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Analysis of PET post-consumer through Thermal treatments

Análisis de PET posconsumo mediante tratamientos Térmicos

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Abstract

This research work analyzes the process of determining post-consumer contaminant material for plastics and identification of acceptable material to be reused. Burn tests were carried out on recycled material (different plastic wastes) in order to recognize, by means of color change, the type of raw material that is contaminating and thus avoid its entry into the recycling process. The burning was carried out in a thermoreactor at a temperature of 230°C for 30 minutes, with methods and equipment used in a well-known company in the region. In this study, waste from some well-known brands used in homes in the state of Guanajuato was used, considering that the separation was supported by TOMRA equipment and manual classification by the company's personnel. For the burn tests, plastic trimmings were used, elaborated in a handmade way, therefore, the work of a mechanical shredder will not be taken into account.

Postconsumer, PET, Thermal Treatments, recycled material

Resumen

El presente trabajo de investigación, se analiza el proceso de determinación de material contaminante posconsumo para plásticos e identificación de material aceptable para ser reutilizado. Se realizaron pruebas de quemado a material reciclado (diferentes desechos plásticos) con la finalidad de reconocer, mediante el cambio de color, el tipo de materia prima que es contaminante y de este modo evitar su entrada al proceso de reciclaje. El quemado se realizó en un termoreactor a una temperatura de 230°C durante un tiempo de 30 minutos, con métodos y equipos utilizados en una empresa conocida en la región. En este estudio se tomaron desechos de algunas marcas conocidas y usadas en los hogares del estado de Guanajuato, considerando que desde la separación se apoyo con equipo TOMRA y clasificación manual del personal de la empresa. Para las pruebas de quemados se usa recortes plásticos, elaborados de forma artesanal, por lo tanto, no se tomará en cuanta el trabajo de una trituradora mecánica.

Posconsumo, PET, Tratamientos Térmicos, Material reciclado

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Introduction

Materials made from PET (polyethylene terephthalate) can be identified at a glance by its 01 identifier within the recycling symbols known as easy-to-reference plastic commodities. With a melting point of 255° C, PET is one of the most widely used in different applications, such as food and beverage packaging to make them last longer, as well as being lighter than other materials, e.g. glass, which is heavier to transport. Other applications are in soft drinks and beverages, food packaging, textile fibres, videotapes, X-rays, etc.

It has barrier properties preventing the entry of contaminants into and/or outgassing of soft drinks, it is a flexible and versatile material.

The types of recycling that exist for the aforementioned material are: chemical recycling, mechanical recycling and energy recycling.

The burn tests will be analysed in order to subsequently consider mechanical recycling of the materials accepted at this stage.

Objective

To carry out a process of discarding post-consumer PET resins by thermal treatment, analysing the change in colour of the flakes in order to select acceptable material for recycling.

PET Material (Polyethylene Terephthalate)

Polyethylene terephthalate is a derivative of polyester that is converted into a type of plastic blend; its origin is from petroleum.

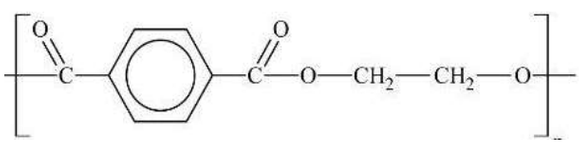

Figure 1 Chemical structure of terephthalate

Parts of a cylinder

The parts of a bottle are generally composed of three elements which can vary in chemical composition. These parts are the cap, the label and the body of the bottle (Figure 2).

Figure 2 PET bottle parts

Recycling

Recycling consists of subjecting a material or product that has already been used to a new cycle of total or partial treatment, in order to obtain a raw material or a new product.

For plastic recycling, the different types of plastics must be separated into individual fractions.

Type of recycling of the post-consumer material to be used.

Mechanical recycling is the conversion of post-industrial or post-consumer waste into granules that can be used in the production of other products, such recycling makes it possible to obtain different plastics in certain proportions or products composed of a single type of plastic.

Mechanical recycling of the resin leads to changes in the following material properties:

– Thermal properties
– Mechanical properties
– Fluidity
– Morphology
– Colour

The mechanical recycling process is composed of the stages of separation, grinding and washing, drying, extrusion, granulation, agglutination and finally obtaining the recycled pellets (Figure 3).

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Figure 3 General outline of Mechanical Recycling

Methodology

Burning Tests

The tests were carried out on PET plastic bottles, with the aim of verifying which of them are contaminants and to continue with the task of indicating to the manual sorting operators which bottles should be removed.

The procedure consists of collecting bottles from the bulk PET material, sorting them as follows:

– Capacity of contents (ml, lt).

– Types of substances (Water, Soft Drink, Detergents, Juices, Sauces, Shampoo, etc.)

– Brand

The bottles were washed, removing impurities with soap and water. Subsequently, the bottles were dried and weighed, and the elements that make up the bottle were weighed separately, recording the data.

The next step was to cut the PET part of the bottle into small squares by manual procedures, with scissors (in small flakes), placing them in aluminium containers and identifying each material by brand. The data recorded were the brand (from different companies) and the capacity of the bottle (ml, lt), they were placed in the oven at 210°, 230° and 250°C for 4 and 5 hours, after the cooling time the samples were taken out, and the contaminants were identified visually, observing that they take on a grey or yellow colour of different shades. This information was documented in tables for further analysis.

Results

Tables 1 and 2 show the different types of bottles discarded and analysed, their weight obtained during the contaminant identification process. It also shows the result with respect to the material obtained, it is considered acceptable or not acceptable, with green being a positive indication and red a negative indication.

