Introducing light and heavy polyethylene and getting to know its manufacturing companies in Iran

Focus on familiarizing yourself with polyethylene

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***Abstract*— Polyethylene (PE), as one of the most widely used thermoplastic polymers in industry, is produced in two main forms: low-density polyethylene (LDPE) and high-density polyethylene (HDPE). Low-Density Polyethylene (LDPE) is characterized by its branched structure and low density (0.910–0.940 g/cm³), offering high flexibility, good chemical resistance, and excellent insulating properties. This polymer is produced via high-pressure radical polymerization and is widely used in applications such as soft packaging (films, plastic bags), flexible containers, and protective coatings.**

In contrast, High-Density Polyethylene (HDPE) features a linear structure with higher density (0.940–0.970 g/cm³) and greater crystallinity, resulting in superior mechanical strength, better thermal resistance (up to 120°C), and abrasion resistance. HDPE is primarily synthesized using Ziegler-Natta or metallocene catalysts under low pressure and is employed in the production of pressure pipes, rigid containers (e.g., milk bottles), toys, and industrial components.

Introduction

Polyethylene (PE) is one of the most widely used thermoplastic polymers in the world, which has a special place in various industries due to its unique properties such as chemical resistance, flexibility, and relatively low production cost. This material is divided into two main categories: light polyethylene (LDPE) and heavy polyethylene (HDPE), each of which has different molecular structure, production method, and applications.

The story of the discovery of light-weight polyethylene (LDPE) and heavy-weight polyethylene (HDPE)

In 1933, two English chemists named Eric Fawcett and Reginald Gibson were researching chemical reactions under high pressure at ICI (Imperial Chemical Industries). Their goal was to study the behavior of ethylene gas (C_2H_4) under unusual conditions.

They subjected ethylene to a pressure of 1,400 atmospheres and a temperature of 170 degrees Celsius. Unexpectedly, a white, waxy substance formed in the apparatus. Unfortunately, oxygen leakage into the apparatus caused the reaction to get out of control and the laboratory exploded.

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In 1935, their colleague Michael Perrin decided to repeat the experiment, but this time with careful purification of the ethylene and removal of oxygen, which made the result amazing. A flexible and transparent polymer called light-weight polyethylene (LDPE) was produced!
The discovery of HDPE has a different story, and is related to developments after World War II: in the 1950s, German chemist Karl Ziegler and Italian Giulio Natta developed the Ziegler-Natta catalyst. This catalyst allowed the polymerization of ethylene at low pressure and moderate temperature. Unlike branched LDPE, this method linked ethylene molecules in a linear and regular manner, producing a high-density polymer (HDPE). The discovery of LDPE and HDPE was not just a coincidence, but also showed how collaboration between chemists, engineers and industry can create revolutionary raw materials. Today, these polymers are the backbone of modern life, from water bottles to city pipes.

History of Propylene Production in Iran

Propylene (C_3H_6) is one of the most important raw materials in the petrochemical industry, used to produce polypropylene (PP), acrylonitrile (AN), propylene oxide (PO) and other petrochemical products. Iran, as one of the leading countries in the Middle East in the field of petrochemicals, has an interesting history in the development of propylene production.

The beginning of the petrochemical industry and propylene production (1970s)

- In 1964, with the aim of developing the petrochemical industry, NPC was established.
- The first Iranian petrochemical unit was in Abadan, which began operating in the 1970s in cooperation with foreign companies such as Mitsubishi of Japan. The complex mainly focused on the production of basic products such as ethylene and propylene.

Developments after the revolution and the war (1991s)

- The Iran-Iraq War (1970–1998) destroyed Iran's petrochemical infrastructure, but after the war, plans - In the 1990s, the Bandar Imam Petrochemical Complex (in Khuzestan Province) was launched with propylene and polypropylene production units. This complex is known as one of the main bases for propylene production in Iran.
- During this period, Iran collaborated with European and Asian companies such as BASF of Germany and Saipem of South Korea to localize propylene production technology.

Production leap with mega projects (1980s)

- Jam Petrochemical in Bushehr province became one of the largest propylene producers in the Middle East with advanced propane cracking (PDH) units and propylene production.
- Fanavaran Petrochemical (G Plus) launched a propylene production unit with a capacity of 450,000 tons per year in 1987 using American Lummus technology.
- Iran increased its propylene production in this decade and began exporting this product to countries such as China, India, and Turkey.

Self-sufficiency and sanctions (1990s)

- Severe Western sanctions against Iran (especially after 1991) limited access to advanced technologies, but Iran, relying on domestic engineering, implemented projects such as the Bu Ali Sina Petrochemical to produce propylene.
- In 2016, Kavian Petrochemical was introduced as one of the most modern units in the Middle East with a capacity to produce 550,000 tons of propylene per year.

