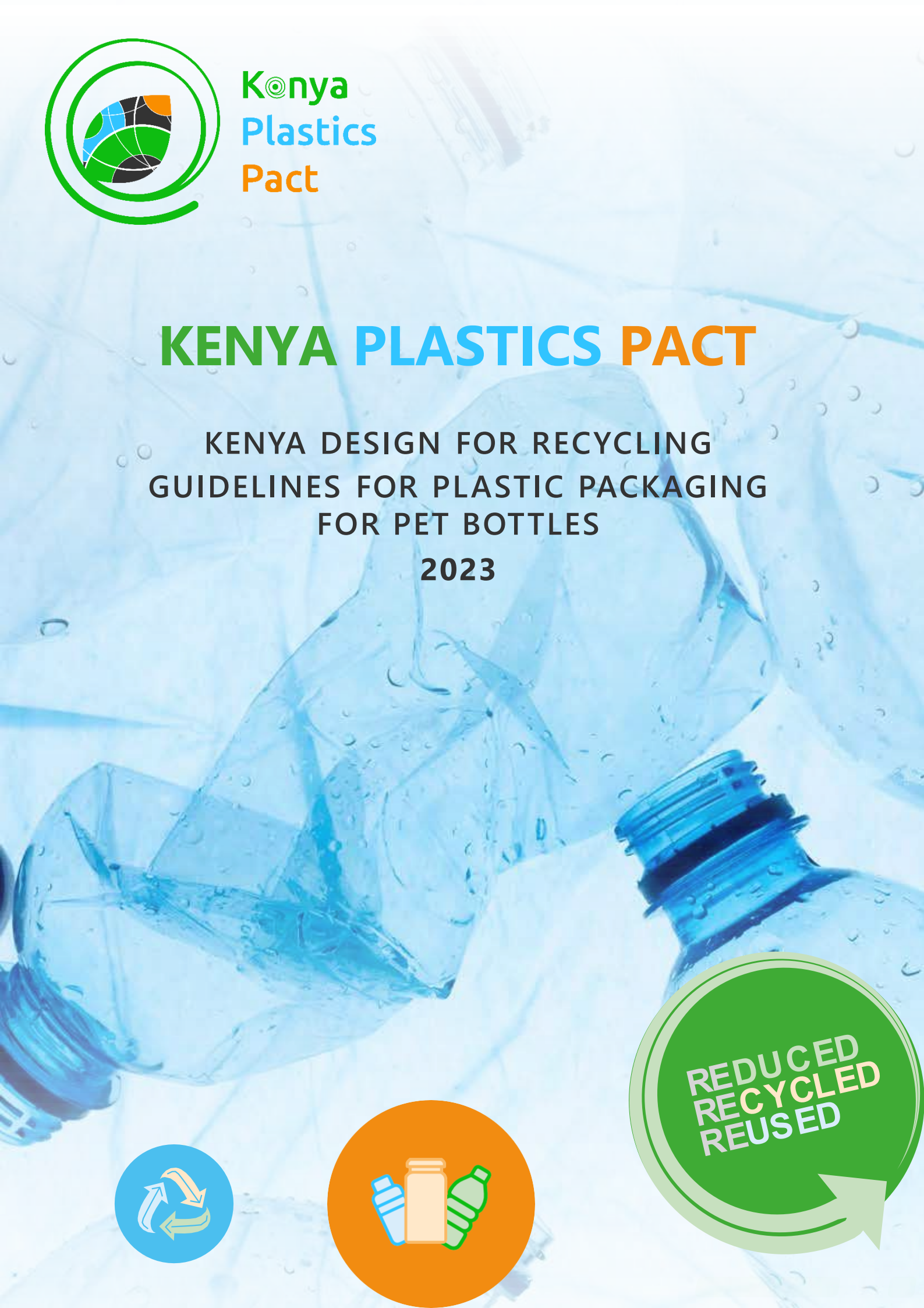
Kenya Plastics Pact

KENYA PLASTICS PACT

KENYA DESIGN FOR RECYCLING GUIDELINES FOR PLASTIC PACKAGING FOR PET BOTTLES

2023



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INTRODUCTION

Our heavy reliance on plastics packaging has long been of growing concern. Over the years, plastics packaging has become an essential material for many industries and indeed for the economy fulfilling many essential roles; from protection, storage and transport functions.
These functions essentially contribute to sustainability, as packaging prevents damage to sensitive products and loss of food.

In many cases, the environmental impact of producing the packaged good is considerably greater than the impact of producing the packaging itself. In other words, when designing sustainable packaging, the protection of products must also be considered.

In Kenya, approximately 80% of plastic packaging materials used locally are made of imported virgin polymers (processed into packaging domestically) and, to a lesser extent, domestically recycled materials with only around 20% of packaging being imported in the form of packed/made products[1]. Additionally, of the total plastics produced in Kenya, approximately 36% are used in packaging, with approximately 85% (of the 36%) destined for landfills and unregulated dumpsites[2]. Plastic packaging being dumped or ending up in landfills poses a critical and often immediate threat to countless endangered species, ecosystems, and dependent socio-economic systems nationwide. The systemic challenge raised by this environmental crisis lies at the heart of the Kenya Plastics Pact (KPP).

The unregulated dumping and plastics packaging ending up in landfills pose a critical and often immediate threat for countless endangered species, ecosystems and dependent socio-economic systems all over the country. The systemic challenge raised by this environmental crisis lies at the heart of the Kenya Plastics Pact (KPP).

In recent years, a growing demand for greater sustainability in packaging design has been apparent. Sustainable packaging incorporates functionality and the protection of products, while keeping its ecological footprint to a minimum and enabling reuse and recycling.
To achieve higher material recycling rates, and move towards circularity, we need to rethink the design of packaging to improve its future recyclability while guaranteeing its functionality.

80%

of plastic packaging materials of imported virgin polymers

36%

of the total plastics are used in packaging

20%

of packaging being imported in the form of packed/made products

85%

approximately 85% (of the 36%) ending up in landfills

[1]KAM (2019). Kenya Plastic Action Plan
[2]nited Nations Environment Programme & Consumers International (2020). "Can I Recycle This?" A Global Mapping and Assessment of Standards, Labels and Claims on Plastic Packaging.

DEFINITION OF RECYCLABLE

The current legislation related to waste management in Kenya does not provide a clear definition of recyclable. Due to a lack of a harmonised definition of recyclable, recyclability claims are not necessarily based on real-life conditions such as the availability of recycling infrastructure, market conditions and the financial viability of recycling operations. To ensure a clear definition, the Kenya Plastics Pact has adopted the definition of recyclable from the Ellen MacArthur Foundation's Global Commitment definitions: 'a packaging or a packaging component is recyclable if post-consumer collection, sorting, and recycling is proven to work in practice and at scale'[3] .

PURPOSE OF THE DESIGN FOR RECYCLING GUIDELINES FOR PLASTIC PACKAGING

These design for recycling guidelines for plastic packaging aim to provide clear recommendations to decision-makers on how to design plastic packaging to be compatible with current (and future projection of) mechanical recycling infrastructure.

These guidelines will be regularly updated and amended in response to changes in collection, sorting, recycling technologies and infrastructure within Kenya.

DESIGN GUIDELINES RATINGS

The design guidelines are presented in three categories, signifying compatibility with recycling:

Green	Yellow	Red
Green denotes packaging features that are generally compatible with or separable from the main material and is acceptable in recycling processes in large volumes.	Yellow denotes packaging materials that are recyclable in some applications, but could contaminate the recycling process.	Red denotes packaging items and materials that are generally not compatible with the current recycling systems or not separable from the main material in current processes and will contaminate the recycling process.

[3]Ellen MacArthur Foundation (2018). New Plastics Economy Global Commitment, 25 October. Ellenmacarthurfoundation.org:https://www.ellenmacarthurfoundation.org

PET

Polyethylene terephthalate (PET) is widely used for food and beverage packaging applications as it is clear, strong and lightweight with good barrier properties which provide improved shelf life. Additionally, PET offers excellent water resistance which makes it great for containers carrying liquid. With its clear appearance, it's perfect for allowing consumers to see the contents and enhance product presentation.

PET plastic packaging can be recycled into different products and its status as one of the most used plastic packaging materials due to its performance qualities and its highly recyclable nature[4]. Due to its high value PET is more likely to be recycled, hence less likely to end up in landfill or being dumped.

An average of 25% of all PET packaging is recycled in Kenya[5], making it the most locally recycled plastic packaging material.

