.3 Color and appearance

The color and appearance of the recyclates shall be agreed upon by both the supplier and the buyer. To meet the corresponding requirements, necessary colorants, anti-ultraviolet agents, etc. may be added in appropriate amounts.

In most cases, color and appearance (such as color, transparency and cleanliness) requirements are easily met when pre-consumer materials are recycled, as long as strict controls and good manufacturing practices are followed.

When recovered materials come from post-consumer materials, there are often great difficulties in meeting color and appearance requirements, especially when the recovered materials or products consist of various containers and disposable utensils from different sources and uses. Therefore, even if effective separation operations are completed, how to effectively sort various wastes by color or other characteristics may still be a challenge. In order to meet this basic need of end users of recyclates, it is desirable to develop a method based on visual sorting.

6.4 Properties of recyclates

The properties of recyclates may be affected by the way they were recovered, the environment in which they were previously used, and other factors, such as contaminants, and chemical or structural changes that occur during recovery and processing.

The use of appropriate sorting techniques, minimization of contaminants and implementation of appropriate recovery operations can help reduce the adverse effects on the properties of recyclates. This can be monitored through relevant tests that meet the expected requirements, such as density, melt flow rate, oxidation induction time, and tensile properties.

The addition of modifiers (including new materials) can improve certain properties of recyclates. The supplier and the buyer should reach a consensus and list the additives used in the material specification and material safety data sheet.

6.5 Criteria for acceptance

Each recovery and recycling process results in significant changes to the material. It is important to ensure the quality, safety and functionality of recovered and recycled materials for the next generation of products. Therefore, the quality and environmental impact of recyclates should be fully evaluated. The criteria for acceptance of the recyclates are determined by the use requirements or the agreement between the supplier and the user. The criteria for acceptance may include the following:

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