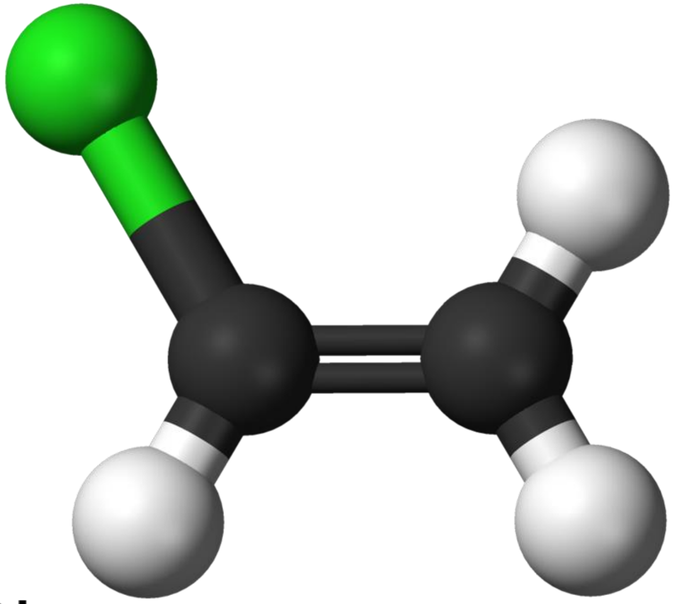
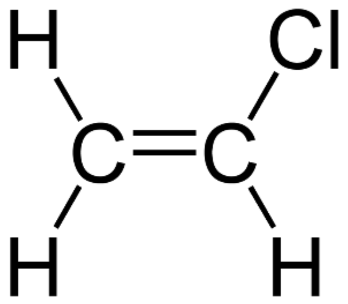
VCM
(Vinyl Chloride Plant)
&
PVC
(Poly Vinyl Chloride)
Processes

Contents

- VCM Process
- PVC Process
- Applications of VCM/PVC
- Market Scenario of PVC





Introduction

Vinyl Chloride Monomer (VCM) is a key building block in the production of **polyvinyl chloride (PVC),** one of the most widely used plastics in the world.

The VCM manufacturing process involves a series of intricate steps, from sourcing raw materials to the final packaging and shipping of the product.

This comprehensive overview will guide you through the various stages of the VCM production lifecycle, showcasing the attention to detail and innovation that goes into creating this essential industrial chemical.

Properties of Vinyl Chloride

Physical Properties

Diamond	Hazard	Value
	Health	2
	Flammability	4
	Instability	2
	Special	

VCM is a colourless gas, it is extremely flammable and unstable. It has a mild, sweet odour. The threshold for detecting odour is 3000 parts per million. VCM is soluble in many organic solvents but is not soluble in water. VCM is considered a volatile organic compound by the National Pollutant Inventory.

- Specific gravity: 0.9106
- Melting Point: -153.8
- Boiling Point: -13.4
- Relative vapour density: 2.2
- Flash point: -77.8

Chemical properties

VCM can polymerise rapidly due to heating and under the influence of air, light and contact with a catalyst, strong oxidisers and metals such as copper and aluminium, with fire or explosion hazard. As a gas mixed with air, VCM is a fire and explosion hazard. On standing VCM can form peroxides, which may then explode. VCM will react with iron and steel in the presence of moisture.

DETAILED PROCESS VCM MANUFACTURING

Raw materials

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Ethylene

The primary raw material used in the VCM manufacturing process is ethylene, a colorless, flammable gas derived from natural gas or crude oil refining.

Chlorine

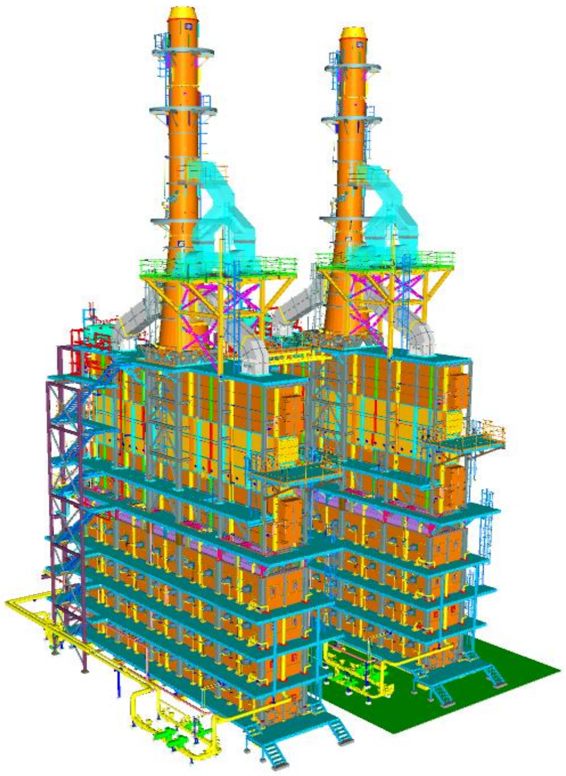
Chlorine, a greenish-yellow gas, is another essential raw material required for the chlorination and oxychlorination steps of VCM production.

Hydrogen

Hydrogen gas is used in the hydrogenation stage to remove chlorine from the intermediate products and produce the final VCM.

Ethylene is typically obtained from steam cracking of hydrocarbons, while chlorine can be produced via the electrolysis of sodium chloride (salt) in the chlor-alkali process.

