# Plastikos

National Institute of Green Technology
President
Sanghyup Lee

# Heat and Pressure

Greek: Plastikos

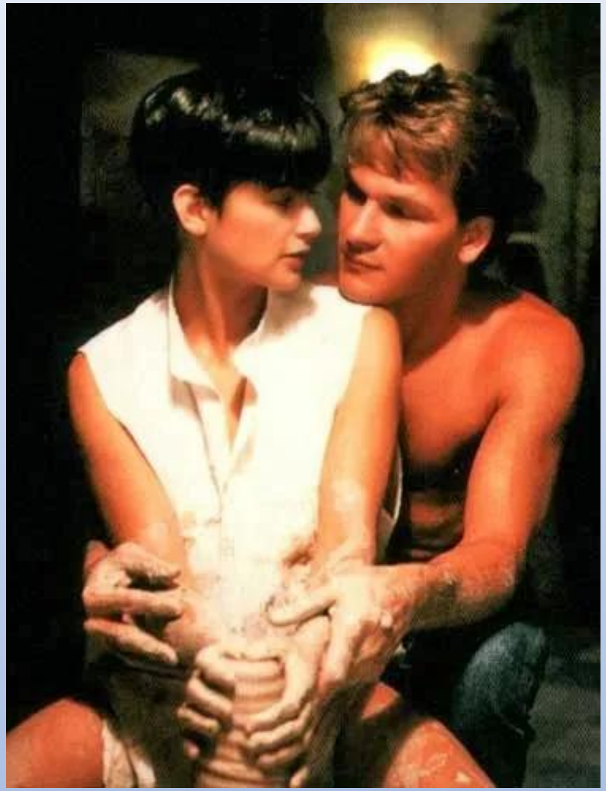
Latin: Plasticus

Modern term: Plastic

Future: (Coming Soon)

‘everything’

# Organic Compound of C + H



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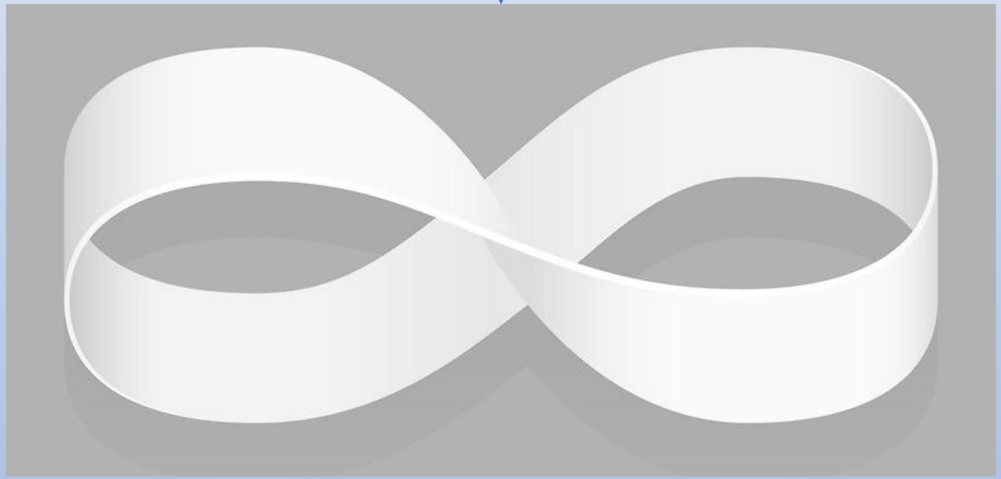

