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Promoting Sustainability through the Recycling and Reutilization of Polyethylene Packaging

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Promoting Sustainability through the Recycling and Reutilization of Polyethylene Packaging

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Abstract. The outstanding performance and low carbon footprint of polymeric materials conflict with the sharp growth in plastic trash, which is why the current global plastics economy is largely linear. Reducing environmental problems requires a shift to a circular economy that keeps plastic in its most valuable state and encourages reduction, reuse, and recycling. The existing mechanical recycling procedures are constrained by cost, deterioration of mechanical qualities, and uneven product quality, but mechanical recycling is a crucial instrument in an environmentally and economically sustainable economy of plastics. Through the lens of a circular economy, it's important to properly sort and recycle (PE) packaging to ensure its maximum potential for reuse. In this paper it discusses the optimum ratio between the recycled and raw (LDPE) pellets in order to create a plastic packaging with the same mechanical, physical and chemical properties with less cost in comparison to the ordinary one. Fourier Transform Infrared Spectroscopy (FTIR) and Energy Dispersive X-ray Spectroscopy (EDX) were used to characterize both raw and recycled (LDPE) pellets. The environmentally friendly LDPE nano-particles in polymer packaging will be tested in the second experimental section, and the results will be compared with those of regular polymer packaging.

1. Introduction

Globally, there is an increasing need for plastics. It is anticipated that the yearly amount of plastic in circulation will increase from 236 million tons to 236 million tons by 2030. Because it stops the deliberate or accidental release of more polymeric materials into the environment, recycling or reusing plastics that are currently in use is essential to lowering environmental pollution. In 2016, only sixteen percent of the polymers in flow were gathered for recycling; the other seventy-five percent were burned and the remaining forty percent were dumped in landfills. A global push to convert the linear economy into a circular model is needed to meet consumption demands and protect the environment at the same time. The creation of novel feedstocks for the plastics industry has received a lot of attention in the field of sustainable polymers; nevertheless, many of these novel polymers find it difficult to satisfy the demanding demands of being inexpensive, scalable, and possessing unique qualities. Recycling needs to get better if full circularity is to be achieved, with zero land-filling of collected waste being the goal. The project aims to Reducing the total cost of both materials and process, Elimination of carbon dioxide emissions and decreasing the quantity of pure LDPE pellets. On plastic products, LDPE is denoted by the number "4" inside an arrow triangle. A thermoplastic polymer that is 100% recyclable, odorless, transparent, and flexible is called LDPE. It is frequently found in goods like cling wrap, juice containers, and grocery/garbage bags. The material experiences viscous shearing and thermal conduction applied to polymers inside an extruder, which causes thermo-oxidative and shear-induced chain scission, chain branching, or crosslinking. How effectively a plastic bag performs is determined by its intended use, which is to carry and transport goods like LDPE pellets in factories.

2. Sustainability

The 1987 Brundtland Report is credited with originating the idea of sustainability as a policy term. The contradiction between humankind's hopes for a better life and the constraints placed by nature was the subject of the written document. Over time, the idea has come to be understood in terms of three dimensions: social, economic, and environmental.

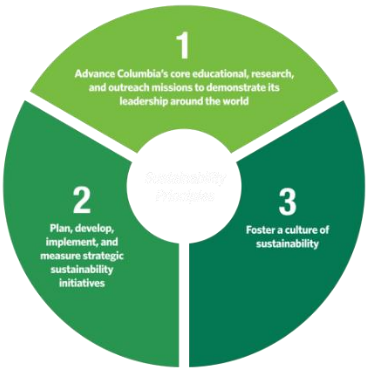

Figure 1. Sustainability principles

3. Recycling

The process of reclaiming scrap or waste plastic and turning it into useful products—sometimes entirely different from their initial form—has been referred to as plastic recycling. We use a lot of plastic, which is an extremely useful and well-liked material. Reducing the amount of plastic, we produce can be achieved by reusing and recycling items as much as possible [1]. This implies that we can preserve fossil fuels that aren't renewable (oil), Decrease the amount of energy used to produce new plastic, Lessen the quantity of solid waste dumped in landfill and lessen the number of gases, such as carbon dioxide, that are released into space.

4. Materials used in project

Raw LDPE pellets, Recycled LDPE pellets, HDPE, Calcium Carbonate as filler, Master Batch as color, Lubricant.