Reference design			
Brand and presentation	Water Kirkland (500 ml)	Water Ciel (600 ml)	Water Bonafont (600 ml)
Bottle	10.12	12.6	15.3
Cap	0.87	1.71	1.85
Label	0.17	0.31	0.39
Total	11.16	14.62	17.54
Result			

Table 1 Weight of the different components of a PET bottle, units in grams

Table 1 shows that there are no contaminants in the bottles that store water. Table 2 with other bottles shows some examples of material that would be discarded because they do not comply with the colour characteristics in the burn tests.

Reference design					
Branding and presentation	Santa Clara Yoghurt (235 ml)	Biosol Oil (845 ml)	Botanera Sauce (1 lt)	Salvo (900 ml)	Pinol (1.650 lt)
Complete bottle	1.13	1.03	1.14	1.12	1.28
Cap	0.39	0.45	0.32	0.78	0.45
Label	0.12	0.1	0.19	0.14	0.13
Total	1.64	1.58	1.65	2.04	1.86
Result					

Table 2 Other analysed bottles and their components, units in grams

Figure 4 shows examples of the shade (colour) of the material after leaving the kiln.

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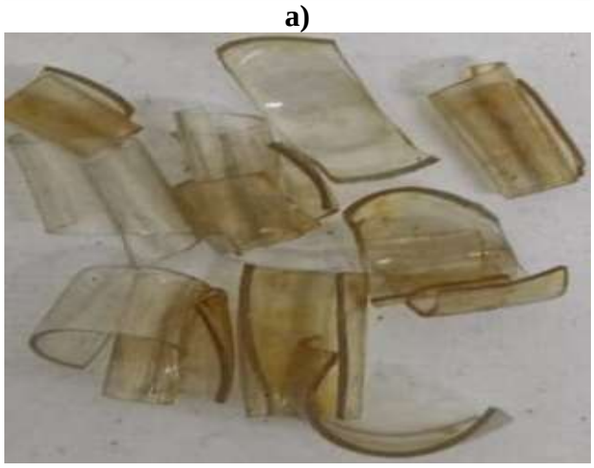
a)



b)

Figure 4 a) Acceptable material and (b) unacceptable material

The criterion for determining whether materials are acceptable or not depends on the colour obtained during the burn test. A light grey colour represents desirable characteristics of the material and is therefore considered acceptable, while the opposite is true for material with a yellow colour.

An analysis with pure water bottles was subsequently analysed as follows:

No.	Trademark	Flake thickness (mm)	Quantity of material (grams)
1	Kirkland	0.12	8.295
2	Ciel	0.17	10.712
3	Bonafont	0.18	12.250

Table 3 General data for the PET flake analysis

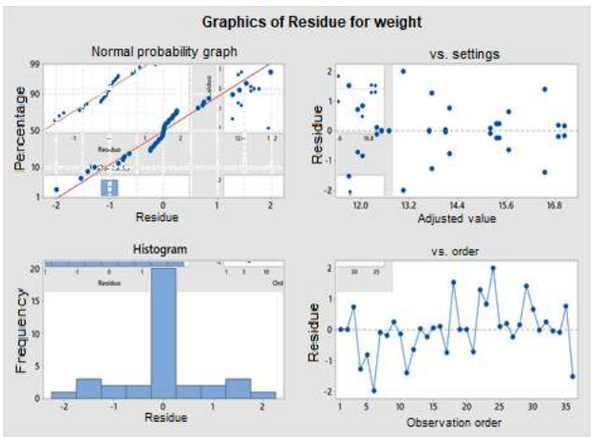
With the quantities of each material obtained from each bottle, the flakes were weighed in grams and also measured with a digital vernier to analyse the thickness of the PET bottle.

It should be noted that the PET flakes do not contain the thick part of the thread, as it was not possible to grind them. Table 4 shows the variability in the weight of the flakes, including their aluminium container with a weight of 42.06 g. This material was subjected to different temperatures: 210°, 230° and 250° with a time of 30 minutes in the oven; after cooling the material, its weight in grams was obtained.

Matriz	210°	230°	250°
1	50.432	51.376	50.156
2	64.218	64.824	64.454
3	58.263	53.01	51.792

Table 4 Weight analysis of Kirkland, Ciel and Bonafont water bottles at different temperaturas

With the data of the weights, an analysis was carried out with 3 factors, different temperatures and the following graphs were obtained in the minitab programme.



Graph 1 a) Probability graph, b) vs. adjustments, c) Histogram, d) Order of observation

Observing in graph a) a behaviour between residual and adjusted percentage in a linear way with slight variability, in graph c) the histogram shows a frequency between 0 and 20 gr. In graphs b) and d) the residual data of the data analysis are checked.

Conclusions

Of the commercial grade brands analysed by heat treatment, it can be concluded that the only two that meet the requirements for proper recycling are Santa Clara and Salvo soap, as they do not show yellowing when burned at a temperature of 230°C for 30 minutes, which was the only temperature applied to the materials in table 2.

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And as shown in table 1, all the bottles containing water passed the first burn tests. Therefore, it was considered to analyse the PET at other temperatures, to consider the variability of its weight in grams, considering how much the material is reduced without reaching its plasticisation point.

Research in the area of plastics recycling is still in its early stages, it is intended that in the future this process will be cradle to cradle in order to achieve a circular economy where plastics are fully reused or recycled, thus avoiding the huge volumes of daily waste.

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