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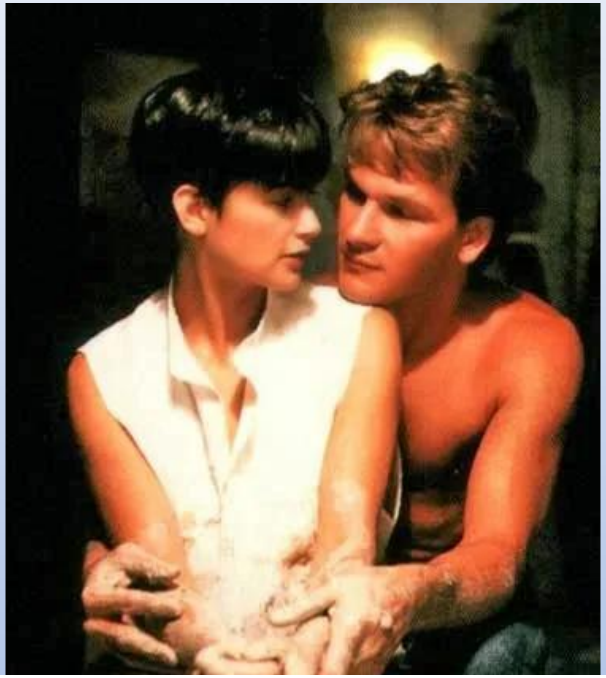
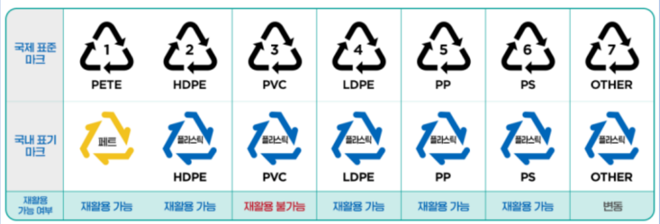





https://news.skecoplant.com/plant-tomorrow/10567/

??

**Beautiful. Done**

**Convenient. Done**

# Waste Ceramics: Waste Plastic

X

O

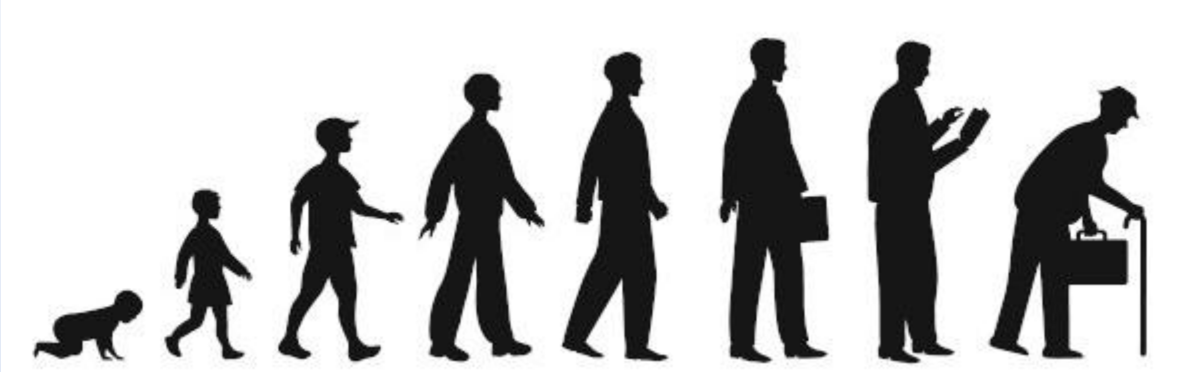
C + H
Organic
Compound

Micro Ceramics
Environmental Problem??

Microplastic
Environmental Problem!!

# C + H Organic Compound

## ‘Aging’ = Damage, Deterioration



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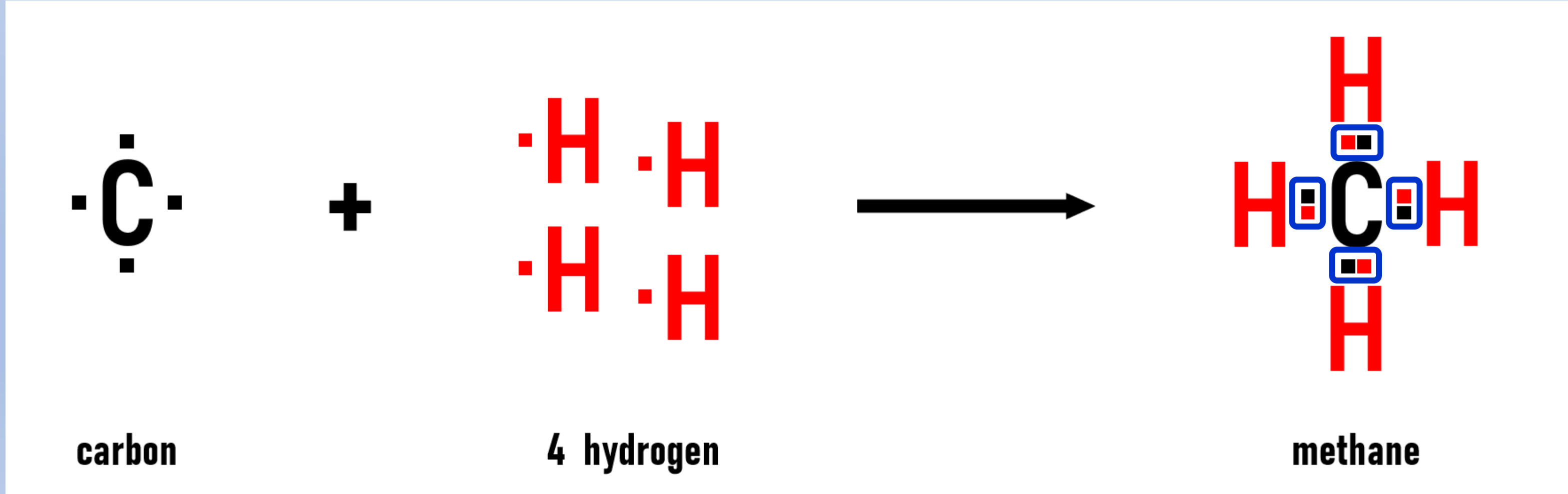
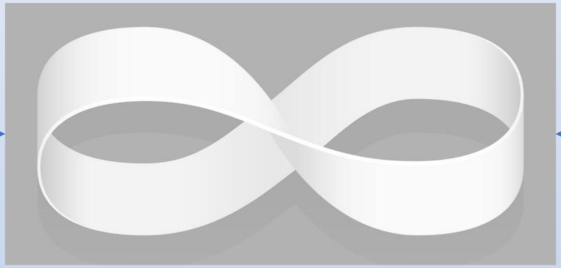