EDC Cracking



1 Raw Material

The raw material for this process is typically Ethylene Di Chloride (EDC) Which is produced from Ethylene and Chlorine by addition reaction of from HCL, O2 and Ethylene by Oxychlorination

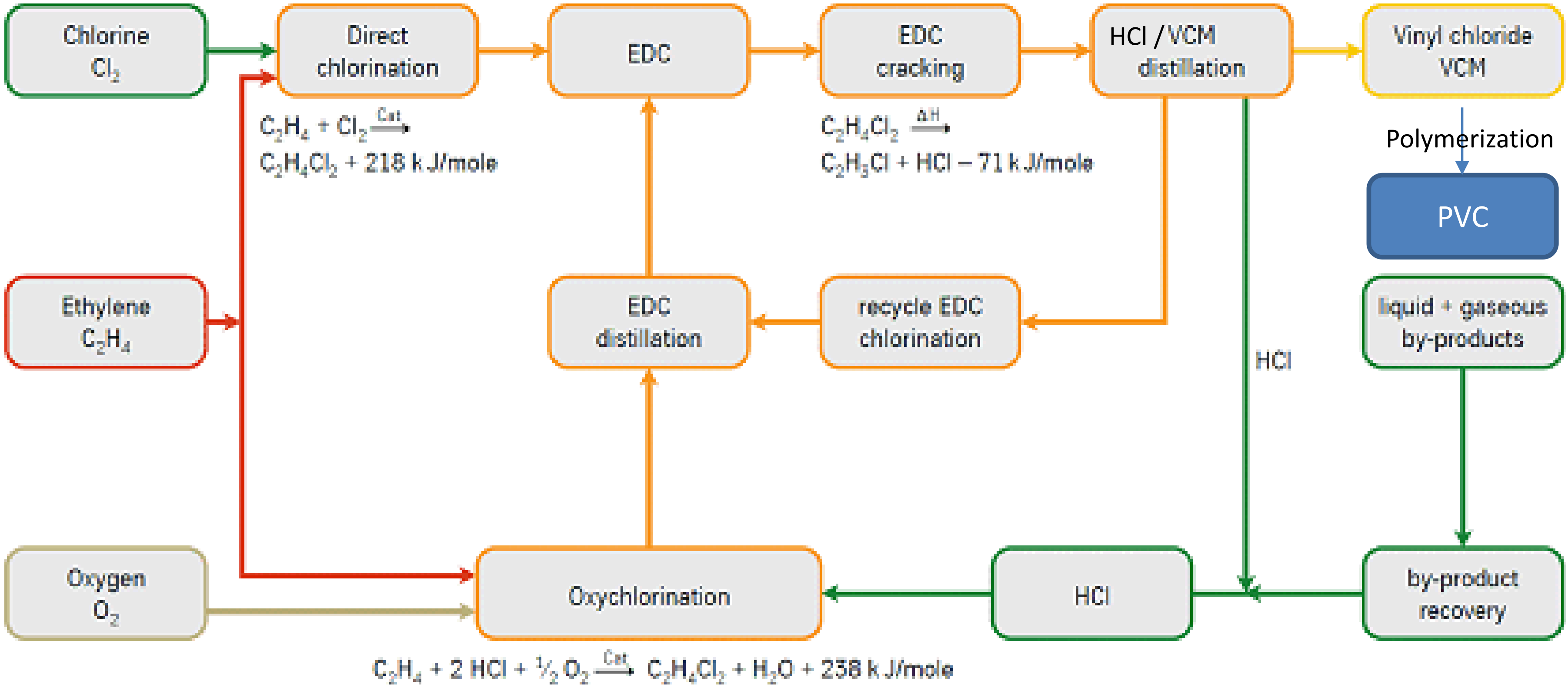
2 High Temperature Furnace

EDC is heated to extremely high temperatures, typically around 490°C, in a furnace to break down the ethylene dichloride into HCL and VCM.

3 Rapid Quenching

The hot gas is rapidly cooled to stop the cracking reaction and preserve the desired product.

Block Diagram



Process Description in Brief

EDC produced by direct chlorination can be sent directly to cracking unit whereas the EDC from the oxychlorination process has to pass a purification stage (EDC distillation) before cracking.

In the EDC cracking unit, EDC is cracked to VCM and hydrogen chloride (HCl).

These, together with any unconverted EDC, are separated in a HCL/VCM distillation unit.

The VCM, as final product, is sent to the next production stage or for polymerization with PVC Process to make PVC, which have many applications.

The HCl is returned to the oxychlorination unit and the unconverted EDC via EDC distillation unit to the cracking section.

Direct chlorination: $C_2H_4 + Cl_2$ ⇨ C2H4Cl2 + 218 kJ/mole

Oxychlorination: C2H4 + 2 HCl + ½ O2 ⇨ C2H4Cl2 + H2O + 238kJ/mole

EDC cracking: C2H4Cl2 ⇨ C2H3Cl + HCl – 71 kJ/mole

- Water obtained from oxychlorination process is stripped free of chlorinated hydrocarbons and treated in appropriate water purification plants.

- Waste gases as well as liquid by-products are fed to the HCl recovery unit and converted to HCl.

- The recovered HCl is re-used either for the production of hydrochloric acid, Calcium Chloride or in the oxychlorination process. This leads to a complete usage of the chlorine input.

Direct Chlorination

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1

Ethylene Feedstock

Ethylene, a flammable gas, is the primary raw material for chlorination.

2

Chlorine Addition

Chlorine gas is carefully added to the ethylene in a controlled environment.

Ethylene and chlorine gases are combined in a reactor under controlled conditions of temperature and pressure.