CURRENT PET BOTTLES RECYCLING PROCESS IN KENYA

Recycling of PET bottles starts with separation usually at the collection centre or at the recycling plant and partly at source. Generally collection is done through different systems and this includes deposit schemes, waste collectors, and consumer-driven initiatives. Recyclable materials are separated out, with glass, paper and metal moving into their own recycling streams. Once all the non-plastic waste has been removed, high-value recyclable plastics like PET plastic packaging are separated by hand. Once the PET packaging has been collected and separated according to colour, they are compressed into bales for ease of transport. At the recycling plant, PET is shredded into small, crushed flakes.

BOTTLE TO FIBRE

The flake material is melted and solid contaminants removed using a melt filter. Recyclers in Kenya spin the melted PET into recycled polyester yarn. This is then turned into fabrics that can be used in seat belts, bags, carpets, roofing insulation, clothing etc.

BOTTLE TO BOTTLE

Part of the recycling process is also converting the melt into PET-pellets for export for the production of PET bottles. There is currently no PET bottle-to-bottle recycling in Kenya, but it is desirable.

[4] National Association for PET Container Resources (NAPCOR). (2021). 2021 PET Recycling Report.

[5] Eunomia (2018). Plastic Packaging Waste Flows in Kenya.

PET BOTTLES

MATERIALS & MATERIALS COMBINATIONS

PET (polyethylene terephthalate) plastic is recyclable, but it's typically recycled separately from other polymers due to several reasons.

Firstly, PET is often recycled as a single material because its unique properties make it suitable for bottle-to-bottle recycling, with its homogeneous composition simplifying the recycling process compared to mixed plastics.

However, mixing PET with other polymers can lead to compatibility issues during recycling, as differences in melting points, chemical compositions, and behaviors pose challenges to efficient recycling processes.

Additionally, combining PET with other plastics risks contamination, which can degrade the quality of recycled PET (rPET) and limit its usability. Moreover, separating PET from other polymers during recycling presents significant challenges, emphasizing the importance of effective separation methods to ensure the production of high-quality rPET.

Polyvinyl chloride (PVC) is a plastic that is not compatible with PET recycling. When PVC is melted with PET, it can produce harmful gases that are dangerous to workers and the environment. PS has a lower melting point than PET and can cause problems during the recycling process of PET bottles.

Materials such as metal, paper, and cardboard are not compatible with PET recycling. They can damage recycling equipment or contaminate the recycled PET, leading to lower quality recycled material.

HDPE closures common on PET bottles

BARRIERS AND COATINGS

When PET bottles are recycled, certain barriers and coatings can pose challenges and affect the quality of the recycled material.

EVOH (ethylene vinyl alcohol) barrier is often added to PET bottles to prevent oxidation and maintain product freshness. EVOH can be difficult to remove during the recycling process and can reduce the quality of the recycled PET.

At 5% EVOH concentration, the mechanical properties are degraded whereas EVOH content in films of more than 5% would lead to incompatibilities in mechanical recycling[6].

PVdC coatings are used in some PET bottles to provide a moisture barrier and prevent flavour transfer. However, PVdC is not recyclable and can contaminate the recycled PET if not removed[7]. Because of the fairly narrow range of feasible processing temperatures for PVdC, its coextrusion with polymers that require high processing temperatures such as PET (280–310◦C) hinders recycling[8].

Polyamide is commonly used as a barrier material in PET bottles to improve their gas barrier properties. When used in multilayer PET bottles, polyamide should be typically incorporated at low levels, usually less than 6wt% which doesn't complicate the PET bottle recycling process[9].

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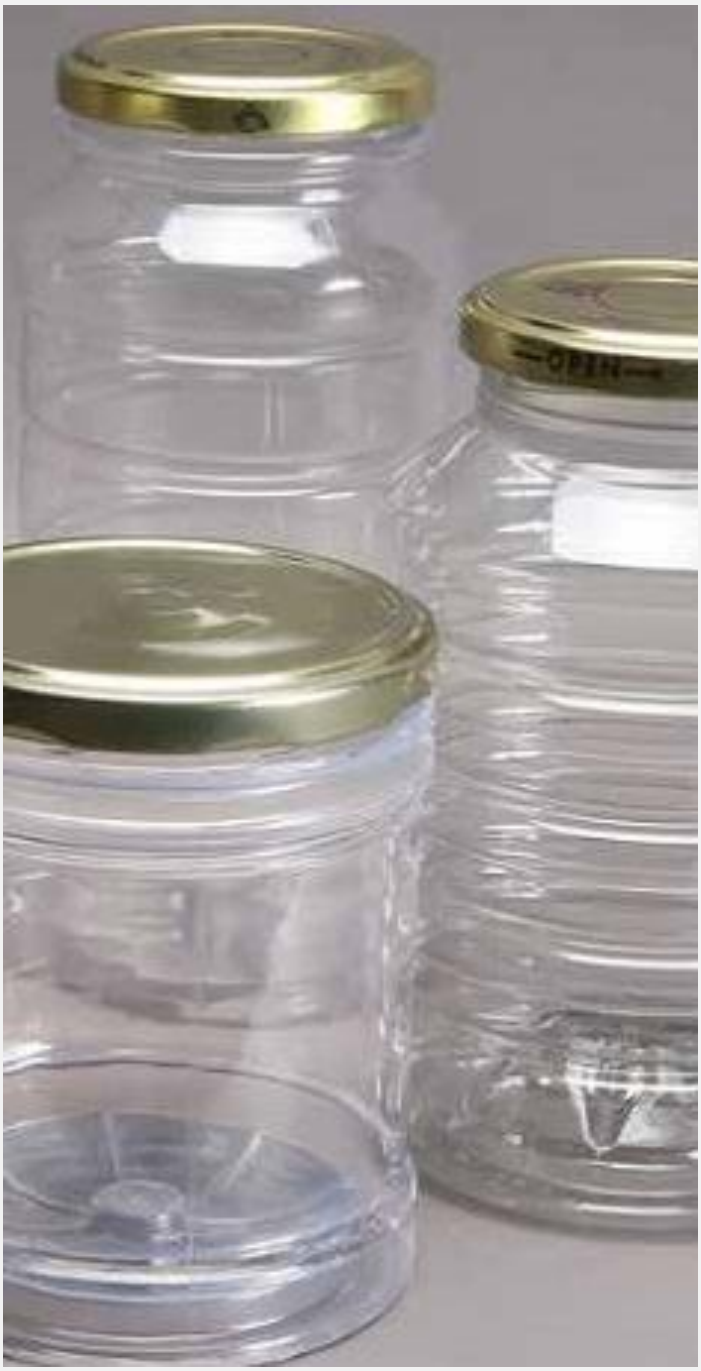
[6]Hanae Touil , Udo Pankoke , Dominik Schmitz and Roland Bothor; (2022). Recycling compatibility of EVOH barrier polymers in polyethylene-based packaging compositions

[7]Robinson, Timothy M. (1990): Factors determining the adhesion and barrier properties of PVdC-coated PET beverage containers. Loughborough University. Thesis.

[8]Mokwena KK, Tang J. Ethylene vinyl alcohol: a review of barrier properties for packaging shelf stable foods. Crit Rev Food Sci Nutr. 2012;52(7):640-50. doi: 10.1080/10408398.2010.504903. PMID: 22530715.

[9]Kaiser K, Schmid M, Schlummer M. Recycling of Polymer-Based Multilayer Packaging: A Review. Recycling. 2018; 3(1):1.

CLOSURES (CAPS, SEALS AND LINERS)



Metal Closures on PET bottles

Closure systems without liners are preferred. PP or HDPE closures on PET bottles are preferred as they separate from PET in a float/sink tank.

Closures made of metal, aluminium-containing materials (with a layer thickness greater than 5 µm), PS, Acetal plastic, also called polyacetal and polyoxymethylene (POM) and PVC are considered contaminating materials, as they interfere with the sorting and reprocessing of the material and can damage extruders and equipment, among other things.

COLOUR

PET can be pigmented in many colours. Clear bottles are fully recyclable with light blue bottles being acceptable as they can be blended in small amounts with clear bottles for recycling.

Green and brown bottles are also recycled but have a much lower value than clear bottles. Pale, light, dark or opaque material can be collected and recycled, but has fa lower end market value than transparent material.