https://blog.kakaocdn.net/dn/t9Fm8/btrJhjPnYMk/95M5SGY7eFbD84Js4JvF0K/img.png

C + H Organic Compound

C + H Organic Compound X



O C

Naturally Derived

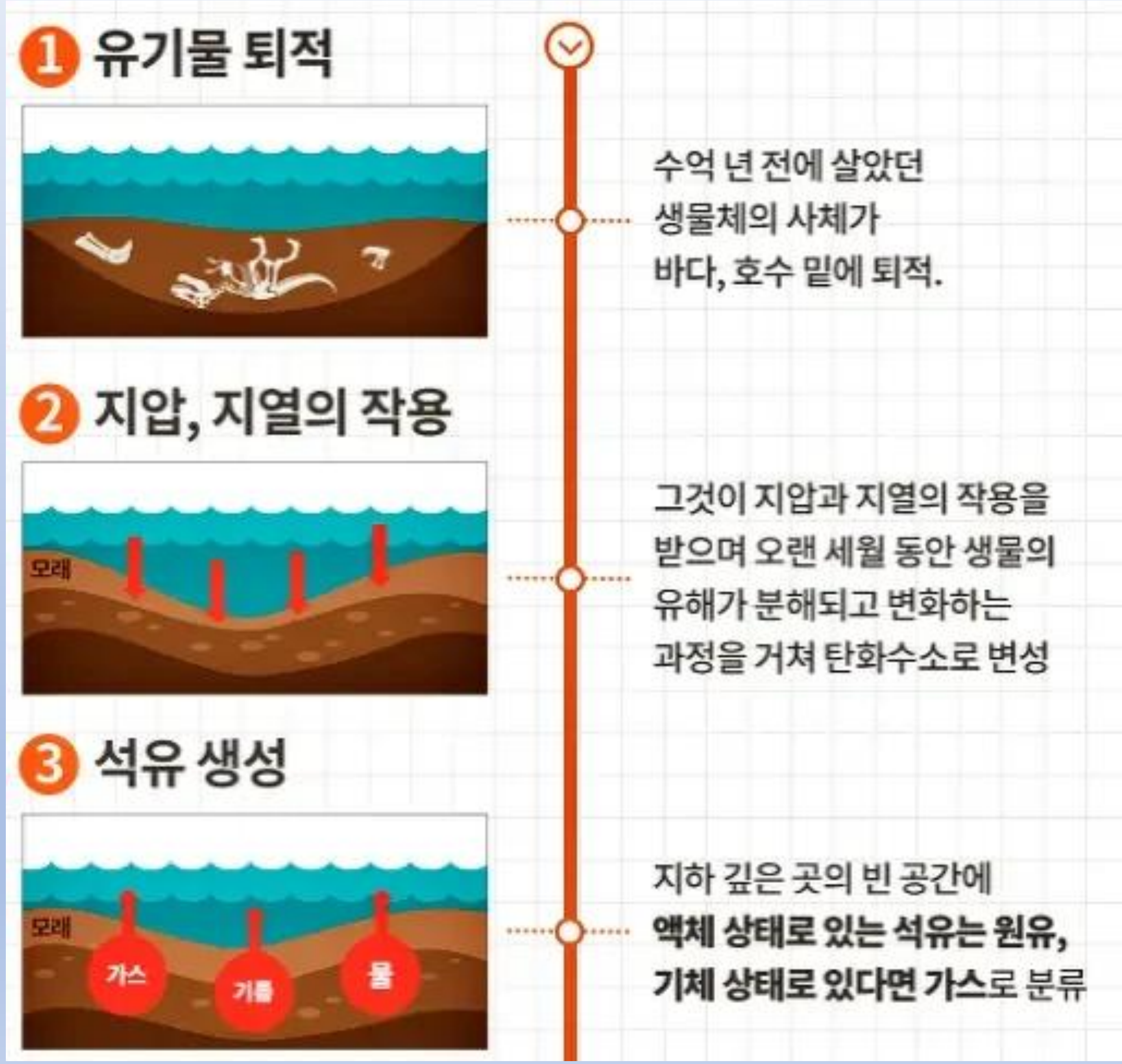
C + H Organic Compound

Naturally Derived

C + H Organic Compound