- **Sustainable Development and New Technologies (2011)**
- Launch of the Bushehr Petrochemical PDH unit with a capacity of 600,000 tons of propylene per year.
- Development of Pars Petrochemical propylene production units in cooperation with foreign companies.
- Research on the production of propylene from non-fossil sources such as biomass is being conducted in cooperation with domestic universities.

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- With the lifting of some sanctions in recent years, Iran is exporting propylene to new markets such as Europe and Africa.

Challenges of propylene production in Iran

1. Restrictions on access to world-class catalysts and technologies due to sanctions
2. Propylene production processes, especially PDH, are energy-intensive
3. Shortage of propane as a raw material in some periods

The future of the propylene industry in Iran

- Iran plans to increase its propylene production capacity to 4 million tons per year by 1408.
- Focus on a circular economy by recycling polypropylene plastics.
- Cooperation with countries such as China and Russia to transfer advanced technologies.

Industrial applications of light-weight polyethylene (LDPE)

- Packaging industry: production of nylon films, plastic bags, and food protective coatings.
- Medical industries: manufacturing sterile containers and liquid transfer pipes.
- Agriculture: production of greenhouse coatings and mulch.
- Electricity industry: Cable and wire insulation.

Industrial applications of high-density polyethylene (HDPE)

- Pipe and fittings industry: Production of water, gas, and sewage pipes.
- Packaging: Production of milk bottles, detergents,and chemical-resistant containers
- Automotive: Manufacturing fuel tanks and interior parts.
- Construction: Manufacturing waterproof sheets and lightweight materials

Due to its access to oil and gas resources, Iran is one of the major producers of polyethylene in the Middle East and exports a significant portion of its products to global markets. Some of the major exporting companies are listed below:

Important companies producing light polyethylene (LDPE)

A. Jam Petrochemical Company: The largest petrochemical complex in Iran and the Middle East in the production of polyethylene (LDPE and LLDPE products)
B. Amir Kabir Petrochemical: LDPE products of various grades.
C. Marun Petrochemical Company: LDPE and EVA products

LDPE production complexes in Iran				
No.	**Petrochemichal Complex**	**Production Capacity (KTons/Year)**	**License**	**Production years**
1	Bandar Imam Petrochemical Company (2 Phase)	2*50	TOSOHCORP	1994 1995
2	Amirkabir Petrochemical Company	300	Bassell	2010
3	Laleh Petrochemical Company	300	SABTEC	2007
4	Aria Sasol Petrochemical Company	375	SABTEC	2008
5	Shazand Petrochemical Company (Arak)	75	BP	1994
6	JAM Petrochemical Company	300	Bassell	2008
7	Kurdistan Petrochemical Company	300	Lyondell Bassell	2015

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LDPE Projects under construction				
No.	**Petrochemichal Complex**	**Production Capacity (KTons/Year)**	**License**	**Year of Operation**
1	Negin Mahestan Kangan Petrochemical Company	90	MITSUI & Lyondell Bassell	2026
2	Ehda Polymer Pak	36	--------	2026

Important Companies producing heavy polyethylene (HDPE)

A. Kavian Petrochemical: HDPE and linear polyethylene (LLDPE) products
B. Bandar Imam Petrochemical: HDPE, polypropylene (PP), and other polymers products
C. Pars Petrochemical: HDPE products with special grades for pressure pipes
D. Tabriz Petrochemical: HDPE production for industrial use
E. Fajr Petrochemical: LDPE production
F. Zagros Petrochemical: Focus on HDPE

HDPE production complexes in Iran				
No.	**Petrochemichal Complex**	**Production Capacity (KTons/Year)**	**License**	**Production years**
1	Bandar Imam Petrochemical Company	150	MITSUI	1994
2	Amirkabir Petrochemical Company	140	BASELL	2002
3	Maroon Aria Sasol Petrochemical Company	300	Uhde	2005
4	Aria Sasol Petrochemical Company	300	BASELL	2008
5	Mehr Sasol Petrochemical Company	300	MITSUI	2009
6	JAM Petrochemical Company	300	BASELL	2007
7	Shazand Petrochemical Company (Arak	85	Hoechst	1994
8	Tabriz Petrochemical Company	100	BP	2006
9	Kermanshah Polymer Company	150	BASELL	2012
10	Ilam Petrochemical Company	300	MITSUI	2013

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HDPE Projects under construction				
No.	**Petrochemichal Complex**	**Production Capacity (KTons/Year)**	**License**	**Operation Time**
1	Olefin Bushehr Petrochemical Company	300	Petrochemical Research and Technology Company	2027
2	Kian Petrochemical Company	500	Lindeh	2031
3	Ethylene Rayan Polymer Pouya Company	300	--------	2027
4	Aria Sasol Petrochemical Company	300	Lyondell Bassell	2027
5	Soroush Mahestan Asaluyeh Petrochemical Company	300	MITSUI & Lyondell Bassell	2025
6	Negin Mahestan Kangan Petrochemical Company	300	MITSUI & Lyondell Bassell	2025
7	Kangan Petrochemical Development Company (Kangan Polyethylene-HDPE)	300	Mitsoui	2026

Light and Heavy Polyethylene Market Analysis

Current Market Status According to MarketsandMarkets (2023), the global polyethylene market was valued at approximately $130 billion in 2023 and is projected to reach $162 billion by 2028, with a CAGR of 4.5%.