Heavily pigmented PET bottle

Clear/transparent PET bottle

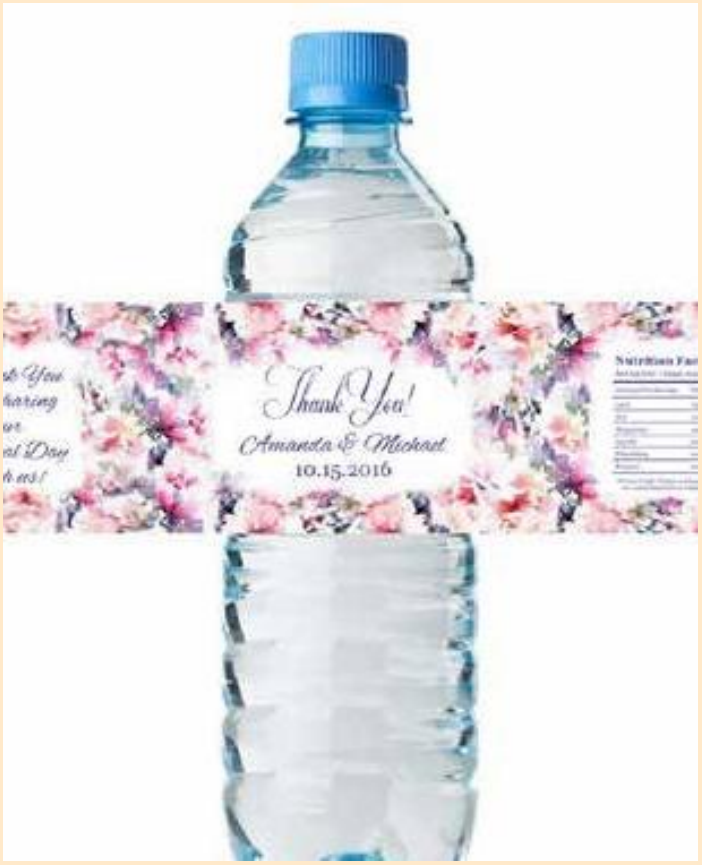
Light blue PET bottle

DECORATIONS (LABELS, ADHESIVES, SLEEVES, INKS, DIRECT PRINTING)

LABELS

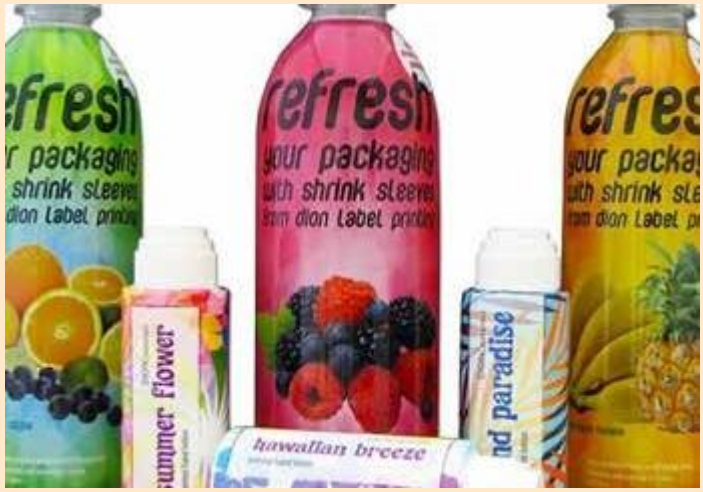
If using paper labels, these should not delaminate in the washing process.
PE and PP labels are preferred.
Paper labels can be more difficult to remove in the recycling process and bits of paper fibre and glue that remain on PET after the separation process can burn and cause black marks when the flake is later heated.

PE and PP labels are easily and accurately removed from the PET flakes by passing the PET flakes through a sink float separation tank, through which separation occurs due to the difference in density between PET and PE/PP labels, PET sinks whereas PE and PP labels float.



Paper label on PET bottles

SLEEVES



Shrink sleeve labels on PET bottles

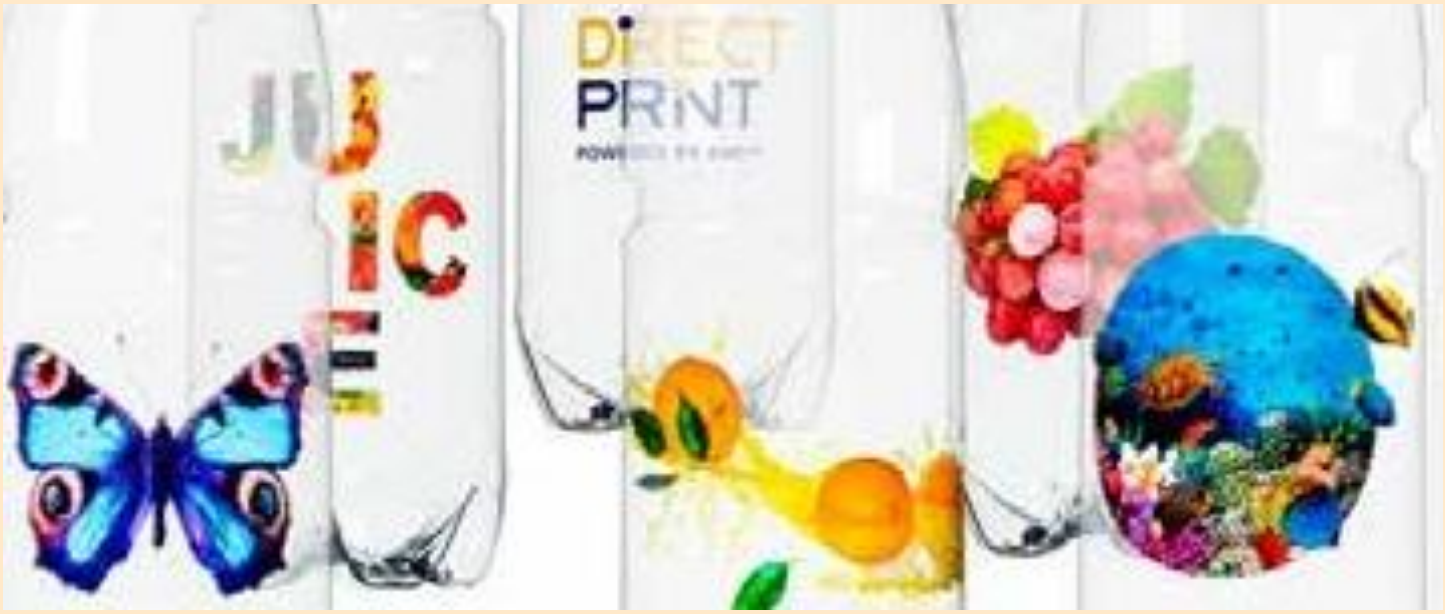
The use of PET sleeves with PET bottles should be avoided. Although made of the same material, PET sleeves are usually highly pigmented and are not easily separated.

Furthermore, sS leeves should be designed to completely detach from the container or else they become contaminants.
Research shows that shrink sleeve films made of PVC, PETG, PLA &OPS are incompatible with PET recycling[10].

First, if PVC shrink label films are used on PET bottles, it causes black speck contamination and discolouration during recycling of PET bottles making the container non-recyclable[11].

Secondly, If PVC is recycled at PET processing temperatures it will begin to break down and can produce HCl gas, which is poisonous and corrosive. Third, shrink sleeves made of PVC, PETG, PLA & OPS sink in water together with PET during the sink-float separation hence making them it difficult to separate.

[10]The Association of Plastic Recyclers (2021). Shrink Sleeve Labels on PET Containers APR Resource. https://plasticsrecycling.org/images/Design-Guidance-Tests/APR-RES-LBL-2-shrink-label-resource.pdf
[11]Recoup (2009) Plastics Packaging - Recyclability by Design, 2009 revised edition



Direct printing on PET bottle

INKS

During the water-based separation process, bleeding inks can contaminate recycled flake and cause discoloration of recycled plastic.
Inks containing heavy metals should not be used for printing as they may contaminate the recovered plastic. Inks that would dye the wash solution should be avoided as this may discolour the recovered plastic diminishing its value.