Able to Circulate!

# Circulation of Naturally Derived C + H Organic Compound 1

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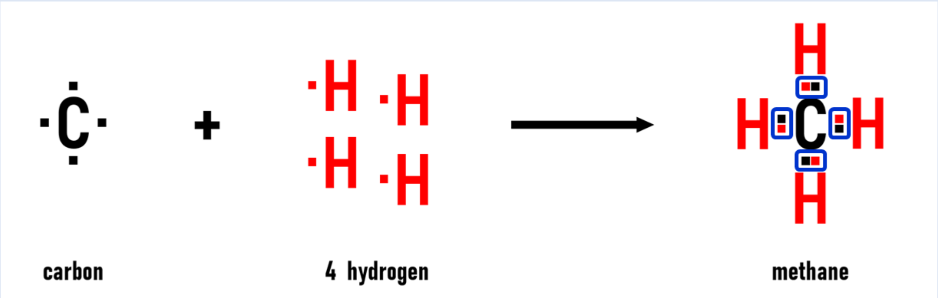
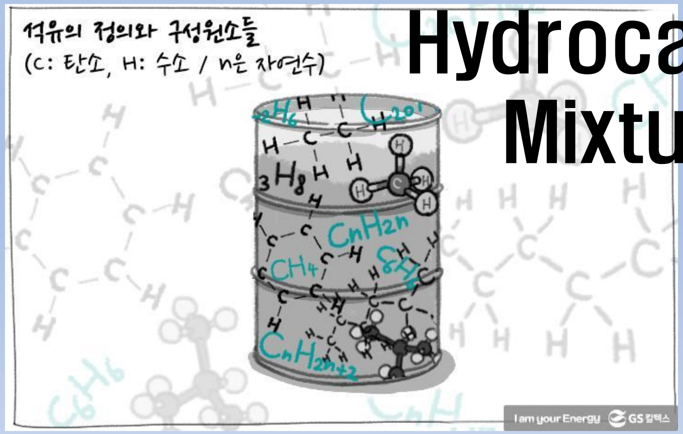
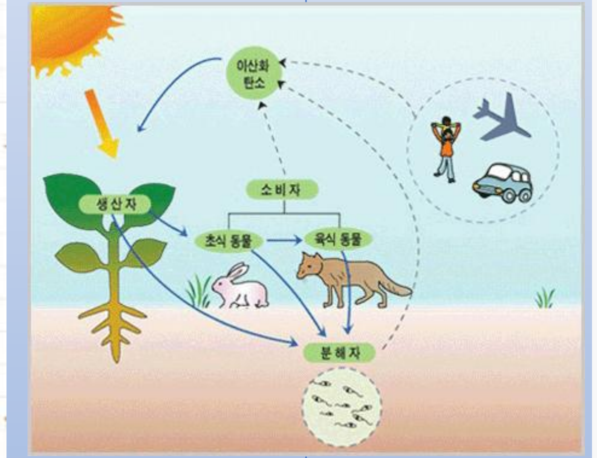