Market Growth Drivers

- Growing demand in the packaging industry: growth of e-commerce and need for durable packaging.
- Infrastructure development: HDPE pipe manufacturing projects in developing countries.
- Attention to environmental sustainability: recycling of polyethylene and production of recycled granules (rPET and rHDPE).

Market challenges

- Fluctuations in crude oil prices (as a raw material).
- Environmental constraints of using single-use plastics.
- Competition with alternative polymers: such as polypropylene (PP) and biodegradable polymers.

Market opportunities

- Growing demand for polyethylene consumption in emerging economies such as India, Indonesia, and Nigeria due to rapid urbanization.
- Use of recycling technologies with the development of recycled polyethylene rLDPE and rHDPE as a solution to reduce carbon footprint.
- The green energy industry uses HDPE in the production of solar panels and wind turbines.

Future Vision

With increasing demand in sectors such as green energy (e.g. HDPE tanks for hydrogen) and medicine, light and heavy polyethylenes are expected to continue to hold a major share of the polymer market. Innovation in production technologies (e.g. ultra-high density polyethylene) and the development of hybrid polymers have also opened a new path for the industry.

Finally, LDPE and HDPE, as two basic materials in the plastics industry, play a vital role in modern life, but moving towards a circular economy and reducing the carbon footprint will be the main challenges facing manufacturers.


Major countries producing light polyethylene (LDPE)

1- China: The world's largest producer, focusing on the packaging and plastic film industries (companies such as Sinopec, PetroChina)
2- America: With the growth of petrochemical production from shale gas (companies such as Dow Chemical and ExxonMobil)
3- Saudi Arabia: SABIC is one of the largest LDPE producers in the Middle East, mainly exporting to Asian and European markets.
4- Germany: Polymer production hub in Europe with companies such as BASF and LyondellBasell.
5- Russia: Major production by Lukoil and Sibur, focusing on Eurasian markets.

Major countries producing high-density polyethylene (HDPE)

1- USA: World leader in HDPE production using cheap ethylene from shale gas (companies such as Chevron Phillips, Dow)
2- China: Mass production for construction, pipes and containers (companies such as CNOOC, Sinopec)
3- Saudi Arabia: SABIC and Aramco have increased HDPE production with huge petrochemical projects such as Sadara.
4- India: Rapid growth in HDPE production with companies such as (Reliance Industries) the world's largest petrochemical complex in Jamshidpur.
5- Iran: Significant HDPE production by companies such as Jam Petrochemical, Amirkabir, etc. with the aim of exporting to Asia and Africa and other parts of the world.

Other important countries include South Korea (LG Chem, Hanwha Solutions), Canada, (Nova Chemicals), Brazil (Braskem) and the United Arab Emirates (Borouge).

Major countries consuming low-density polyethylene (LDPE)

1- China: The largest global consumer due to high demand in the packaging, construction, and industrial manufacturing industries and rapid growth in the retail and agricultural sectors.
2- America: High consumption in the food packaging, medical products, and industrial manufacturing industries (large companies such as Amazon and Walmart create huge demand).
3- India: Consumption growth due to high population, retail development, need for cheap packaging as well as agriculture and irrigation systems also have a significant contribution.
4- Germany: European industrial hub with high consumption in the automotive, chemical, and luxury packaging sectors.
5- Southeast Asian countries (Indonesia, Vietnam, Thailand): Consumption growth in the agricultural sector (greenhouse films) and food industry

Major countries consuming high-density polyethylene (HDPE)

1- China: Main consumer of HDPE in infrastructure projects (water and gas piping), petrochemical production, and packaging.
2- America: High demand in the construction sector (pipes and fittings), automotive industry, and production of durable containers (companies such as P&G and Coca-Cola play a key role).
3- India: Rapid consumption growth due to infrastructure development (water and wastewater) and increased production of consumer plastic products.
4- Middle East (Saudi Arabia and UAE): Significant consumption in oil projects (oil and gas pipelines) and construction
5- Other important countries: Turkey (growing demand in construction and packaging industries), Russia (consumption in gas pipelines and urban projects), Mexico (automotive and packaging industries), South Korea (advanced petrochemical production).


Sources:

- MarketsandMarkets Reports (2023)
- World Polyethylene Forum (WPO)
- Polymer Science and Technology Journal
- Proceedings of the Middle East Petrochemical Conference (GPCA)