ADHESIVES

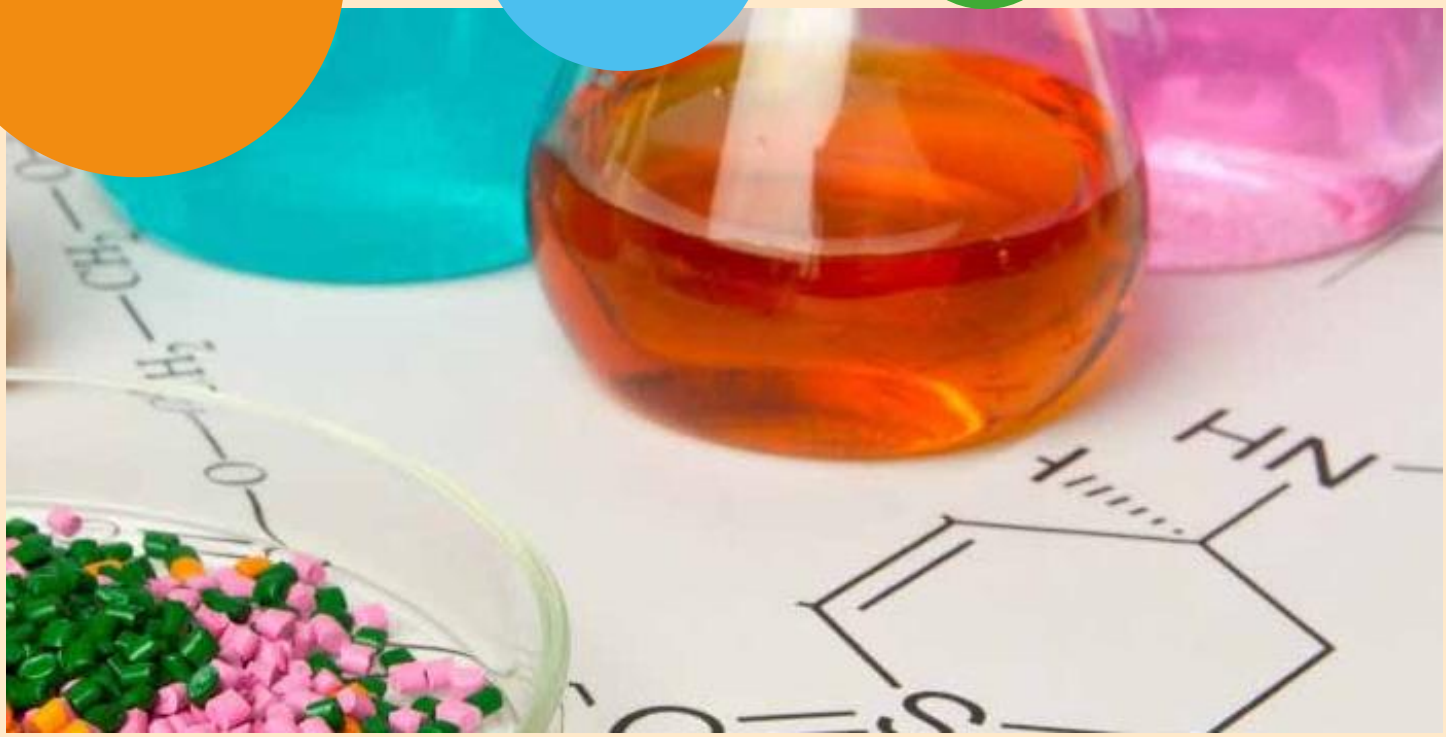
Adhesives that are water soluble at between 60 - 80 degrees Celsius and hot melt alkali soluble adhesives are the most readily removed during the recycling process[12].

For most plastic bonding applications cyanoacrylate adhesives, UV curable adhesives as well as some epoxy and structural adhesives can be used.

DIRECT PRINTING

Direct printing, with the exception of date and batch coding, onto PET bottles should be avoided as direct printing contaminates the PET recycling stream and discolours the resultant material.

[12]World Packaging Organization (2020). A global recommendation for circular packaging design.



ADDITIVES

Acetaldehyde is a compound that can cause off-flavours and off-odours in PET products and can also reduce the shelf life of food and beverage products stored in PET bottles.

AA blockers, also known as AA scavengers or AA absorbers, are added to the PET resin during the production process to prevent the formation of acetaldehyde.

Acetaldehyde (AA) blockers are compatible with PET (Polyethylene terephthalate) recycling because they are specifically designed to prevent the formation of acetaldehyde, which is a by-product that can be formed during the production and storage of PET bottles[13].

In beverage packaging, it is essential to reduce acetaldehyde content in PET bottles. Acetaldehyde forms during the thermal degradation of the PET polymer.

UV stabilizers are often added to PET plastics to protect them from degradation caused by exposure to sunlight.

This can help to maintain the strength and appearance of the material over time, which is important for many applications.

However, UV stabilizers can also make it more difficult to recycle PET plastics because they can interfere with the chemical processes used to break down and melt PET for recycling[14].

Specifically, UV stabilizers can create a residue on the surface of the PET that can cause problems during the recycling process, such as discoloration and poor quality of the recycled material[15].

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[13]Pinter, E.; Welle, F.; Mayrhofer, E.; Pechhacker, A.; Motloch, L.; Lahme, V.; Grant, A.; Tacker, M. (2021). Circularity Study on PET Bottle-To-Bottle Recycling.

[14]Curtzwiler, Greg & Williams, Eric & Maples, Austin & Davis, Nathan & Bahns, Ted & DeLeon, Eliseo & Vorst, Keith. (2017). Ultraviolet Protection of Recycled Polyethylene Terephthalate. Journal of Applied Polymer Science. 134. 10.1002/app.45181.

[15]Yang, Y. P.; Hu, C. Y.; Zhong, H. N.; Chen, X.; Chen, R. J.; Yam, K. L. (2016) Effects of Ultraviolet (UV) on Degradation of Irgafos 168 and Migration of Its Degradation Products from Polypropylene Films. J. Agric. Food Chem. DOI: 10.1021/acs.jafc.6b03018

SUMMARY OF DESIGN FOR RECYCLING GUIDELINES FOR PET BOTTLES

ITEMS	GREEN	YELLOW	RED
MATERIAL & MATERIAL COMBINATION	PET		• PVC • PS • Metal • Paper • PE • PP
BARRIERS AND COATINGS	EVOH < 5%	PA-MXD6 multilayer with <6wt%	• EVOH / PA >5% monolayer blends • PA-Polyamalyde multilayer with >6wt% • PVdc
CLOSURES	• Closures made of PP, HDPE or other materials with a density less than 1 g/cm3. • Closure systems without liners.	ethylene vinyl acetate (EVA) or Thermoplastic elastomers (TPE) liners	Closures made of metal, aluminium-containing materials (with a layer thickness greater than 5 µm), PS, Acetal plastic, also called polyacetal and polyoxymethylene (POM) and PVC.
COLOUR	Transparent clear and transparent light blue are fully recyclable.	Other transparent colours	Opaque colours
LABELS	PE and PP labels	Conventional paper labels. During washing process of conventional paper labels, fibres come out that contaminate the recyclate.	• Large-scale decorations covering more than 50% of the packaging surface can impair the sorting of the packaging. • Full body label. • PET as well as non-wet-strength paper labels can contaminate the PET fraction. • PS labels
SLEEVES	If sleeves are used, they should cover a maximum of 40% of the packaging and be made of a material (e.g PP and PE) with a density less than 1g/cm3 to enable ease of separation in the sink float separation process.		Sleeves made of a material with a density greater than 1 g/cm^3 (e.g., PVC, Oriented Polystyrene (OPS), Polylactic acid (PLA) should be avoided.
INKS	Non-bleeding inks are preferable to avoid potential contamination.		Bleeding inks.
ADHESIVES	Cyanoacrylate adhesives, UV curable adhesives as well as some epoxy and structural adhesives[1].		Adhesive materials containing metal or aluminium (with a layer thickness of greater than 5 microns µm) can lead to unwanted sorting into the metal fraction.
DIRECT PRINTING	The batch coding and the indication of the best-before date should ideally be carried out in the form of an embossing or laser marking.	The batch coding and indication of the best-before date done by means of minimal direct printing with other coding systems (e.g., ink-jet), provided that food-grade inks are used	Extensive direct printing on the packaging is disadvantageous, as released printing inks can impair the clarity of the recyclate or contaminate the recycling stream via released printing inks in the wash water.
ADDITIVES		• ultraviolet (UV) stabilisers • Acetaldehyde (AA) blockers	Acrylonitrile Butadiene Styrene (ABS)

[10]Silva SM, Medeiros ES, Galvão LS, Santos ASF. Characterization of adhesive content in post-consumer poly (ethylene terephthalate) bottles and assessment of its impact on poly (ethylene terephthalate) recyclability. Progress in Rubber, Plastics and Recycling Technology. 2023;0(0). doi:10.1177/14777606231152507

APPENDICES

APPENDIX 1: OVERVIEW OF KENYA PLASTICS PACT

The Kenya Plastics Pact is an ambitious, collaborative initiative that brings together businesses, governments, researchers, NGOs and other stakeholders across the whole plastic value chain to set time bound commitments to transform the current linear plastics system into a circular plastics economy.

This Plastics Pact aims to ensure that plastics never become waste by eliminating the plastics we don't need, innovating to ensure that the plastics we do need are reusable or recyclable, and circulating all the plastic packaging items we use to keep them in the economy and out of the environment.

The Kenya Plastics Pact has proposed a set of targets which serve as a framework and are derived from the overarching targets in the Ellen MacArthur Foundation's New Plastics Economy Global Commitment and adapted to the national context.

The following are the proposed targets to be achieved by 2030 in Kenya:

Eliminate unnecessary or problematic single-use plastic packaging items through redesign, innovation, and reuse delivery models.