## Heat and Pressure
## Polymerization

## Hydrocarbon Mixture

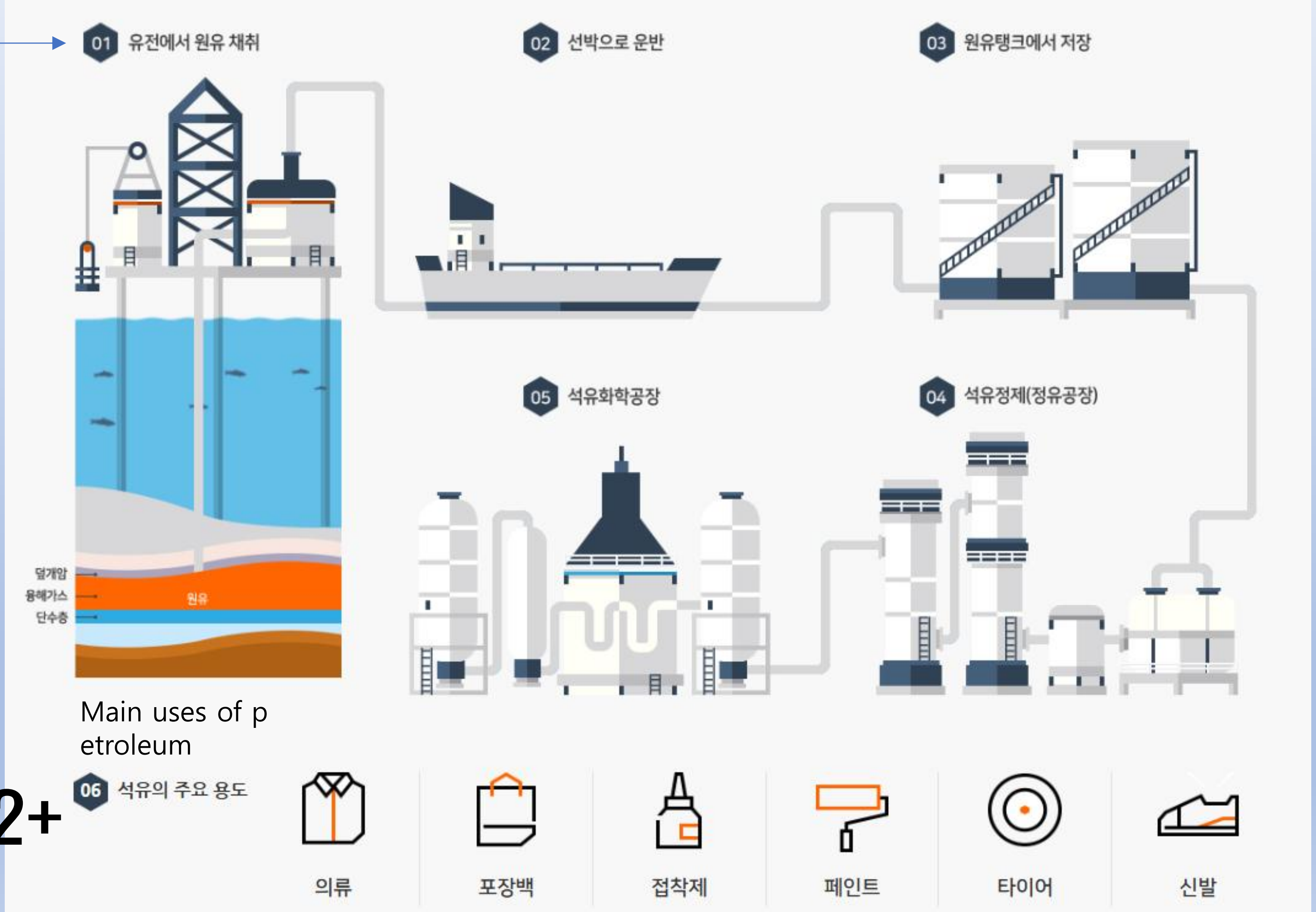


# Circulation of Naturally Derived C + H Organic Compound 2


Light Energy

CO2+

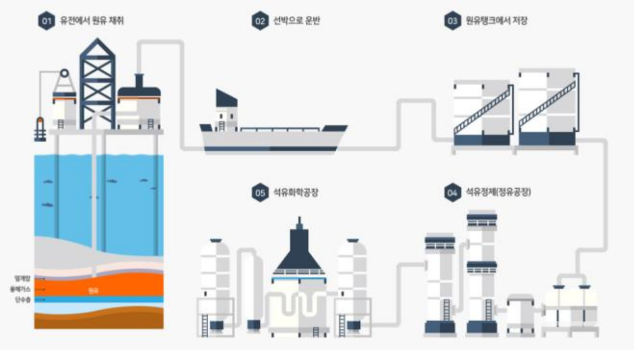



Main uses of p etroleum

https://www.forest.go.kr/kfsweb/kfi/kfs/cms/cmsView.do?mn=AR02_04_07_02&cmsId=FC_000148