3

Dichloroethane Formation

The chemical reaction between ethylene and chlorine produces 1,2 dichloroethane (EDC), the key intermediate.

The reaction is exothermic and typically requires a catalyst, such as cuprous chloride (CuCl).

EDC Washing System

- The oxy EDC is treated to remove hydrogen chloride, chloroethanol and trichloroacetaldehyde (chloral).
- Hydrogen chloride is removed to prevent corrosion of the down-stream equipment, whereas the chloral and chloroethanol are removed to prevent the formation of an azeotropic mixture with EDC in the Light Ends column.
- Neutralization of the EDC in the caustic wash system is accomplished by mixing the EDC with a dilute solution of caustic soda.
- The desired outlet alkali concentration is maintained by continually adding a small quantity of fresh caustic solution.

Vinyl Chloride Formation

- Vinyl chloride is produced by the pyrolysis (thermal cracking) of purified ethylene dichloride (EDC) via a homogeneous gas phase reaction.
- An EDC molecule undergoes de-hydrochlorination, forming vinyl chloride and hydrogen chloride.
- The reaction is endothermic and requires the input of heat to sustain it.
- elevated temperature is needed and thereforTo get acceptably rapid conversion rates
- The practical operating range of the coil outlet temperature is 480 ºC to 510 ºC.

$$C_2H_4Cl_2 + \text{Heat} \Rightarrow C_2H_3Cl + HCL$$

EDC Cracking

Vaporized EDC is superheated in the convection section of the furnace and flows into the shock and radiant sections where cracking occurs at temperatures above 400 ºC

The furnace may contains parallel process coils. There are multiple burners on each side of the furnace.

A temperature controller (located on the furnace coil outlets) resets the set point of the fuel gas pressure controller that maintains steady the fuel gas header pressure regulating the fuel flow.

Quench

On leaving the reaction coil, the gaseous mixture of vinyl chloride, hydrogen chloride and unreacted EDC is quenched at the furnace outlet by a stream of liquid from the bottom of the quench column.

The cooled stream of vapor and excess liquid then returns as a two-phase mixture to the quench column.

Almost all of the entering material exits as overhead vapor from the column. However high boiling byproducts, small amounts of tar and coke concentrate up in the residual liquid.

Condensation

The quench overhead saturated vapour is condensed in two stages;

The condensed liquor from the first stage is primarily used as reflux for the quench column, whereas the uncondensed vapours are fed to the second stage where further condensation takes place.

HCL Column

The HCL column separates hydrogen chloride from EDC and VCM.

HCL is the top product vapour with EDC and VCM as a liquid bottoms stream.

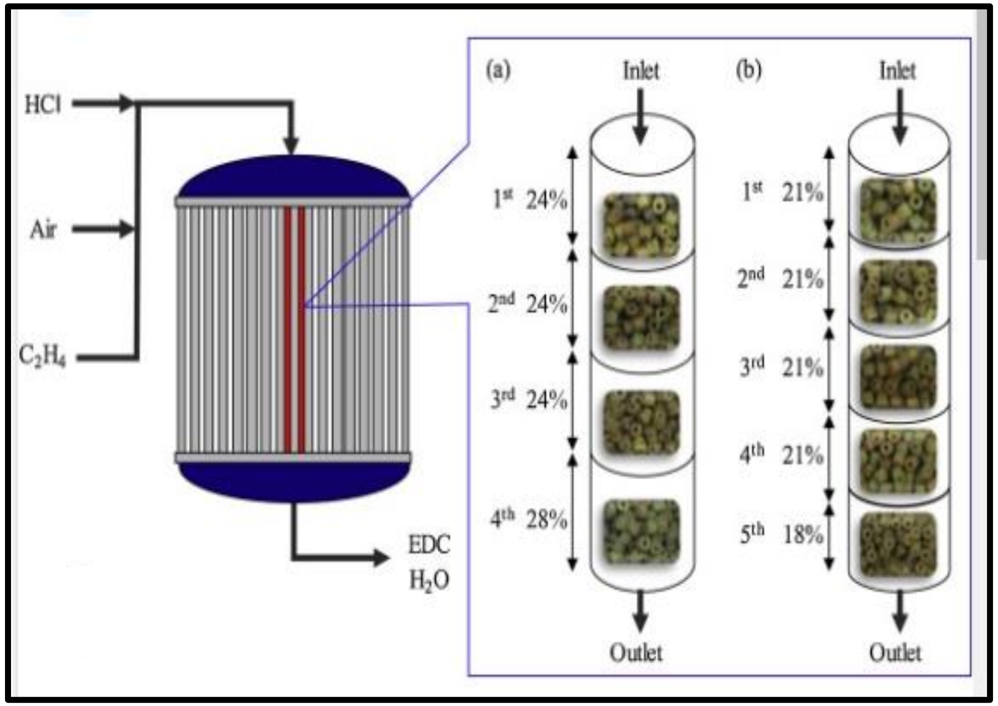
VCM Column

The Vinyl Chloride Column, provides purified vinyl chloride as overhead product and an EDC bottoms product essentially free of vinyl chloride.

Impurities such as butadiene, methyl chloride and vinyl acetylene will also finish in the top product; essentially all other components should be removed in the bottom product.

Oxychlorination Process Reactions

Oxychlorination is a process for generating the equivalent of chlorine gas (Cl_2) from hydrogen chloride and oxygen. This process is attractive industrially because hydrogen chloride is less expensive than chlorine



Mechanism

The reaction is usually initiated by copper(II) chloride ($CuCl_2$), which is the most common catalyst in the production of 1,2-dichloroethane. In some cases, $CuCl_2$ is supported on silica in presence of KCl, $LaCl_3$, or $AlCl_3$ as co-catalysts.