100% of plastic packaging is reusable or recyclable.

40% of plastic packaging is effectively recycled.

15% average recycled content across all plastic packaging.

Kenya Plastics Pact

KENYA PLASTICS PACT

KENYA DESIGN FOR RECYCLING GUIDELINES FOR HDPE BOTTLES & JARS

2023

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HDPE BOTTLES AND JARS

High Density Polyethylene (HDPE) is a thermoplastic with a high strength-to-density ratio, which makes it useful for plastic bottles and jars. HDPE bottles and jars are also lightweight & food -and-beverage safe with careful choice of materials, and the translucent nature of HDPE bottles makes it possible for consumers to view the amount of product in them.
Additionally, HDPE bottles can be produced in all shapes, sizes, and colors.

Due to its moisture-barrier properties and chemical resistance, HDPE is used for many bottling applications, including milk bottles and containers for industrial chemicals, household cleaners, and detergents.

In Kenya, of the 23,006 metric tons of plastic packaging recycled annually, 19% consists of HDPE plastic packaging[1].

CURRENT HDPE BOTTLES AND JARS RECYCLING PROCESS IN KENYA

HDPE recycling starts with the separation process either at a collection centre/aggregation point or at the recycling plant and rarely at source.
HDPE is separated by grade (categorizing it based on its specific characteristics, such as thickness, density, or quality).
In the context of recycling, separating HDPE by grade helps ensure that only materials of similar properties are processed together. This allows for more efficient recycling and ensures that the resulting recycled HDPE products meet the required quality standards.

For example, HDPE containers used for food packaging may have different grade requirements compared to HDPE pipes used for industrial purposes.
By separating HDPE by grade, recycling facilities can better control the recycling process and produce recycled materials that meet the specific needs of different applications.

The plastic will then be thoroughly cleaned to remove debris or residual contaminants, such as dirt or liquid. Any impurities mixed in with the plastic would compromise the end product.

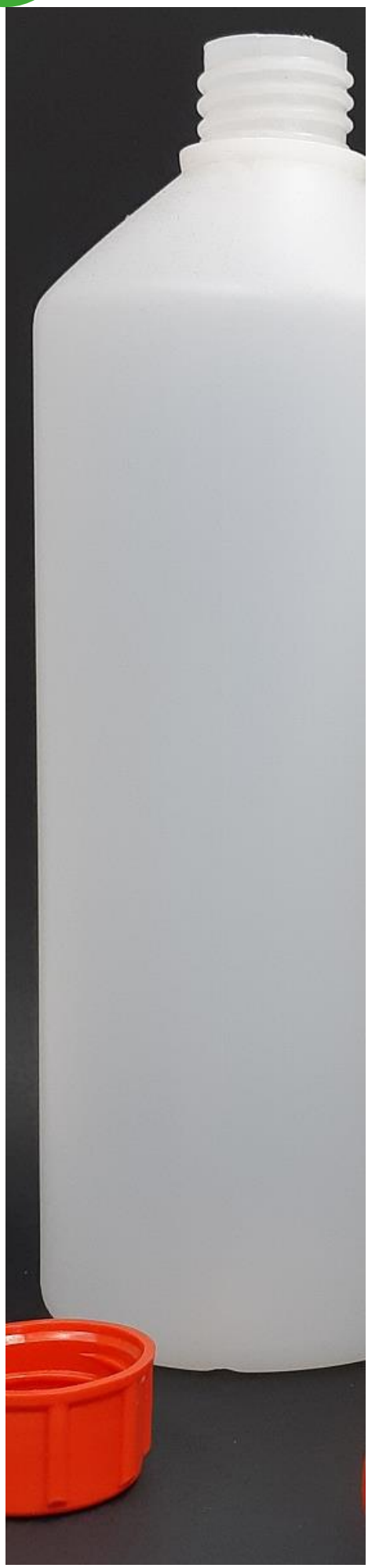
Sorting separates the HDPE products with other materials and polymers so that any other plastics mixed with it do not inhibit HDPE-specific recycling.

Sorting can be done through several methods. For instance, PET plastic can be isolated from HDPE through sink-float separation, where the different densities of these materials will float at different levels in a liquid.
With the HDPE properly removed from other plastics and debris, it then undergoes granulation; machines shred the HDPE and melt it down before reforming it into uniform granules, the basic building blocks of HDPE recycled products.

HDPE Bottle photo

[1]KAM (2019). Kenya Plastic Action Plan.

HDPE BOTTLES AND JARS



MATERIAL AND MATERIAL COMBINATION

HDPE bottles can be easily recycled into a wide range of products, including new HDPE bottles and plastic lumber. Manufacturers sometimes use a combination of these plastics to create products that require specific properties from each material.
For example, a container might be primarily made of HDPE for its strength and durability, while certain components or features of the container could be made of PP for its flexibility or heat resistance.

Achieving separation of HDPE and PP materials during the recycling process typically involves several steps.

1. First, sorting occurs at recycling facilities, where plastic waste is sorted based on material type, color, and other properties, using automated machines and manual labor.

2. Then, density separation methods like sink-float separation are used, where plastic flakes are placed in varying concentrations of tap water, ethanol solutions, and sodium chloride at serve as the densification medium. Polymers with densities lower than that of the medium float to the surface, while those with higher densities sink to the bottom. Complete separation of HDPE from PP is achieved when a concentration of 31% v/v is used. Recoveries of HDPE and PP occur for a density of the aqueous medium ranging from 0.935 to 0.955 g/cm^3[2] .

It's important to avoid using materials or material combinations that are not compatible with HDPE recycling, such as PVC or other types of plastics including PLA and PS that may contaminate the HDPE plastic and reduce the quality of the recycled material.

[2]Achilias DS, Roupakias C, Megalokonomos P, Lappas AA, Antonakou EV (2007) Chemical recycling of plastic wastes made from polyethylene (LDPE and HDPE) and polypropylene (PP). J Hazard Mater 149:536–542.

BARRIERS AND COATINGS

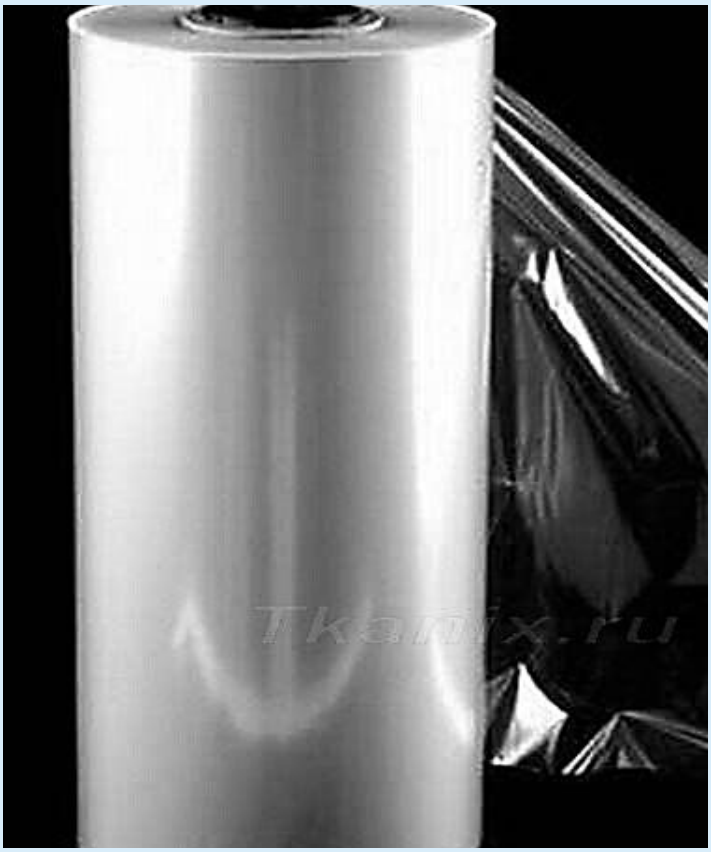
EVOH barriers are highly effective at preventing the penetration of oxygen and other gases, making them useful for packaging products that require a longer shelf life.

When HDPE bottles with high concentrations of EVOH are recycled, they tend to create impurities and lower the overall quality of the recycled material.
As such, EVOH concentration of more than 5 % can create issues such as increased melt viscosity, reduced melt strength, and increased sensitivity to temperature variations[3].

These factors can make it more challenging to process the recycled HDPE material effectively, leading to reduced quality and potential production issues. In that regard, EVOH concentration of less than or equal to 5% concentration is recommended.