https://www.yncc.co.kr/ko/product/chemistry/oil1.do

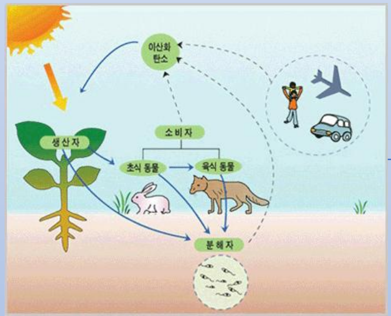
# Circulation of Plastic





C + H Organic Compound

CO2 Light Energy





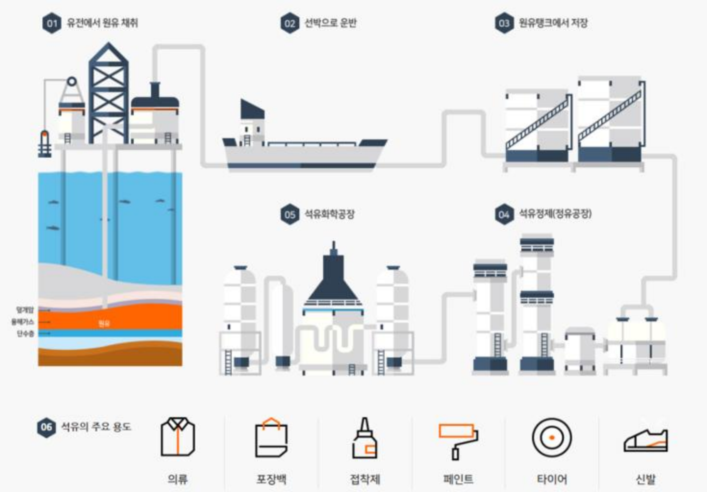
Other than C and H

4-6%

(95%)

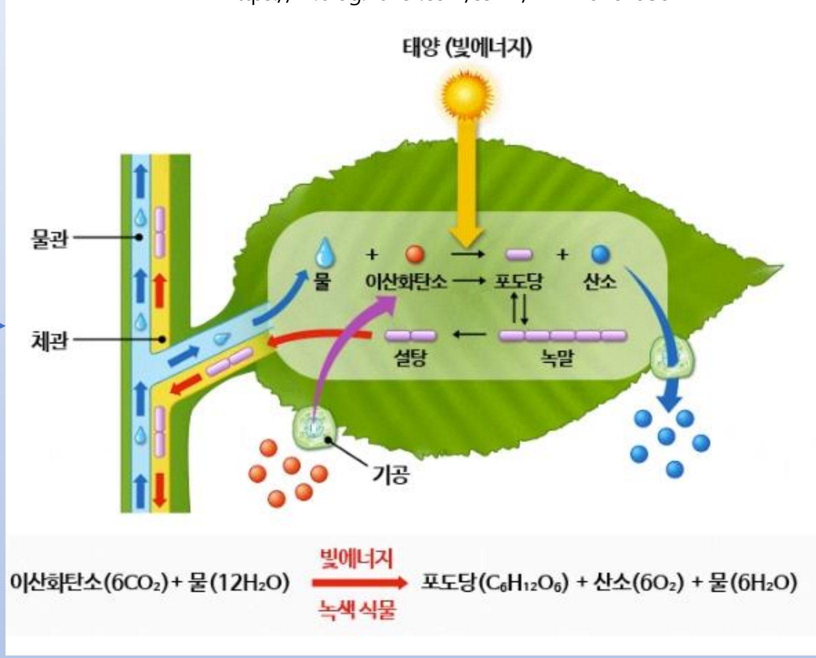
Shiny

# Photosynthesis

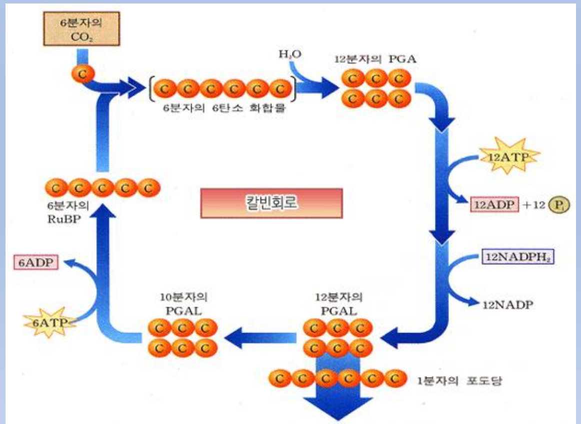



C
+
CO2

https://m.blog.naver.com/ssf17/221779184958




Perfect!