The reaction is highly exothermic (238 kJ/mol)

$CH_2{=}CH_2 + 2\ CuCl_2 \rightarrow 2\ CuCl + ClH_2C\text{-}CH_2Cl$

Other Distillation

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- **VCM Product Stripping**

Traces of HCL that are present in the product from the VCM Column are removed by distillation in the VCM Stripping Column C-230. This is a column with 30 trays. The preferred place for the feed is to tray number 26 because this serves to concentrate up an HCL rich stream in the top product.

- **Recycle EDC Column**

The Recycle EDC Column, C-240 is a 75-tray column whose main purpose is to remove by fractional distillation the heavy components from the Oxychlorination and Recycle EDC streams.

Emergency Vent Scrubber

- The Vent Scrubber C-253 is a column constructed in Vinyl Ester Resin with an internal liner. The trade names are Dera Kane 470 with an internal Halar liner.

- A vent stack is mounted on top. The dry and wet relief headers enter the column separately in the bottom.

- In addition to receiving the emergency vent discharges the scrubbing tower C-253 may be set up to receive also those vent gas streams diverted from the Vent Gas Incinerator in the case of an incinerator trip; however, that arrangement is the responsibility of those designing the incinerator system.

Distillation

The VCM manufacturing process includes a critical distillation step to **separate** and **purify** the vinyl chloride monomer.

During distillation, the reaction mixture is heated and the components are vaporized and then condensed based on their different boiling points.

This allows the vinyl chloride to be isolated from other byproducts and impurities, ensuring a high purity final product.

Hydrogenation

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1

Hydrogen Gas

Introduce hydrogen gas into the process

2

Catalyst

Use a nickel-based catalyst to facilitate reaction

3

High Temperature

Heat the mixture to 200-300°C

The hydrogenation step involves reacting the chlorinated compound with hydrogen gas in the presence of a nickel-based catalyst. This process takes place at high temperatures, typically between 200-300°C, and results in the removal of chlorine atoms and the addition of hydrogen atoms to the molecule. This is a crucial step in the overall VCM manufacturing process.

DETAILED PROCESS PVC MANUFACTURING

INTRODUCTION TO PVC

- Polyvinyl Chloride (PVC) is a synthetic polymer widely used in various industries due to its versatility and durability.
- It is a thermoplastic polymer derived from the polymerization of vinyl chloride monomer (VCM).
- PVC is renowned for its excellent chemical resistance, electrical insulation properties, and affordability.
- Its widespread use can be attributed to its adaptability to different manufacturing processes and its ability to be formulated with various additives to meet specific application requirements.

SCOPE OF PVC INDUSTRY

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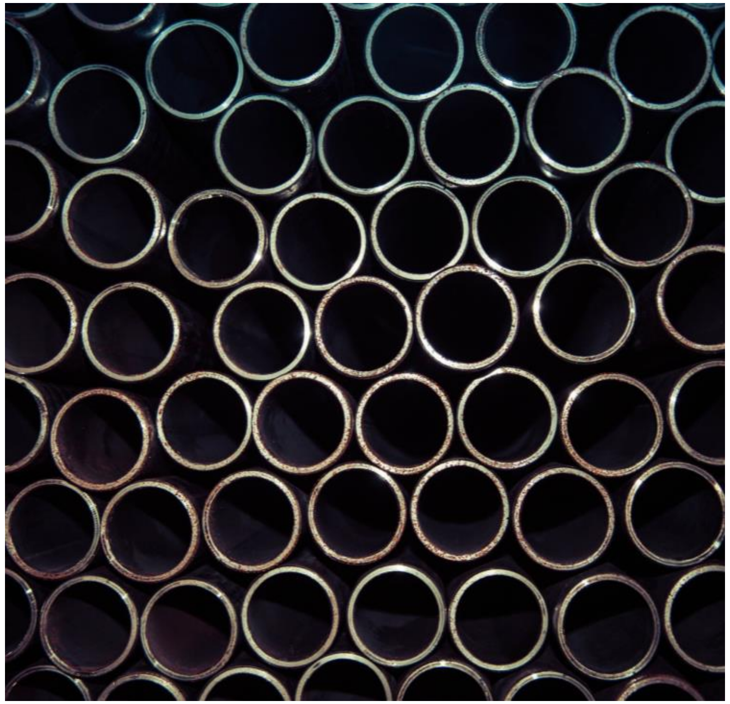
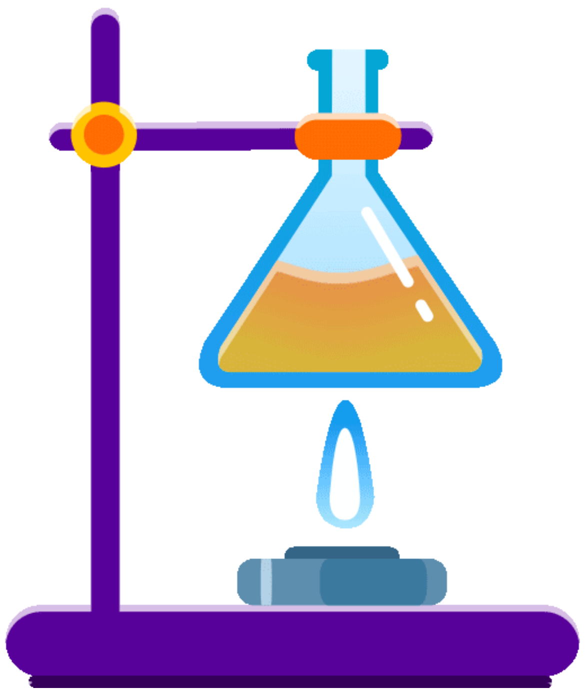


- PVC finds widespread scope in both domestic and global market.
- PVC finds application in pipes and fittings.
- It is light weight, flexible, safe material, flame resistant so finds wide application

RAW MATERIAL

- PVC is produced from two primary raw materials:

  Ethylene (derived from petroleum or natural gas) and
  Chlorine (obtained from sodium chloride through the chlor-alkali process)



POLYMERIZATION IN VCM

Starting Material:

Vinyl chloride monomer (VCM) is the key building block for polyvinyl chloride (PVC) production.