4.1 LDPE

Low Density Polyethylene (LDPE) is a thermoplastic polymer that is 100% recyclable, odorless, transparent, and flexible. It is widely used in products like juice containers, cling wrap, and grocery and trash bags. Due to its toughness, flexibility, and resistance to corrosion, along with its low cost and high efficiency of production, LDPE is a popular choice for engineering applications, which drives the annual production of millions of tons of the material [2]. On plastic products, LDPE is denoted by the number "4" inside an arrow triangle. A thermoplastic polymer that is 100% recyclable, odorless, transparent, and flexible is called LDPE. It is frequently found in goods like cling wrap, juice containers, and grocery/garbage bags.

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4.2 First batch preparation

The process began as adding 50 kg recycled white LDPE, 50 Kg of raw transparent LDPE and 50 Kg raw LDPE. Then mixing both quantities in a mixer to create the first layer which is without any additives or master batch, then start the second layer by mixing 10 Kg LDPE transparent, 20 Kg white LDPE, 30 Kg HDPE and 45 Kg filler in the mixer. Next step is to add the first layer and the second layer mix in the hopper in a blown film machine which has an extruder that melts the mix into a polymeric melt by setting the adequate temperature at 150°C ,followed by extruded this melt after adding lubricant to prevent the metallic contact and reduce the extrusion load into a bubble then it flattened by a nip rollers in order to make it into a flat sheet, then introduce an antistatic gun to remove the electric charge from the polymer packaging film. Last step is to use the spectrophotometer to ensure the desired width which is 45 cm.


Figure 2. Raw LDPE pellets

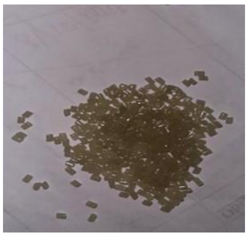
Figure 3. Recycled LDPE pellets


Figure 4. Mixer


Figure 5. Adequate temperature


Figure 6. First batch


Figure 7. Spectrophotometer

4.3 Second batch preparation

The procedure starts by adding 150 kg raw LDPE to generate the first layer. Then start the second layer by mixing 10 Kg LDPE transparent, 20 Kg white LDPE, 30 Kg HDPE and 45 Kg filler, 1 Kg black color master batch in the mixer. Subsequently, the first- and second-layer mixes are added to the hopper of a blown film machine. This machine has an extruder that melts the mixture into a polymeric melt by maintaining a temperature of 150°C. The melt is then extruded into a bubble and flattened using nip rollers to form a flat sheet. Finally, an antistatic gun is used to eliminate the electric charge from the polymer packaging film. The final step is to utilize the spectrophotometer to confirm that the 45 cm desired width has been achieved. Equipment utilized are Blown film machine, Spectrophotometer, Mixer, Antistatic gun.


Figure 8. Master batch


Figure 9. Second batch

4.4 Fourier Transform Infrared Spectrum (FTIR)

This At the Pharos University Pharmacy Facility in Alexandria, an FTIR Cary 630 (Serial No. MY16022005) was used for this test. This method obtains the infrared spectrum's absorption or emission from a solid, liquid, or gas. An FTIR spectrometer by chance gathers high-resolution spectral data over a wide variety of spectrums. This has several advantages over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time. The absorbed radiation is converted into vibrational and/or rotational energy by the sample molecules. The sample molecules transform the absorbed radiation into rotational and/or vibrational energy. The detector's final signal is a spectrum that displays the molecular fingerprint of the sample.

Figure 10. *FTIR Cary 630*

5. Characterisation

5.1 Energy-Dispersive X-ray Spectroscopy (EDX)

It's a method for determining a material's elemental makeup using X-rays. Applications include deformation, troubleshooting, materials and product research, and more. Using JSM- IT200 Series Scanning Electron Microscope. A spectrum of observed energies is formed when the detected X-rays are divided into energy channels according to how they interact with the detector. We may use the spectrum to pinpoint the peak energies, identify the electron transition that took place, and identify the element to which it corresponds. This was done at faculty of Science in Alexandria University.

Figure 11. EDX Scanning Electron Microscope**.**

5.2 Fourier Transform Infrared (FTIR) Spectroscopy

It allows for the partial characterization of vibrational bands associated with particular starch samples, much as the folding of amylose and amylopectin chains and the display of ratios between crystalline and amorphous materials. Figure 12 suggests that there was an observation of a broad band in the infrared spectrum, with two maximums at 2914.3 and 2847.1 cm^{-1}. These peaks or bands represents the functional groups that exists in the sample. The O-H does exist as the vibration rang is 3650 – 3000

cm^{-1}. The 2847.1 cm^{-1} peak represent the CH stretch of CH_3 Alkyl group. Figure 13 illustrates that there was an observation of a broad band in the infrared spectrum, with two maximums at 2914.6 and 2847.1 cm^{-1}.The peak at 2233.0 indicates the C-H double bond.

