# Preparation of display substrates using recycled plastic material

Haoran Hu

Unionville High School, Markham, Canada

Corresponding author: 350673844@gapps.yrdsb.ca

**Abstract.** With the intensification of environmental problems and people's attention to environmental issues, more and more people are discovering the seriousness of the environmental hazards of plastics. The mainstream and most common solution in the world today is recycling. OLED displays and flexible displays, which are used as screens for folding cell phones because of their foldable nature, are also very popular in the market. This article describes how to recycle and purify different types of plastic products according to their type, and reuse the recycled plastic products to manufacture OLED displays as well as their plastic substrates for environmental purposes. The ultimate vision for this chain is that within the next 20 years, there will be a single chain that will reach the point where recycled plastics can be recycled and completely used for production in an optimal way to achieve carbon neutrality.

**Keywords:** Recycled Material, OLED display, Plastic.

## 1. Introduction

On a worldwide scale, plastic pollution is pervasive. It may be found in seas, lakes, and rivers, as well as soil, the atmosphere, and even animal bodies. According to current estimates, 150–200 million tons of the 359 million tons of plastics generated yearly worldwide [1] end up in landfills or the environment [2].This proliferation is driven by the fast rise of plastic manufacture and consumption, as well as people's lack of understanding of plastic pollution. There is no unified worldwide waste management system, particularly for plastics, to securely dispose of plastics, and the difficulty of recycling plastics has resulted in an unavoidable rise in plastic pollution into the environment. According to studies, around 8 million metric tons of big plastics enter the seas each year. Plastic contamination on the continents has not been quantified. If plastic production grows at the current rate, the amount of poorly managed waste per year is expected to more than double by 2050. Despite studies showing the scale of plastic movement in the oceans, national efforts are needed if one is to come up with a solution to ameliorate the problem of plastic pollution, and a program for the reuse of pollutants is lacking.

A more obvious step for the use of recycled plastics is necessary to improve and expand the utilization of the recycling process, increase the money from recycling, and marginally reduce the cost of recycling. As a result, specific processes for recycling and reusing plastics must be established in order to address the demands and challenges of environmental protection and resource scarcity. There is currently a lack of information on the value of recycling, and there is a need to develop a unified standard for the most efficient recycling and use of plastic products due to uneven standards for plastic products across the world.

## 2. The most basic plastic recycling methods

### 2.1. Identify the various types of plastics

First of all for recycling plastics, we need to know how to distinguish between various types of plastics, here are a few common types of plastics. Plastic bottles, jugs, pots and trays. Plastic bottles of all types are usually made from two types of easily recyclable plastics - PET and HDPE. most plastic recycling companies will recycle this type of plastic, and people can also collect it at home recycling collections, or recycling centers. This type of plastic is the main type of plastic needed for

research. Recently, some supermarkets and retailers have started to ban the use of plastic bags. This means that people have less access to this type of plastic as well, but this is still one of the main types of plastic for environmental pollution as well as ocean pollution, so recycling and using this plastic is very necessary. Once the types of plastics are distinguished, they need to be recycled. The traditional types of plastics that are recycled.

There are several varieties of plastics. As a result, recycling all plastics in the same way is difficult. However, there are two ways to recycle plastics. Mechanical recycling is another name for conventional recycling. This process may be used to recycle thermoplastic materials. The classic technique of recycling includes melting the plastic and transforming it into a new plastic product. Recyclers melt the plastic and then use injection molding to turn it into a new product. Because high purity polymers are required in industrial manufacturing, this is not relevant in our investigation. Chemicals are used in advanced recycling, which breaks down plastic materials. This strategy consists of three distinct steps. These methods include pyrolysis, chemical recycling, and vaporization. Plastic trash may be converted into crude oil through a process called pyrolysis. Polymers are broken down chemically into monomers that can be utilized to create new products. The suitable screen plastic is then created in this article using this polymer. Traditional and sophisticated recycling both have advantages. The implementation of any of these two strategies, however, is dependent on the facilities available. The plastic required to create the screens, for the purposes of this essay, also leads to the characteristic that only advanced recycling may be employed.