Water-based coatings are applied to HDPE bottles to enhance their appearance and offer extra protection against scratches and other forms of damage.
These coatings, typically clear, are applied to the bottle's surface, resulting in a smooth and glossy finish. They are compatible with the recycling of HDPE bottles. When applied to untreated HDPE, water-based paint does not spread evenly. However, after plasma treatment, there is a noticeable improvement in surface adhesion, as indicated by the paint spreading more evenly across the surface[4].

Plasma treatment of HDPE does not directly affect its recyclability. Plasma treatment is typically used to modify the surface properties of HDPE, such as improving adhesion or wettability, without altering its bulk properties. However, if the plasma treatment introduces contaminants or additives to the HDPE that cannot be effectively removed during the recycling process, it may impact the quality of the recycled material. Therefore, proper handling and monitoring of plasma treatment processes are necessary to ensure that they do not hinder the recyclability of HDPE[5].



[3]Caroline Maes, Wout Luyten, Geert Herremans, Roos Peeters, Robert Carleer & Mieke Buntinx (2018) Recent Updates on the Barrier Properties of Ethylene Vinyl Alcohol Copolymer (EVOH): A Review, Polymer Reviews, 58:2, 209-246, DOI: 10.1080/15583724.2017.1394323

[4]De Leon, M. J., & Vasquez, M. (2021, October 1). Adhesion of water-based paint on plasma-treated high-density polyethylene sheets. Materials Research Express, 8, 105306.

[5]Mandolfino, C., Lertora, E., Gambaro, C., & Bruno, M. (2014). Improving adhesion performance of polyethylene surfaces by cold plasma treatment. Meccanica, 49.

CLOSURES (CAPS, SEALS AND LINERS)

CAPS

PP is a contaminate to the HDPE stream, but is marginally compatible with HDPE after melt blending and so HDPE based tubes that employ a PP closure are considered recyclable, but with a detrimental feature[6].

HDPE caps are also commonly used with HDPE bottles because they are made from the same material and have similar properties. They are compatible with recycling because they can be easily separated from the HDPE bottles during the recycling process.

It's important to note that caps made from materials such as PVC, PS, or PET are generally not compatible with HDPE bottles recycling and should be avoided. These materials can contaminate the recycled material and reduce its quality. Caps that are compatible with HDPE bottles recycling should have a similar density to HDPE plastic, which is between 0.940 and 0.965 grams per cubic centimetre (g/cm^3) . This means that caps made from materials with a density outside of this range may not be compatible with HDPE bottles recycling. For example, caps made from high-density polyethylene (HDPE) have a similar density to HDPE bottles and are therefore compatible with recycling. On the other hand, caps made from materials such as polyethylene terephthalate (PET) or polystyrene (PS) have densities that are outside of the range of HDPE plastic and are generally not compatible with HDPE bottles recycling.

[6]https://www.plasticsmarkets.org/jsfcontent/APRTubesDesign_jsf_1.pdf

[7]Aumnate C, Rudolph N, Sarmadi M. Recycling of Polypropylene/Polyethylene Blends: Effect of Chain Structure on the Crystallization Behaviors. Polymers (Basel). 2019 Sep 6;11(9):1456. doi: 10.3390/polym11091456. PMID: 31489944; PMCID: PMC6780393.

SILS

Seals are an important component of HDPE bottles and it's important to choose ones that are compatible with recycling. Here are some types of seals that are commonly used with HDPE bottles and are considered to be compatible with recycling:

Induction seals

Induction seals are a type of liner that is heat-sealed to the top of a bottle using an electromagnetic field. Induction seals are often made of aluminium foil or other materials.
Aluminum seals can be separated from HDPE bottles during the recycling process using various methods, including mechanical sorting and shredding. However, the presence of aluminum seals in HDPE recycling streams can pose challenges. If not properly separated, aluminum seals can contaminate the HDPE recycling process, affecting the quality of the recycled HDPE material.
Additionally, the presence of aluminum may also impact the mechanical properties of the recycled HDPE, potentially reducing its quality and suitability for certain applications.
Therefore, it's important to ensure effective separation of aluminum seals from HDPE bottles to maintain the recyclability and quality of the HDPE material.

Foam seals

Foam seals are often used with HDPE bottles to provide a tight seal and prevent leakage. Foam seals, particularly those made from polyethylene foam, are often used with HDPE bottles to provide a tight seal and prevent leakage.
Polyethylene foam is a type of plastic that is compatible with HDPE recycling processes. When HDPE bottles with foam seals are recycled, the foam seals can be separated from the HDPE material and processed accordingly. However, it's important to ensure that the foam seals are made from recyclable materials and are effectively separated from the HDPE bottles during the recycling process to maintain the quality and recyclability of the HDPE material.

Pressure-sensitive seals

Pressure-sensitive seals are a type of liner that is adhered to the top of a bottle using pressure. Pressure-sensitive seals are often made from materials such as polypropylene or polyethylene, which are compatible with HDPE recycling processes.

Expanded Polyethylene

Expanded Polyethylene (EPE) seals are often used with HDPE bottles to provide a tight seal and prevent leakage. EPE seals are typically made from expanded polyethylene foam, which is compatible with recycling. Expanded polyethylene foam is compatible with HDPE recycling, these EPE seals do not hinder the recyclability of HDPE bottles.

It's important to note that seals made from materials such as PVC or PET are generally not compatible with HDPE bottles recycling and should be avoided. These materials can contaminate the recycled material and reduce its quality.
Regardless of material, designs that require complete removal by the consumer of the safety sleeve are Preferred, as the material will not be introduced into the recycling stream[8].

[8]The Association of Plastic Recyclers. (2024). Liners and safety seals on closures.

LINERS

Liners are commonly used in HDPE bottles to provide a seal and protect the contents of the bottle.

PE liners

PE liners are often used in HDPE bottles because they are made from the same material and have similar properties.
They are compatible with recycling because they can be easily separated from the HDPE bottles during the recycling process.
PE liners do not significantly affect the recyclability of HDPE bottles. Since both materials belong to the same polymer family and have similar properties, PE liners can typically be recycled alongside HDPE bottles without causing significant issues.
However, it's essential to ensure proper separation of materials during the recycling process to maintain the quality of the recycled HDPE material.

PP liners

PP liners are also commonly used with HDPE bottles because they have a high melting point and are resistant to moisture and chemicals.
They are compatible with recycling because they can be easily separated from the HDPE bottles during the recycling process.
PP possesses a higher melting point compared to HDPE, enabling the utilization of thermal separation techniques.
By heating the mixture to a temperature where PP[9] can be effectively separated from the HDPE.

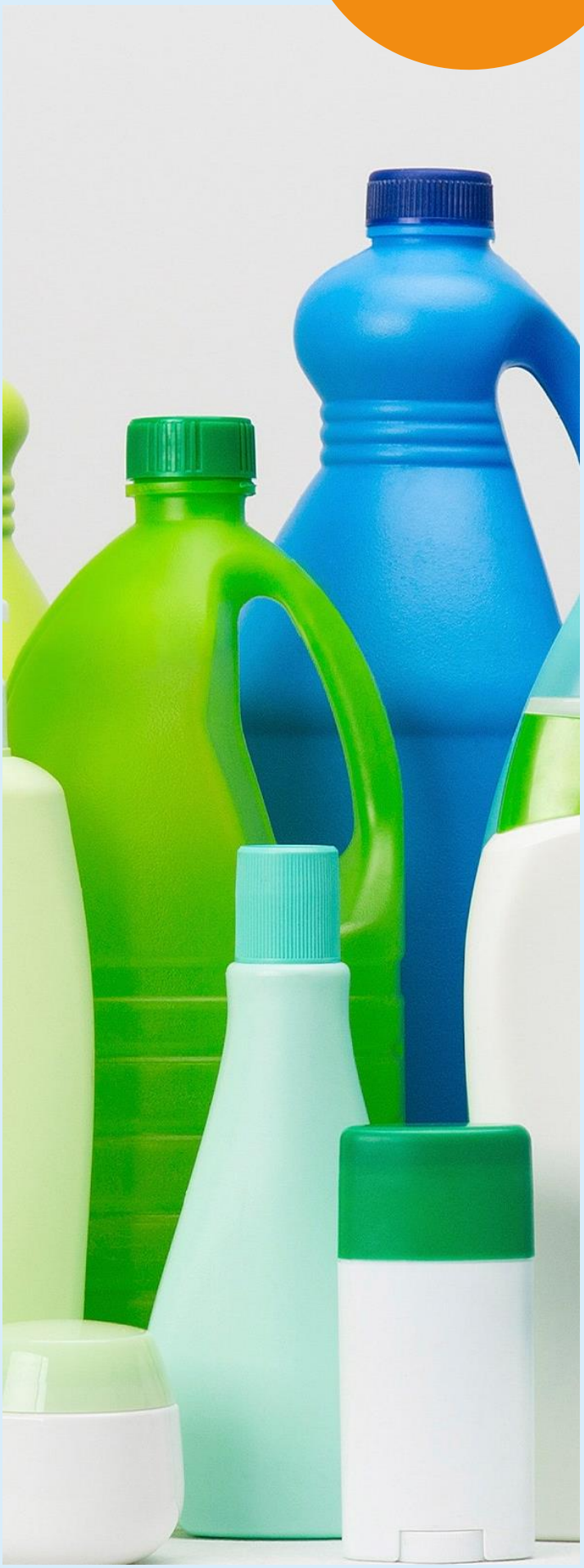
Alternatively, solvent separation methods involve the use of chemical solvents that dissolve PP while keeping HDPE intact.
Through careful selection of solvents, the liner can be dissolved, leaving the HDPE bottle behind.
Mechanical separation techniques, such as shredding or grinding, can also be employed to break down the bottle and liner into smaller fragments.
These pieces can then be sorted using density separation or other mechanical sorting methods to facilitate effective separation.

