British Journal of Global Ecology and Sustainable Development
Volume- 40, May 2025
ISSN (E): 2754-9291

WASTE GENERATED DURING THE POLYETHYLENE PRODUCTION PROCESS AND THEIR RECYCLING METHODS

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Abstract
This article analyzes the types, origins, and properties of waste generated during the production of polyethylene using modern SCLAIRTECH technology, as well as methods for their utilization, recycling, and neutralization. The study identifies the sources, composition, and environmental risks of various waste streams, and evaluates the potential for their reuse as secondary raw materials. The results show that approximately 98% of the production waste can be repurposed either as an energy source or as industrial feedstock, highlighting the compatibility of SCLAIRTECH technology with sustainable, low-waste manufacturing practices. The article includes graphical and tabular data illustrating waste volumes, composition, and management mechanisms, making it a valuable resource for addressing contemporary environmental challenges in polymer production.

Keywords: SCLAIRTECH technology, polyethylene production, industrial waste management, waste recycling, environmental sustainability, secondary raw materials, polymer industry, waste utilization, green technology

Introduction

With the advancement of modern industrial technologies, ensuring environmental safety and waste-free production has become a pressing issue. This is especially relevant to the production of polymer materials, such as polyethylene, where the resulting waste and its negative impact on the environment require serious attention.
SCLAIRTECH is a highly efficient polyethylene production technology developed by the Canadian company NOVA Chemicals. It is primarily used for the production of low-density polyethylene (LDPE) and high-density polyethylene (HDPE).

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The polyethylene production process using the SCLAIRTECH technology is carried out in the following stages:

1.Monomer Preparation

The main raw material is ethylene (C_2H_4).
Comonomers such as butene-1, hexene-1, or octene-1 are often added to produce low-density polyethylene (LDPE).

2.Polymerization Process

Reactor type: This technology utilizes low-pressure loop or tubular reactors.
Catalysts: Ziegler–Natta or chromium-based (Phillips) catalysts are used.
Polymerization occurs at low pressure (20–50 bar) and low temperature (80–100°C).
During polymerization, ethylene molecules join together to form polyethylene chains.

3.Product Separation from the Reactor

At the reactor outlet, the resulting mixture (solution or suspension) is directed to a flash tank, where pressure is reduced and the polymer is separated.
The separated solvent, in either gaseous or liquid form, is directed to a recycling system.
The polymer is transferred for drying and further processing.

4.Polymer Pelletizing

The solidified polyethylene particles are turned into pellets using extrusion.
They go through specific drying and cooling stages.
The pellets are then packaged and delivered to the consumer.

5.By-product Processing

Gases or solvents formed during polymerization and suitable for reuse are directed to processing systems.
Polyethylene production using the SCLAIRTECH technology is known today for its high efficiency and relatively low waste levels. This technology includes measures at every production stage to identify, capture, and recycle waste as secondary raw materials.
This article analyzes the waste generated within this technology, their characteristics, quantity, composition, and potential environmental impact. For each type of waste, disposal, recycling, or neutralization methods are discussed, based on scientific approaches.
One of the advantages of the SCLAIRTECH technology is that about 98% of the waste is recycled as secondary resources. This is an important factor contributing to the environmental sustainability and industrial efficiency of this technology. In particular, furnace gases and liquid polymer waste released from the pyrolysis unit are processed as energy sources, while solid waste is used as a valuable raw material in cement production.

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In addition, substandard polyethylene, as well as gaseous and powder waste generated during production, are collected using specialized systems and sent to appropriate recycling stages. This ensures environmentally safe management of industrial waste.
Such approaches not only reduce production costs but also make a significant contribution to environmental protection. Therefore, this article includes an environmental analysis of the waste generated during polyethylene production using the SCLAIRTECH technology, as well as scientific and practical recommendations for their effective management.

Air Pollution and Environmental Risks. According to experts, about 4 million tons of harmful substances are emitted into the atmosphere of the Republic of Uzbekistan annually. More than half of this volume is carbon monoxide. In addition, the overall pollution structure includes 15% carbon emissions, 14% sulfur oxide, 9% nitrogen oxide, 8% solid particles, and 4% highly toxic substances (see Figure 1).