VCM is typically synthesized through the thermal cracking (pyrolysis) of ethylene dichloride (EDC), a process that occurs after the chlorination step in PVC manufacturing.

Pyrolysis Reaction:

EDC undergoes thermal decomposition at high temperatures (~500-600°C) to produce VCM and hydrogen chloride (HCl) as by-products.

SUSPENSION POLYMERIZATION & EMULSION POLYMERIZATION

Suspension polymerization is a type of radical polymerization in which mechanical agitation is used	Emulsion polymerization is a form of radical polymerization which usually starts with an emulsion
Essential components are dispersing medium, monomer(s), stabilizing agents and initiators	Essential components are water, monomer and a surfactant
Polymer exists as a sphere suspended in the medium after the formation	Formed polymer can easily be separated and purified
Highly economical and more environmentally friendly	Make high molecular weight polymers in a short time period

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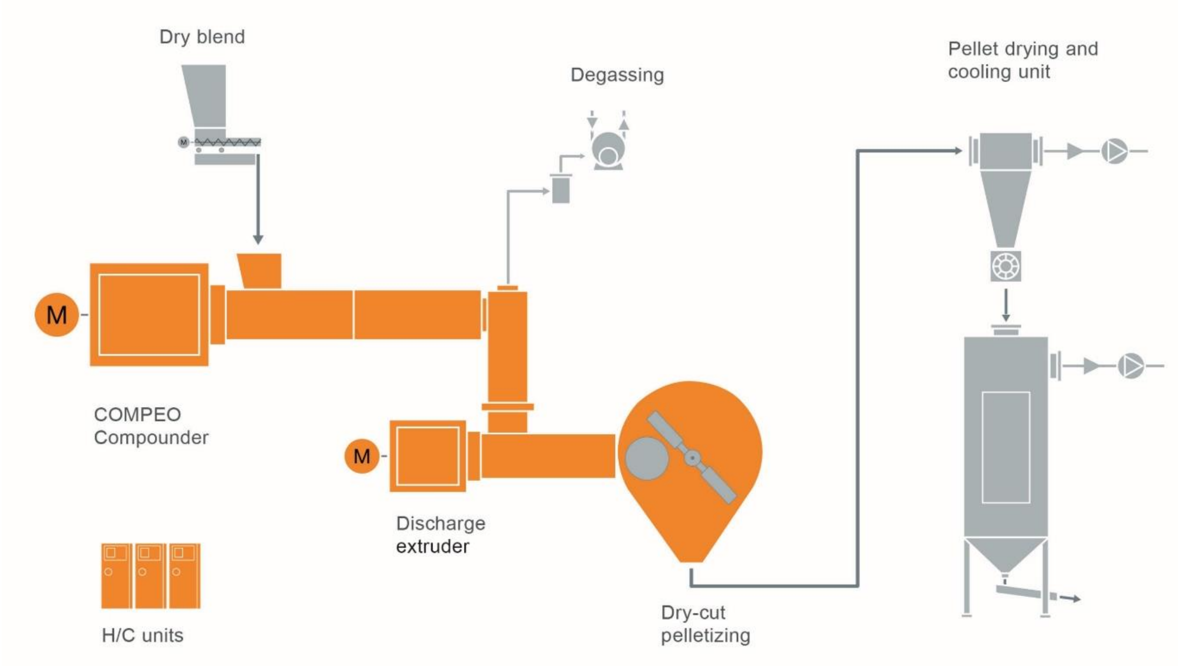
COMPOUNDING PROCESS IN PVC

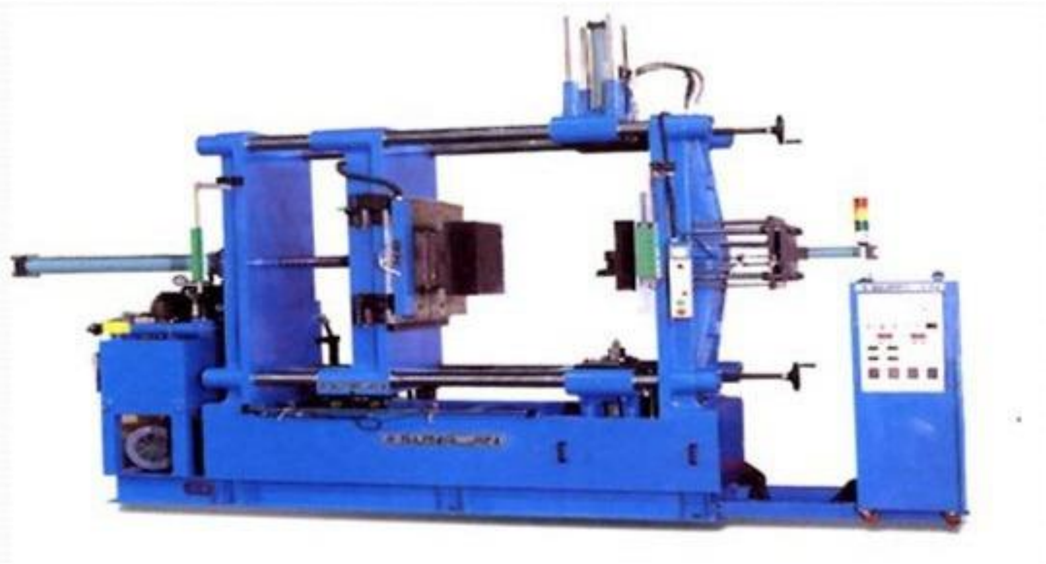
- Compounding plays a crucial role in the PVC manufacturing process by enabling the customization of PVC properties through the addition of various additives.