It's important to note that liners made from materials such as PVC or PET are generally not compatible with HDPE bottles recycling and should be avoided. These materials can contaminate the recycled material and reduce its quality.

[9]Sea Sky Medical (2021): Plastic Melting Temperature Chart.

COLOR

In Kenya, most recycling facilities accept HDPE bottles in natural or clear colour (translucent) for recycling.
This is because clear or natural HDPE bottles are easier to recycle and can be used to make a wider range of products compared to coloured HDPE bottles. It is financially affordable to recycle clear bottles and the recyclate is of high economic value.
Additionally, recycling facilities in Kenya also accept coloured HDPE bottles for recycling, but only certain colours.
The most commonly accepted colours for recycling in Kenya are blue, green, and brown. These colours are easier to sort and can be recycled into a range of products such as flower pots, outdoor furniture, and other household items.



However, coloured plastic packaging is much harder to recycle financially than clear plastic because there is very small need for the resulting recyclate that occurs when containers of all colours are combined.Natural material has the highest value as a recycled stream since it has the widest variety of end-use applications. It can be easily identified for food-grade end use applications.

Recycled unpigmented (natural) material holds the greatest significance due to its versatility across various applications, especially in food-grade contexts. HDPE is often pigmented, facilitating efficient processing and market demand for colored material.

Colored HDPE, meeting specific criteria, is particularly favored as it ensures recognition by NIR sorting technology in Material Recovery Facilities (MRFs), thereby enabling accurate sorting into the colored HDPE stream .

[10]The Association of Plastic Recyclers. (2024). HDPE Design Guidance.

LABELS

Choosing the right label for HDPE plastic bottles is important to ensure that the label does not interfere with the quality of the recycled plastic.
It's important to consider the type of adhesive, density as well as the label material, when choosing a label for HDPE plastic bottles.

Labels that are compatible with HDPE bottles recycling should be designed to be easily removed during the recycling process, without leaving any adhesive residue or contaminants that could interfere with the quality of the recycled plastic.
The compatibility of PE labels with HDPE recycling stems from their similar material composition, ensuring they can be effectively processed together.
Conversely, PP labels may pose a contamination risk, especially those with a density less than 1, as they resist separation through conventional sink-float methods.
Manual separation of such labels proves labor-intensive, underscoring the importance of employing easily separable materials in packaging design to streamline the recycling process.

The density of labels used on HDPE bottles can influence their compatibility with recycling. Generally, labels with lower density are more suitable for HDPE bottle recycling.

PE labels

PE labels typically have a density range of 0.93 to 0.97 g/cm^3, similar to that of HDPE plastic bottles, making them highly compatible with HDPE bottle recycling. They can be easily recycled alongside the bottles.

PP labels

PP labels, with a density range of 0.89-0.91 g/cm^3, are also compatible with HDPE bottle recycling due to their lower density. However, it's worth noting that they may not be as easily removed during the recycling process as PE labels.

Film labels

Film labels with a density exceeding 1.0 g/cm3, meant to remain stuck on HDPE containers during washing, pose challenges in recycling. When paired with non-releasing adhesives, these labels enter the extruder with HDPE, causing compatibility issues.

PVC film labels

PVC film labels cause problems by degrading at extrusion temperatures, rendering much recycled HDPE unusable. While PVC labels that release in the wash sink and are removed, any PVC entering the extruder causes severe quality issues.

Paper labels

Paper labels detach during washing, turning into pulp that burdens filtering systems. Remaining paper on HDPE carbonizes in the extruder, causing color defects. Non-pulping paper labels with non-releasing adhesives compound the problem. However, non-pulping labels with releasing adhesives may alleviate these issues .

[11] PlasticsEurope. (2024). Polyolefins.
[12] The Association of Plastic Recyclers. (2024). HDPE Design Guidance.

SLEEVES

Sleeves are commonly used as labels or decorations on HDPE bottles.

PE sleeves made from the same material as HDPE bottles are compatible with recycling. They can be easily separated from the HDPE bottles during the recycling process.

PP sleeves have a similar density to HDPE bottles and are therefore compatible with recycling. They can be easily separated from the HDPE bottles during the recycling process.

Sleeves made from PVC are generally not compatible with HDPE bottles recycling and should be avoided. These materials can contaminate the recycled material and reduce its quality.

INKS

Water-based inks

Water-based inks are made from pigments that are suspended in water and are a popular choice for printing on HDPE bottles. They are compatible with recycling as they can be separated from the HDPE bottles during the recycling process.
However, during the recycling process, HDPE packages with mixed colors are typically washed in water at room temperature using mild detergents. These conditions are unlikely to significantly affect inks and adhesives, with labels, inks, and adhesives expected to become part of the recycled HDPE product[13].

Metallic inks

Metallic inks contain metallic particles and are not recommended for printing on HDPE bottles. Inks containing heavy metals such as lead, cadmium, and mercury are not recommended for printing on HDPE bottles. They can contaminate the recycled material and pose a health hazard. Inks containing halogens such as chlorine and bromine are not recommended for printing on HDPE bottles. They can create toxic by-products during the recycling process and reduce the quality of the recycled material.

UV-cured inks

UV-cured inks are cured by exposure to ultraviolet light and are a popular choice for printing on HDPE bottles. They are also compatible with recycling as they can be easily separated from the HDPE bottles during the recycling process.

Solvent-based inks

Solvent-based inks are made from pigments that are suspended in solvents such as ethanol or acetone. They are also compatible with recycling as they can be easily separated from the HDPE bottles during the recycling process.

Oil-based inks

Oil-based inks are made from pigments that are suspended in oil and are not recommended for printing on HDPE bottles. They can contaminate the recycled material and reduce its quality.

[13]The Association of Plastic Recyclers. (2024). HDPE Design Guidance.

Water-based adhesives

Water soluble and water releasable adhesives are commonly used in packaging applications and can bond well to HDPE plastic. They can be easily removed during the recycling process. Water-based adhesives are also a good option for HDPE plastic bottles as they do not contain solvents that can interfere with the recycling process. They can be washed off during the recycling process without leaving any residue.

PVC based adhesives

Polyvinyl chloride (PVC) based adhesives should be avoided for HDPE plastic bottles because they contain harmful chemicals that can contaminate the plastic and make it difficult to recycle.

Rubber-based adhesives

Rubber-based adhesives can also be difficult to remove during the recycling process and can contaminate the HDPE plastic. These adhesives are often used for labels or to seal the cap to the bottle.

Pressure-sensitive adhesives

Pressure-sensitive adhesives are commonly used for labels and other materials on HDPE plastic bottles, but they can be difficult to remove during the recycling process.

These adhesives are designed to stick firmly to surfaces, so they can leave behind residue that can contaminate the plastic and make it harder to recycle.

Testing is essential to verify that adhesives can either be thoroughly washed off from HDPE during the recycling process or are compatible with HDPE material.

As standard HDPE recycling conditions may not entirely remove adhesive residue, some leftover adhesive is expected in recycled HDPE.

Any adhesive remnants left on HDPE after washing can result in contamination and color alterations during the recycling process. Therefore, it is recommended to minimize adhesive usage[14].

[14]The Association of Plastic Recyclers. (2024). HDPE Design Guidance.

DIRECT PRINTING

Direct printing on HDPE bottles is a process in which ink is applied directly to the surface of the bottle without using a label or sleeve.
This process is used to add text, graphics, or other design elements to the bottle, and is often used for branding or product identification.
Direct printing on HDPE bottles can be done using various printing methods, including screen printing, pad printing, and digital printing. Each method has its own advantages and disadvantages, depending on the desired outcome and the production requirements.