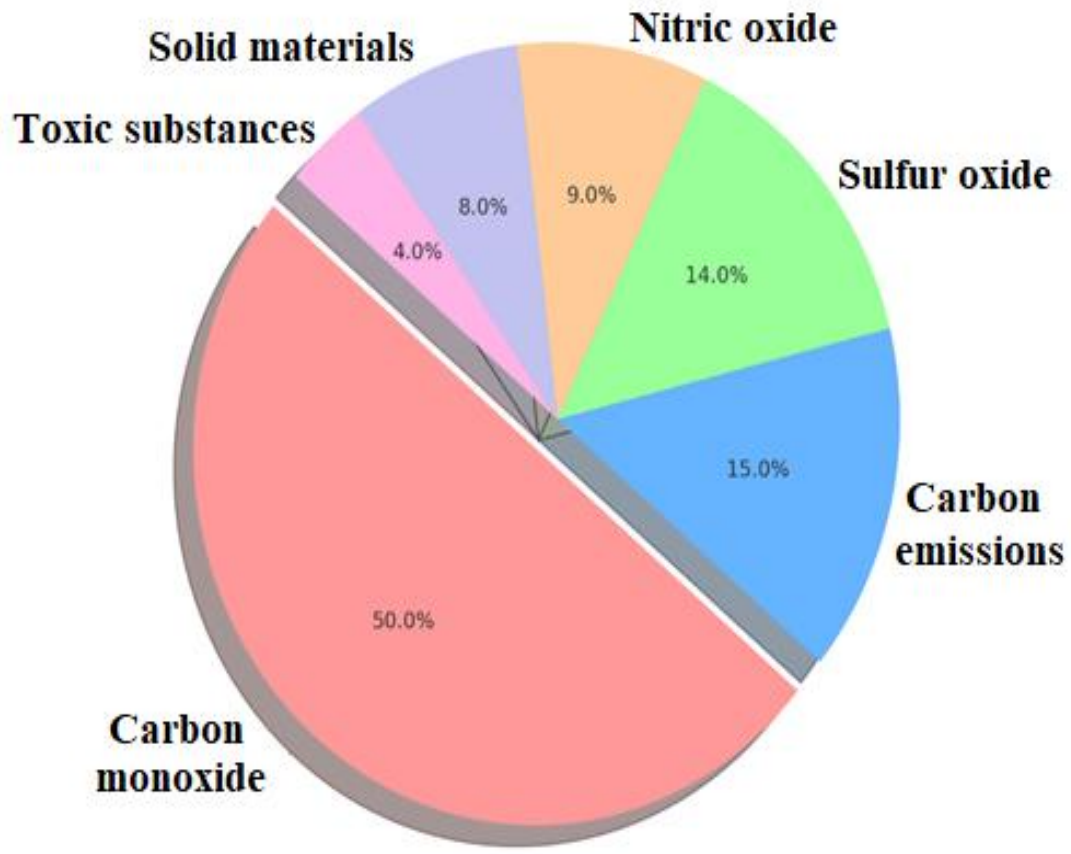

Figure 1. Distribution of Major Harmful Substances Emitted into the Atmosphere (Uzbekistan)

These gases intensify the greenhouse effect, which causes global climate change and contributes to the rise in Earth's atmospheric temperature.

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Types and Sources of Waste in the SCLAIRTECH Technology. In facilities operating under the SCLAIRTECH technology, waste is generated from the following sources:

Pyrolysis Furnaces – Blast furnace gas contains 120–150 mg/m³ of nitrogen oxide and 1 mg/m³ of sulfur oxide. Additionally, 300 kg of polymer oil is released daily, which is used in coking furnaces as raw material.

Purification and Evaporation Systems (Injectors) – During annual cleaning, 175 kg of wet carbon (coke) is generated, which is sent to a cement plant.

Cyclohexane Storage Tank – Emits 1.6 kg of gas per hour (78.6% nitrogen, 21.4% cyclohexane).

Catalyst Storage – During weekly purging, 315 kg of gas is emitted per hour (4.2% water, 92.8% nitrogen, 2.2% cyclohexane, 0.8% HCl).

Lubricant Polymer Waste – 1215 kg of waste is generated per hour (40% cyclohexane, 25% ethylcyclohexane, 5% low-molecular-weight polymers), which is incinerated in a steam generator.

Methods for Processing Solid and Liquid Waste. Annually, 165 tons of substandard polyethylene containing 91% PE and 9% water are generated. This waste is disposed of outside the production complex.

Additionally, 1,120 tons of aluminum oxide (Al_2O_3) are produced annually and sent to the clinker kiln of a cement plant.

During packaging, 600 tons of granulated polyethylene are lost each year, which are also recycled outside the complex.

Each year, 6,000 kg of polyethylene film and bags are consumed.

To destroy waste, the complex is equipped with an incineration unit capable of processing up to 200 kg of various types of waste per hour.

Efficiency of Waste Recycling and Disposal. Another advantage of the SCLAIRTECH technology is the ability to reuse up to 98% of waste as secondary raw materials. Most of this waste is reintegrated into the production process or used in other industrial sectors (Table 1).

A classifier separates non-standard pellets.

In the packaging department, the product is stored in tanks with a capacity of 10,000 tons.

Powdered polymers formed as a result of friction are also collected.

Polymers containing cyclohexane are released from the extruder, which is necessary to maintain product quality

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Table 1 Waste and methods of its processing with SCLAIRTECH technology

Waste source	Waste quantity	Processing method
Pyrolysis furnace	300 kg/day (oil)	Burned in a coke oven
Injector cleaning	175 kg/year (coke)	Sent to a cement plant
Cyclohexane tank	1.6 kg/hour (gas)	Emitted to the atmosphere
Catalyst container	315 kg/hour (gas)	It burns (flare)
Polymer lubricant waste	1215 kg/hour	It is burned in a steam generator
Low quality polyethylene	165 tons/year	Disposed of off-site
Al_2O_3 waste	1120 tons/year	Used in a cement plant
PE granules (bag rupture)	600 tons/year	Disposed of off-site
Incineration plant	200 kg/hour	It is ignited in an igniter
Extruder device	Regular small quantities	Forever separated, destroyed

Non-Recyclable Waste. Certain types of waste — particularly butene-2, monomolecular polymers, and catalyst residues — are considered technically and economically unsuitable for recycling. They are neutralized using specialized incineration methods. These are typically small volumes of waste that do not significantly impact the overall level of pollution.

In polyethylene production using the SCLAIRTECH technology, most of the waste is either recycled or utilized in other industries, thereby reducing environmental risks. The high level of waste management in this technology contributes not only to increased production efficiency but also to environmental protection.

Real-time separation, disposal, and reuse of waste as a resource is one of the most important tasks of modern industry.

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