### 2.2. A step-by-step process for recycling plastic

Making new plastic items is more challenging than recycling existing plastic. But it necessitates exacting standards and close attention to detail. These procedures may take months.

### 2.3. Six basic steps for recycling plastic materials.

The first step in plastic recycling is to collect used plastic products. While this process may seem easy, it is not entirely so. The problem with this stage is that people are not very good at recycling their waste. Sometimes, people do not sort plastic products effectively after use, which results in a large percentage of waste plastics not being recycled well. At the end of the collection process, factories receive the collected waste plastics, where they are sorted by type. As mentioned earlier, different types of plastics will be sorted differently and the plant will know which type the collected plastic belongs to for subsequent recycling. After sorting the plastic, the plant will wash the material. These impurities include food residues, glues and other chemicals. Cleaning is paramount, especially for the screens produced in this article using recycled plastic, to ensure maximum purity of the recycled plastic. Cutting the plastic is done after cleaning the plastic. Because recycled plastic requires smaller plastic pellets, the washed plastic is placed in a shredder. Plastic that has been shredded into smaller pieces is easier to process. Some metal elements can also be separated at this stage. After the sizing is completed, the plastic material must be identified and separated. Therefore, the plastic pellets are subjected to testing. The plastic substance is then separated and further processed according to its properties. During this process, several qualities are evaluated. Density is one of these qualities. To assess the density of the plastic, these plastic pellets are placed in a container filled with water. Plastic pellets that sink have a lower density than those that float. This process also determines the plastic's other properties, such as its color and melting point. Recycling workers examine plastic samples to assess the melting point and color of each substance. Compounding involves melting the plastic pellets to create new pellets. This step is where recyclers convert the plastic pellets into a material that the manufacturer can replicate. This process is also known as extrusion.

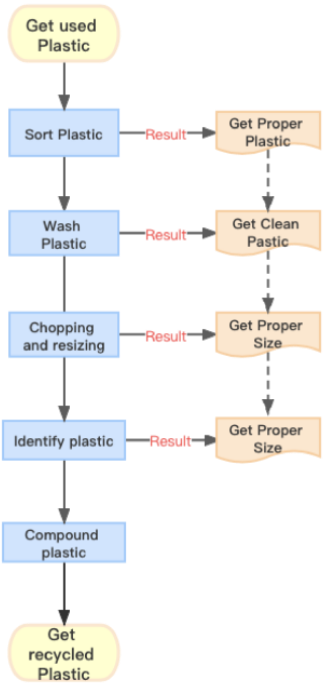


**Fig 1.** Seven steps to recycling plastics

## 3. Main ways of collecting waste plastics

The most prevalent polyester plastic is polyethylene terephthalate (PET), which is manufactured in over 70 million tons yearly for packaging and textiles globally [3]. PET is mostly recycled via thermodynamic methods, which results in a large thermal energy loss [4]. New synthesis techniques are being applied at the current technical level, yet PET waste is building up. The chain's mobility is decreased, therefore PET is a very challenging polyester to hydrolyze [5]. Although a few PET hydrolysis enzymes have been discovered, their output is restricted [6-7]. PET has tremendous recycling potential, which is one of its most remarkable features. The most recycled plastic in the country, PET bottles and containers are recycled in the US on an annual basis to the tune of 1.5 billion pounds [8]. Numerous polymers are accepted by governments in North America and the Post-Axis. To achieve this, locate the number "1" in a tiny triangular mark on the container's bottom or side. Since PET is highly recyclable, it may either be chemically disassembled into its raw constituents an

### 3.1. PET collection and sorting

Post-consumer PET products are collected curbside using single-stream and dual-stream systems. Furthermore, recyclable materials such as PET may be separated from other recyclable materials and packed for shipping to PET recycling operations at material recovery centers. Proper packing handling and storage practices, like with other waste products, should be stressed in order to reduce product contamination. Before being transported to a bale breaker on a conveyor belt, they might be staged. The bottles are then separated once the bundles have been deconstructed. Pre-washing this cloth is an option, and chemical and steam label removal are also options. Any polyvinyl chloride (PVC) bottles will become somewhat brown during the pre-wash step after being run under hot water or through a hot air roller to make it simpler to identify and remove them during the manual sorting stage. Using near infrared (NIR) sorting technology, the pre-wash and label removal procedure removes other contaminants to make it simpler to identify certain products. Metal detectors and hand-sorted tapes are a couple of the other technologies employed [9].