Direct ink printing on HDPE bottles can affect recycling in several ways.

1. First, direct ink printing can leave residual ink on the surface of the HDPE bottles, which can contaminate the recycled material. This can reduce the quality of the recycled material and limit its usability.

2. Secondly, direct ink printing can make it difficult to sort HDPE bottles by colour, which is necessary for many recycling processes.
   If the ink colour is the same as the HDPE colour, it can be difficult to distinguish between different types of HDPE bottles.

3. Thirdly, direct ink printing can make it difficult to separate the HDPE bottles from other materials during the recycling process. This can reduce the efficiency of the recycling process and increase the cost of recycling.

4. Lastly, direct ink printing may use inks that are not compatible with the recycling process. For example, inks containing heavy metals can contaminate the recycled material and reduce its quality. Inks applied through direct printing methods can potentially cause bleeding or discoloration of HDPE during recycling, or introduce contaminants that diminish the quality of the recycled HDPE. It is essential to conduct tests on the ink to assess its impact accurately. Businesses exploring direct printing technologies and uncertain about their recyclability should request test results from their suppliers[15].

[15]The Association of Plastic Recyclers. (2024). HDPE Design Guidance.

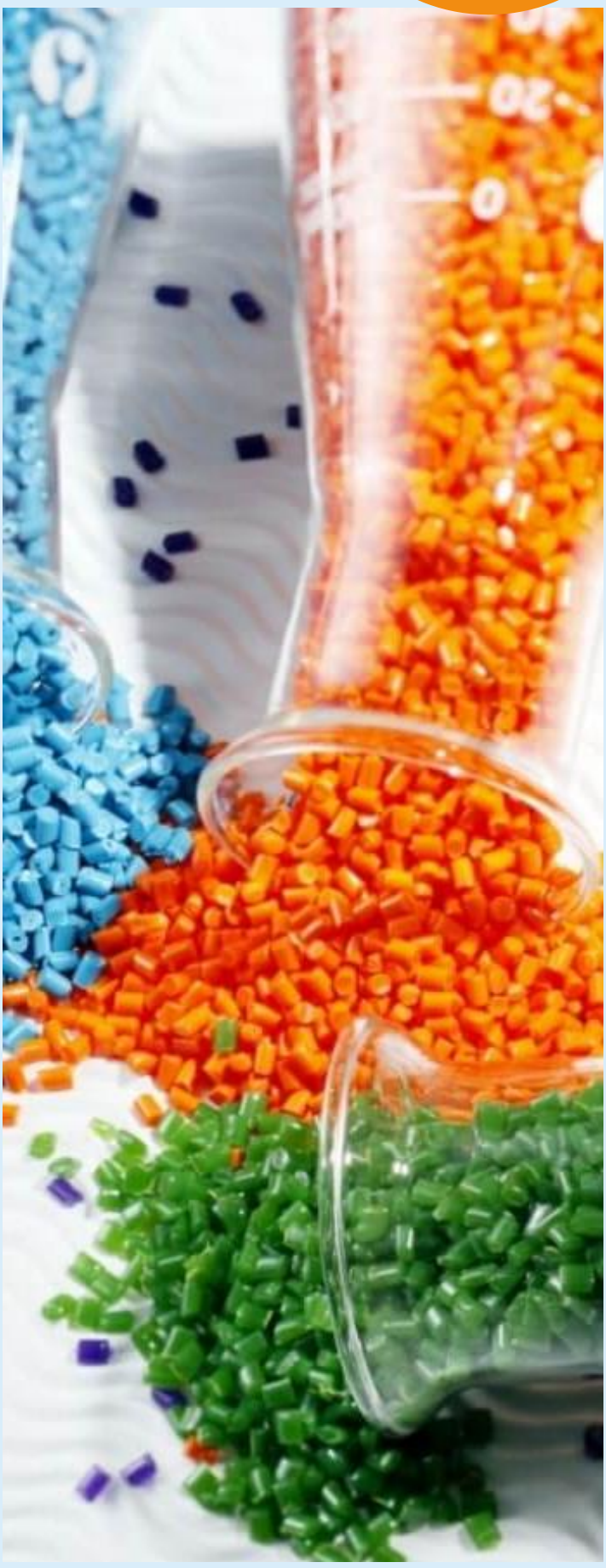
UV stabilizers

Additives are often added to HDPE bottles to enhance their properties and performance.

UV stabilizers help to protect the plastic from UV radiation, which can cause degradation and discoloration. UV stabilizers can be added to HDPE (high-density polyethylene) bottles during the manufacturing process to protect the plastic material from the damaging effects of UV radiation. To ensure compatibility with HDPE recycling, UV stabilizers should be carefully selected and used in moderation to avoid contamination of the recycled material.

Some commonly used UV stabilizers that are compatible with HDPE recycling include[16]:
$CaCO_3$ (calcium carbonate) is commonly used as a filler or extender in HDPE (high-density polyethylene) plastic products, including bottles.
While the addition of $CaCO_3$ can provide benefits such as improved stiffness, impact resistance, and reduced material costs, it can also have a negative impact on HDPE recycling.
The presence of $CaCO_3$ in HDPE can affect the mechanical and physical properties of the recycled material, including its melt flow rate, tensile strength, and impact resistance.

This can make it more difficult to recycle HDPE bottles containing $CaCO_3$ and may reduce the quality and performance of the recycled material. Additionally, the presence of $CaCO_3$ in HDPE can complicate the recycling process by causing equipment wear and tear, increasing energy consumption, and decreasing the efficiency of the recycling process. It also modifies the density which may cause sorting issues if the density increases >1.0g/cc.



[16]OECD (2021), Case study on detergent bottles: An example of weighing sustainability criteria for rigid plastic non-food packaging , OECD Series on Risk Management, No. 63, Environment, Health andSafety, Environment Directorate, OECD

SUMMARY OF DESIGN FOR RECYCLING GUIDELINES FOR HDPE BOTTLES AND JARS

ITEM		GREEN	YELLOW	RED
MATERIAL AND MATERIAL COMBINATION		Multi-layered HDPE, and PP		• Multi-layered PLA, PVC and PS • Multi-layered HDPE, and PP and PET.
BARRIERS AND COATINGS		EVOH barriers less or equal to 5% concentration.	Water based coatings	EVOH more than 5% concentration.
CLOSURES	Caps	PP HDPE		• PVC • PS • PET
	Seals	• Foam Seals • Induction seals • Pressure-sensitive • Expanded Polyethylene (EPE)		• PVC • PET
	Liners	PE	PP (very small amounts have very minimal negative impact on the HDPE flake)	• PVC • PET
COLOUR		• Clear colours • Yellow • Red		Dark colours
DECORATIONS	LABELS	• PVOH (polyvinyl alcohol) labels or other water-soluble materials. • Thermal transfer printed labels • Pressure-sensitive labels with removable adhesive.	PP labels	PVC labels
	SLEEVES	Sleeves in PE & PP (all with density < 1 g/cm^3)	Sleeves in PE, PLA, (all with density >1 g/cm^3)	• Aluminium sleeves • Metallised sleeves • PVC sleeves
	INKS	• Water based inks • Solvent-based inks • UV-cured inks • Non-bleeding inks.		• Oil based inks • Metallic inks • Inks containing heavy metals such as lead, cadmium, and mercury • Inks containing halogens such as chlorine and bromine • Inks that bleed
	ADHESIVES	Water soluble and water releasable adhesives.		• Pressure-sensitive adhesives • Rubber-based adhesives • Polyvinyl chloride (PVC) based adhesives
	DIRECT PRINTING	Production or best-before date		Any other direct printing
ADDITIVES			Calcium Carbonate (CaCO3.)	

APPENDIX 1: OVERVIEW OF KENYA PLASTICS PACT

The Kenya Plastics Pact is an ambitious, collaborative initiative that brings together businesses, governments, researchers, NGOs and other stakeholders across the whole plastic value chain to set time bound commitments to transform the current linear plastics system into a circular plastics economy.

This Plastics Pact aims to ensure that plastics never become waste by eliminating the plastics we don't need, innovating to ensure that the plastics we do need are reusable or recyclable, and circulating all the plastic packaging items we use to keep them in the economy and out of the environment.

The Kenya Plastics Pact has proposed a set of targets which serve as a framework and are derived from the overarching targets in the Ellen MacArthur Foundation's New Plastics Economy Global Commitment and adapted to the national context.

The following are the proposed targets to be achieved by 2030 in Kenya:

Eliminate unnecessary or problematic single-use plastic packaging items through redesign, innovation, and reuse delivery models.

100% of plastic packaging is reusable or recyclable.

40% of plastic packaging is effectively recycled.

15% average recycled content across all plastic packaging.

Developed By

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