- By carefully selecting and incorporating plasticizers, stabilizers, pigments, and fillers, PVC products can be tailored to meet the specific performance requirements of diverse applications across industries such as construction, automotive, packaging, and healthcare.



WHAT IS THE INJECTION MOLDING ?

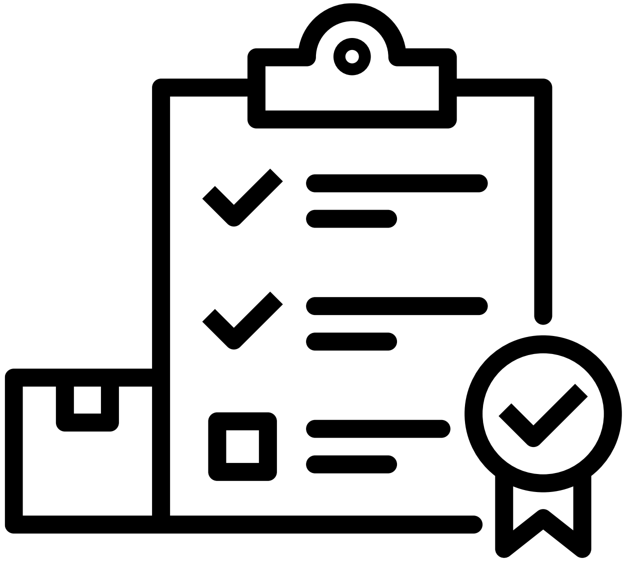
Injection Moulding is a manufacturing process for producing parts from both thermoplastic & thermosetting plastic materials. Material is fed into a heated barrel, mixed and forced into a mold cavity where it cools and hardens to the configuration of the cavity.



QUALITY CONTROL & TESTING QUALITY

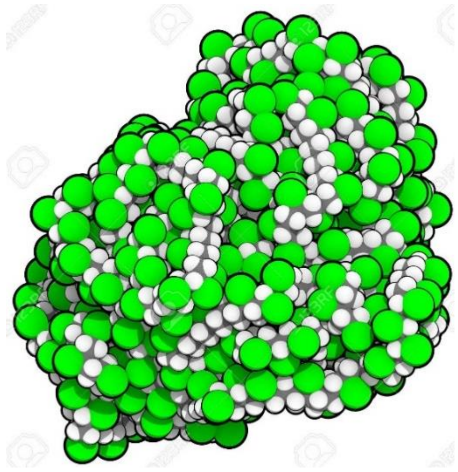
Throughout the manufacturing process, stringent quality control measures are implemented to ensure the PVC products meet required specifications and standards.

Testing may include analysis of physical properties, chemical composition, mechanical strength, and thermal stability.



PACKAGING AND DISTRIBUTION

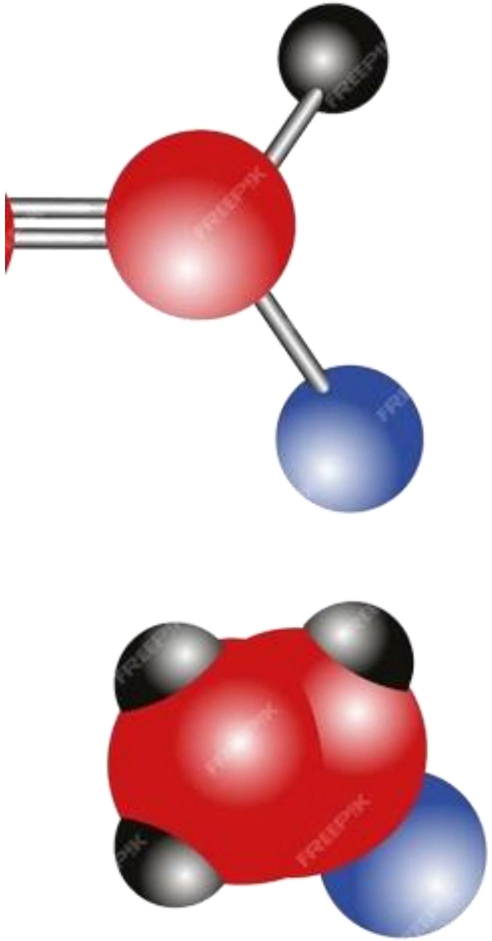
Once the PVC products pass quality control, they are packaged and distributed to customers for various applications in construction, automotive, packaging, and other industries.



ENVIRONMENTAL CONSIDERATION

Efforts are made to minimize environmental impact through waste management, recycling of PVC scrap, and compliance with regulatory requirements for emissions control and pollution prevention.