### 3.2. PET Recycle Process

Following sorting, the PET material is crushed into "flakes," which are little pellets. Maintaining the value of the recovered plastic depends critically on the purity of the flakes. Washing, air classification, and a water bath [10] in which the material sinks or floats, which assists in separating leftover foreign particles, are other separation processes. After using disinfectants and detergents, cleaning is done at normal or higher heat levels. The material is washed after separation to remove any remaining impurities or detergents. After being dried, the recovered PET is ready for further processing or use as manufacturing material [10]. The last stage is melt filtration, which rids the material further refined in the preceding phases of any non-melt impurities. Pellets will be created from extruded material; unmelted material will not be included. The material is uniformly sized and may be restored into the process of production thanks to the pellets.

## 4. A feasible solution for preparing displays using recycled plastics·

Organic light-emitting or organic LEDs, also called as bioelectroluminescent (organic EL) diodes, are light-emitting diodes (LEDs) with a thin layer of organic chemicals as the light-emitting layer that emit light in the existence of an electric current. That have at least single transparent electrode, this organic layer is placed between two electrodes. Digital displays are created using organic light-emitting diodes in devices like TVs, computer screens, and mobile gaming devices like smartphones. A significant field of study is on developing white OLED elements for solid-state lighting systems. OLEDs can be classified as either using polymers or small molecules. A light-emitting improved method (LEC) that functions a little differently can be created from an OLED, PMOLED management controls every row (and line) inside the display gradually, one at a time, whereas AMOLED control accesses and switches each individual element instantly using a skinny transistor (TFT) backplane, leading to greater resolution and bigger display sizes. Doping in LEDs modifies the host semiconductor's conductivity to produce p- and n-regions. In OLEDs, p-n structures are still not employed. Additionally, doping affects the spectrum of photon emission. Since OLED displays emit visible light, they do not need a backlight. Since it is smaller and lighter than liquid crystal displays, this can portray deep black depth (LCDs). OLED panels may provide better contrast than LCDs in low-light environments (like a dark room), regardless of whether the LCD utilizes cold-cathode florescent or LED backlights. The process of making an OLED display is similar to that of making an LCD, but once the TFT (for active matrix displays), installable grid (for passive array displays), or indium tin oxide (ITO) segment has been formed, the display is entrapped with a pore injection layer, a transport layer, and an obstructing layer, and a light-emitting material after the initial 2 layers. It may then be decided to use ITO or metal as the cathode once again, A TFT layer, programmable grid, ITO segment, or metal anode can be used as the anode. The anode can also be constructed of ITO or metal. Both transparent and flexible OLEDs may be utilized to create displays for flexible smartphones and devices with optical mark sensors.

### 4.1. Material technologies

Ching W. Tang and colleagues at Eastman Kodak were the first to create effective OLEDs that used tiny molecules. This kind of device is typically referred to as an OLED, while the name SM-OLED is also in use. Organometallic chelates, conjugated dendrimers, fluorescent and phosphorescent dyes, and Alq3, are among the molecules frequently employed in OLEDs. A number of materials are used because they may carry charges. For example, triphenylamine and its derivatives are often used as the raw material for hole-transporting layers. Bright dyes can be chosen to emit light at different wavelengths, and compounds like perylene, situation or stimulus, and quinacridone derivatives are widely used. Alq3 has been used as an electron transport medium, a host for dyes which emit red and yellow light, in addition to a green emitter. Heat evaporation in a vacuum is typically used to create tiny molecule devices and displays. Because of this, compared to other processing processes, the production process is more costly and less useful for large-area devices.