Carbon: It forms patterns; due to its electron configuration, it can form bonds with up to four additional atoms; it can bind to itself to form long, robust chains known as polymers. Titanium: (TiO_2) is the most commonly used pigment in plastics due to its excellent light scattering efficiency, inertness, thermal stability, dispersibility, and affordability.

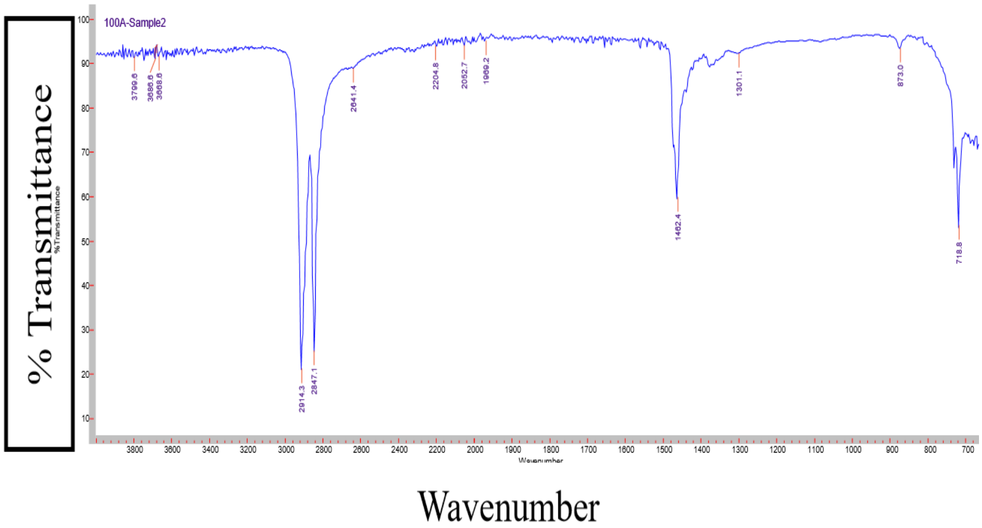

Figure 12. FTIR for the first batch

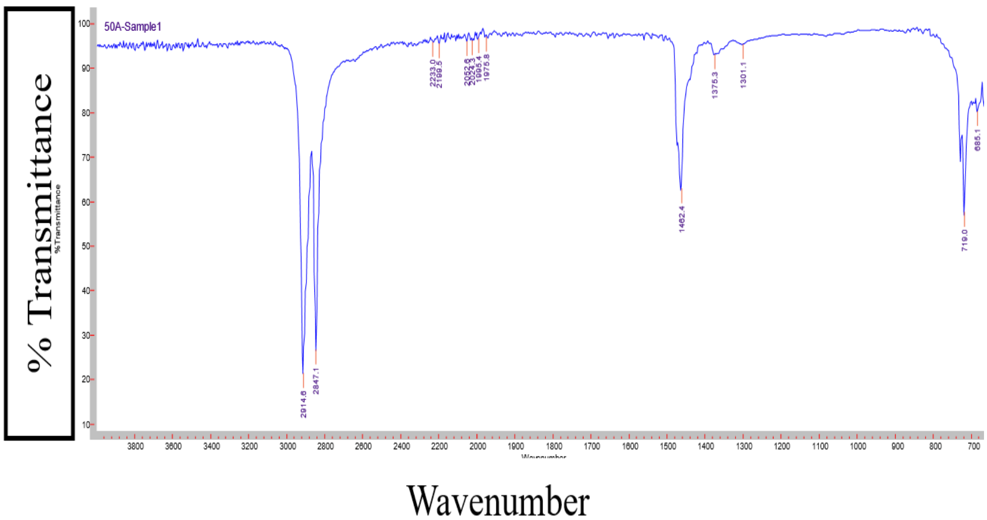

Figure 13. FTIR for the second batch

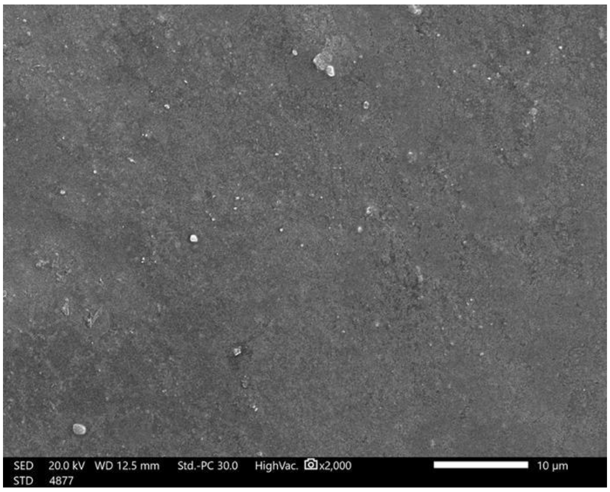

Figure 14. First batch at 2,000x shows filler content spots

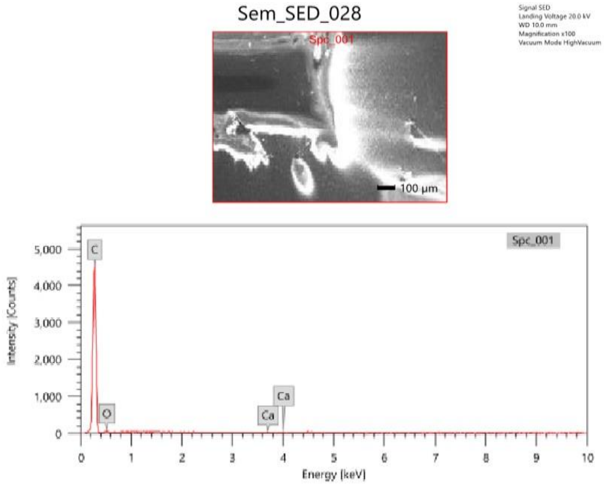

Figure 15. SEM for the first batch

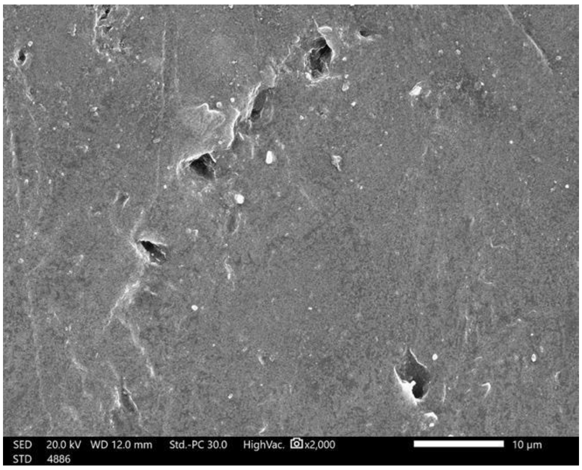

Figure 16. second batch at 2,000x

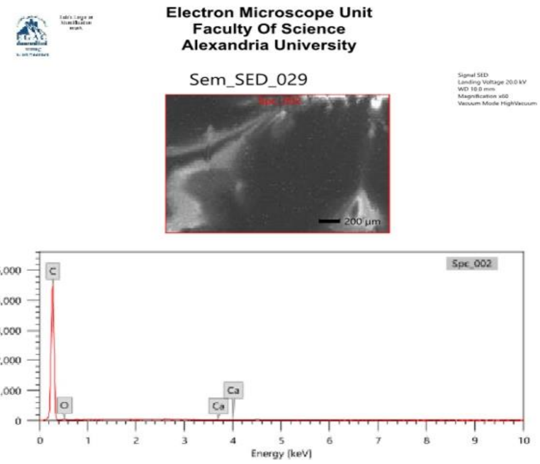

Figure 17. SEM for the second batch

6. Conclusion

Deterioration of material properties, expenses, and sorting problems are the main obstacles to effective mechanical recycling. The use of additives such as antioxidants, chain extenders, blending technologies, fillers, and plasticizers to minimize deterioration is made more difficult by the absence of standards for polymer grades and the additional diversity in recycle quality that these additions cause increased risk when industries incorporate large amounts of recycled content. It is important to take waste management systems into account while creating mixes, polymers, and mechanical recycling procedures. We need to better control the material life cycle of plastics and look for methods that can preserve their worth over time through reprocessing and repeated uses if we are to defend their continued usage, which we should. By maintaining this uniformity, we can reduce the amount of plastic we export, landfill, incinerate, and litter while also increasing recycling rates and product recycled content.

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