Applications of VCM & PVC



Vinyl chloride monomer (VCM) and **Polyvinyl chloride (PVC)** are widely used in a variety of industries due to their unique properties and versatility. From construction materials to medical devices, VCM and PVC play a crucial role in shaping our modern world.

Construction and Infrastructure

Building Materials

VCM and PVC are used to manufacture durable and long-lasting building materials such as pipes, window frames, flooring, and siding.

Infrastructure

PVC pipes are commonly used for water supply, sewage, and drainage systems, ensuring efficient and reliable infrastructure.

Electrical Insulation

PVC's insulating properties make it valuable for electrical cables and wiring, protecting against short circuits and damage.

Packaging and Consumer Goods

Packaging

VCM and PVC are used to manufacture flexible and durable packaging materials, such as food wraps, bottles, and containers.

Medical Devices

PVC is widely used in the production of medical equipment, including tubing, blood bags, and various disposable items.

Toys and Sports Goods

VCM and PVC are used to create a variety of toys, sports equipment, and outdoor products due to their strength and flexibility.

Automotive Industry

PVC is used in the production of automotive parts, such as dashboards, upholstery, and wire insulation, providing durability and versatility

Textile and Apparel

Fabric Coating

VCM and PVC are used to coat and laminate fabrics, creating waterproof, stain-resistant, and durable materials for clothing, bags, and accessories.

Artificial Leather

PVC is a key component in the production of synthetic leather, which is widely used in the fashion and automotive industries.

Flooring and Upholstery

PVC-based materials are employed in the manufacturing of resilient and easy-to-clean flooring, as well as upholstery for furniture and automotive interiors.

Electronics and Electrical Appliances

Electrical Wiring

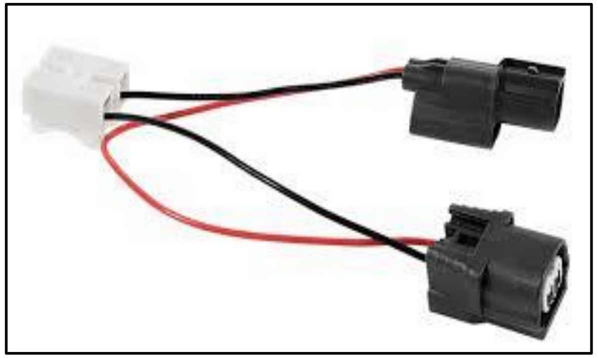
VCM and PVC are used to insulate and protect electrical wiring, ensuring safe and reliable power transmission.

Electronic Housings

PVC is utilized in the production of durable and protective casings for electronic devices and appliances.

Cables and Connectors

PVC's insulating properties make it a valuable material for manufacturing cables, connectors, and other electrical components.



Medical and Pharmaceutical Applications

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Medical Devices

PVC is widely used in the production of medical equipment, such as tubing, blood bags, and various disposable items.

Healthcare Infrastructure

PVC is employed in the construction of healthcare facilities, including water pipes, flooring, and wall coverings, contributing to a safe and hygienic environment.

Pharmaceutical Packaging

VCM and PVC are used to manufacture pharmaceutical packaging, including IV bags, vials, and blister packs, ensuring product safety and integrity.

Emerging Trends and Innovations

1

Sustainability

Efforts are underway to develop more environmentally friendly VCM and PVC production processes, as well as increase the recycling of PVC products.

2

Biomedical Applications

Researchers are exploring the use of PVC in advanced medical applications, such as tissue engineering and drug delivery systems.

3

Smart Materials

Innovative applications of VCM and PVC include the development of smart materials with enhanced functionalities, such as self-healing and shape-memory capabilities.

Introduction to the PVC Market

Global PVC Production and Consumption Trends

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PVC Production Landscape

The global PVC production landscape is dominated by a few key players, with China being the world's largest producer, accounting for over 60% of total output. The US, India, and several European countries are other major PVC manufacturing hubs.

Production Capacity Expansion

PVC producers have been steadily expanding their production capacity to meet the growing global demand, particularly in developing regions like Asia and the Middle East. New state-of-the-art facilities are being built to leverage economies of scale and technological advancements.

Consumption Trends

PVC consumption is closely tied to economic growth and development, with the construction, packaging, and automotive industries being the largest end-users. Emerging markets in Asia and Latin America are driving the global increase in PVC demand.

Regional Dynamics

While China dominates global PVC production, other regions like North America and Europe are major consumers, with a focus on high-value-added applications. Trade flows and regional self-sufficiency vary significantly across different parts of the world.

Key Drivers of PVC Demand

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Construction Industry Growth

Rising infrastructure development and residential/commercial construction activities drive demand for PVC in various applications like pipes, window frames, flooring, and siding.

Expanding Packaging Industry

The growing need for sustainable and versatile packaging materials has increased PVC's usage in food packaging, medical packaging, and consumer goods.

Automotive Sector Advancements

PVC's durability, lightweight, and design flexibility make it a preferred material for automotive interiors, wire and cable insulation, and other auto components.