Homo Sapiens

Plastic as a Member of the Ecosystem

Mimicking Crude Oil (C+H Hydrocarbon Mixture)

Always looking at it as a shiny plastic

# Plastic as a Member of the Ecosystem

| Classification | PLA (Polylactic Acid) | PHA (Polyhydroxyalkanoate) |
| --- | --- | --- |
| Origin | Naturally Derived (Plants) | Naturally Derived (Microorganism) |
| Raw Material | Starch from Corn, Sugarcane, etc. | Organic matter like sugars, lipid, etc., for microorganisms |
| Key Process | Produced by **fermenting** plant-based materials | Stored within their cells by **self-synthesis** of microorganisms |
| Relation to Petroleum | None | None |

## Securing Raw Materials

## Finding Microbial Strains

# Mimicking Crude Oil

| Classification | Key Principle | Main Input Materials | Key Products | Advantages | Disadvantages and Challenges |
|---|---|---|---|---|---|
| **Pyrolysis** | Conversion into oil by **thermally** cutting polymer chains unevenly in an **oxygen-free state** | Mixed waste plastics<br><br>(PE, PP, PS, vinyl, etc.) | **Pyrolysis Oil**<br><br>(Used as petrochemical feedstock such as naphtha after purification) | - Capable of treating various mixed plastics<br><br>- Capable of being used as direct resources called "city oil field" | - Requires advanced post-processing (refining) technology to remove impurities<br><br>- Requires pre-selection of plastics containing chlorine such as PVC |
| **Gasification** | Conversion into gas by **partially oxidizing** polymers in **a high temperature and low oxygen state** to fully decompose the structure | All combustible waste and mixed plastics including low-grade waste | **Syngas**<br><br>(Used as basic chemicals such as hydrogen, methanol, ammonia, etc.) | - Barely no feedstock restrictions<br><br>- Capable of producing high-value feedstock such as hydrogen | - Requires massive investment for initial facilities<br><br>- Requires refinery technology for tar and impurities from syngas |
| **Depolymerization** | Restoration to **original monomers units** by selectively breaking down polymers through the **reverse reaction of polymerization** | Single material plastics<br><br>(PET, PS, nylon, etc.) | **Monomer**<br><br>(Pure materials with the same quality as new products) | - Ensures high-purity feedstock equivalent to virgin<br><br>- Capable of infinite closed-loop without quality degradation | - Applicable plastic types are limited<br><br>- Complexity in selecting specific materials |
| **Solvent-based Recycling** | Selective dissolution and purification using **specific solvents** to isolate desired plastics | Mixed waste plastics | **High-purity Recycled Polymer**<br><br>(Polymer structure maintained) | - Removes additives and contaminants while maintaining polymer structure<br><br>- Production of high-quality recycled feedstock | - Requires effective solvent development for each material<br><br>- Recovery technology for used solvents affects cost-effectiveness |