Compared to poly(n devices, the vapour deposition approach allows for the generation of strictly controlled, homogenous films as well as the creation of extremely intricate multi-layer structures. The key factor contributing to the high efficiency of the tiny molecule OLEDs is the layer design's considerable flexibility, which allows for the formation of different electrical conduction and charge blocking layers. Coherent emission has been seen in a laser color dual SM-OLED device triggered in the sustained regime. The emission is practically diffraction limited and has a spectrum width equivalent to broadband dye lasers. One polymer molecule functions as the light-emitting element in the smallest OLED known to science. In order to create stronger light emissions, scientists are going to refine various materials. Lastly, this discovery represents the first step towards the creation of molecular-scale components with electrical and optical capabilities. A molecular computer may be built from similar parts.

### 4.2. A feasible solution for preparing displays substrate using recycled plastics·

Utilizing recycled plastic in electronics is crucial. The preparation of flexible display substrates may be done using recycled polymers, which can greatly lower the cost of producing displays and environmental pollution, according to an investigation into all electronic devices. For flat panel displays, researchers have created novel flexible fiber glass reinforced plastic (FRP) substrates. Making the coating resin confirms a nice smooth surface morphology. [11] The smoothness of the surface and the bond between the barrier and coating are key factors in the durability of moisture resistance. The barrier substrate's moisture penetration was less than the detection threshold of conventional measuring tools.

## 5. Conclusion

As environmental problems become more serious and people pay more attention to them, more and more people are discovering the seriousness of the environmental hazards of plastics. This article describes how to recycle and purify plastic products, and reuse the recycled plastic products to manufacture plastic substrates for OLED-based flexible displays. The whole process can use a large amount of recycled plastic to achieve the purpose of environmental protection.

## References

[1] Marcus Eriksen , Nikolai Maximenko, Martin Thiel, , et al. Plastic pollution in the South Pacific subtropical gyre - ScienceDirect[J]. Marine Pollution Bulletin, 2013, 68( 1–2):71-76.

[2] Roland Geyer, Jenna R. Jambecakand, Kara Lavender Law, use, and fate of all plastics ever made[J]. Science Advances, 2017, 3(7):1700782.

[3] Faisal Sheikh Khalid, Mohd Irwan Juki, Norzila Othman, et al. Pull-out strength of polyethylene terephthalate bottle fibre in concrete matrix[J]. Malaysian Construction Research Journal, 2017, 21(1):75-85.

[4] Kim, Ragaert, Laurens, et al. Mechanical and chemical recycling of solid plastic waste.[J]. Waste management (New York, N.Y.), 2017.

[5] Elke Marten, Rolf-Joachim Müller, Wolf-Dieter Deckwer. Studies on the enzymatic hydrolysis of polyesters. II. Aliphatic–aromatic copolyesters[J]. Polymer Degradation & Stability, 2005, 88(3):371-381.

[6] Ren Wei , Wolfgang Zimmermann . Microbial enzymes for the recycling of recalcitrant petroleum-based plastics: How far are we?[J]. Microbial Biotechnology, 2017, 10(6):1308.

[7] Fusako Kawai, Takeshi Kawabata & Masayuki Oda. Current knowledge on enzymatic PET degradation and its possible application to waste stream management and other fields[J]. Applied Microbiology and Biotechnology (2019) :4253–4268.

[8] Issra Mohmed Ayoob & P. E. Kavitha . Performance Analysis of CFS Encased Recycled Plastic Laminate Beam[J]. Proceedings of SECON’21 2022 :379-394.

[9] Jean-Paul Lange. Managing Plastic Waste-Sorting, Recycling, Disposal, and Product Redesign[J]. 20219 :15722–15738.

[10] Firas Awaja, Dumitru Pavel . Recycling of PET[J]. European Polymer Journal, 2005, 1453-1477.

[11] Hisashi Ito, Wataru Oka, Hideki Goto and Hideo Umeda1, et al. Plastic Substrates for Flexible Displays[J]. Japanese Journal of Applied Physics. Part 1, Regular Papers, Brief Communications & Review Papers, 2006, 45(5):4325-4329.