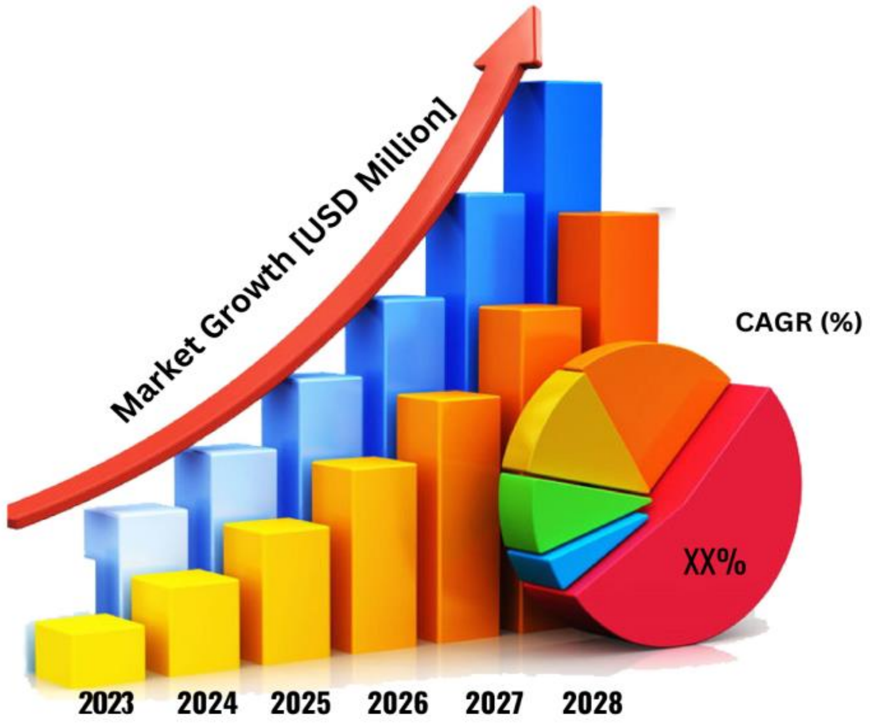
Increasing Demand for Electronics

The rising global sales of consumer electronics like televisions, laptops, and smartphones drive PVC demand for wire and cable housings, electrical insulation, and other components.

Regional PVC Market Dynamics

- The PVC market exhibits significant regional variations in terms of production, consumption, and competitive dynamics. Asia-Pacific is the largest and fastest-growing PVC market, driven by rapid industrialization and infrastructure development in countries like China and India.

- North America and Europe are mature markets with stable demand, while Latin America and the Middle East and Africa are emerging regions with increasing PVC consumption. Regional trade flows, tariffs, and proximity to raw materials influence the competitiveness of PVC producers across different geographies.



PVC Pricing Trends and Volatility

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PVC Pricing Trends and Volatility

PVC prices have experienced significant volatility over the years, driven by changes in raw material costs, supply and demand dynamics, and global economic conditions.

Factors Influencing Prices

Key factors affecting PVC pricing include crude oil and natural gas prices, capacity utilization, trade policies, and environmental regulations.

Regional Price Disparities

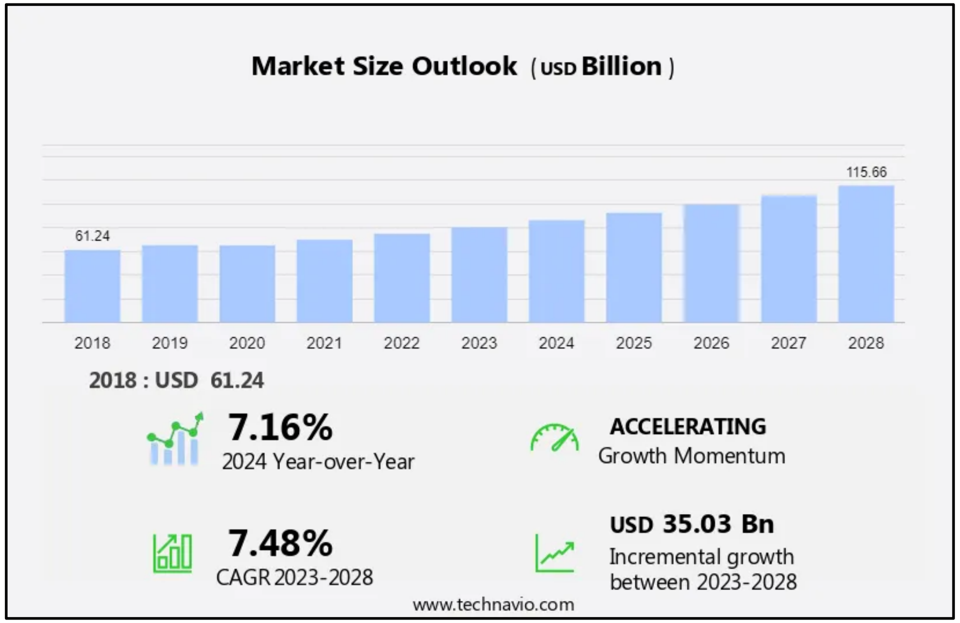
PVC prices can vary considerably across different regions, depending on local supply, transportation costs, and trade barriers.

Emerging PVC Technologies and Innovation

- The PVC industry is continuously investing in innovative technologies to improve production efficiency, product quality, and environmental sustainability. Advancements in chemical processing, catalysts, and recycling methods are enabling PVC manufacturers to develop more environmentally-friendly products and reduce their carbon footprint.

- Novel PVC compounding techniques are also being explored to create advanced materials with enhanced properties, such as increased durability, flexibility, or thermal resistance. These innovations open up new application opportunities for PVC in emerging markets and industries.

Future Outlook and Growth Opportunities



The global PVC market is poised for steady growth driven by increasing demand from construction, packaging, and automotive industries. Technological advancements in PVC production and recycling processes offer opportunities to enhance sustainability and cost-effectiveness.

Emerging economies in Asia and Africa present significant untapped potential for PVC expansion as infrastructure development and urbanization accelerate. Innovative PVC-based products, such as green building materials and medical applications, are expected to fuel future market expansion.

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THANK YOU !