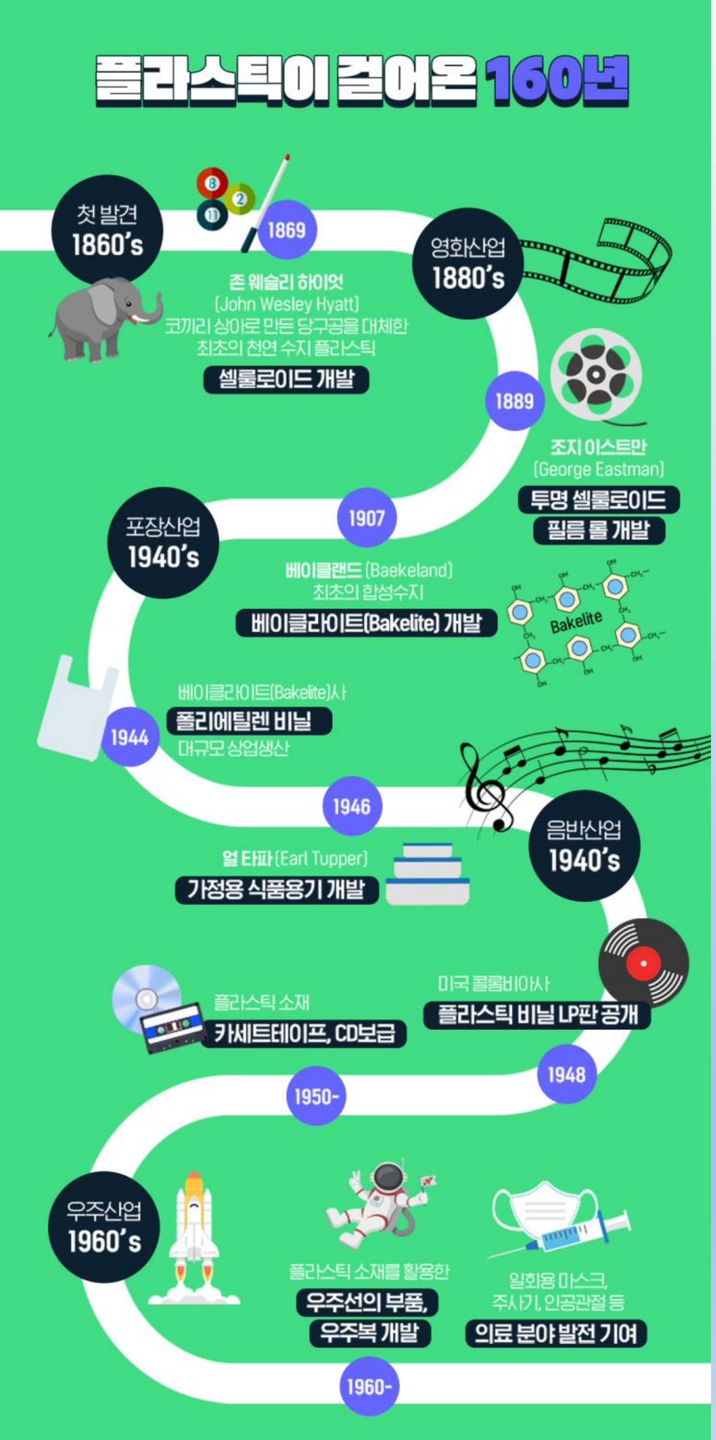
# Always Shiny: Sorting and Separation

| Classification (Process Steps)44 | Key Role | Major Technologies | Technology Development Trends (Advancement) |
|---|---|---|---|
| **Sorting Process** | **The key step of quality** that sorts plastics by materials (PET, PE, PP, etc.) and colors, and removes foreign substances | **Manual Sorting:** Workers manually sort foreign substances and materials on a conveyor belt<br><br>**Mechanical Sorting:**- Wind sorting (separates light vinyl, etc.) – magnetic sorting (removes metals)<br><br>**Optical Sorting (NIR)**: Near-infrared light is used to analyze unique light reflections of materials, and automate sorting | **AI-based Robot Sorting**<br><br>• Robots equipped with deep learning technology recognize materials, colors, shape, and even contamination more accurately and faster than humans<br><br>• Innovatively enhances sorting efficiency and purity of recycled feedstock |
| **Grinding and Crushing Process** | The step that breaks the sorted plastics into small, washable, and processable flakes | **Crusher:** Crushes hard and large plastics<br><br>**Grinder:** Grinds the crushed plastics into finer and consistent sizes | - Low-noise, low-vibration, and low-powered grinding technology<br><br>- Enhanced durability of blades and extended replacement cycles<br><br>- Development of a special grinder that seamlessly handles film-type or flexible plastics |
| **Washing and Separation Process** | The step that **cleans off foreign substances and contaminants** such as dirt, food waste, adhesives, etc. from the grinded flakes | **Density Separation (Washing tank):** Separates floating materials (PP, PE, etc.) and sinking materials (PET, etc.)<br><br>**Friction Wash:** Uses high-speed spinning screw to cause friction by rubbing flakes against each other to remove foreign substances on the surface><br><br>**High-temperature Wash:** uses hot water and chemicals to remove grease and strong adhesives | - **Closed circulation system** that enhances reusage of washing water<br><br>- Development of eco-friendly and high-efficiency washing system<br><br>- Filtering system that minimizes leakage of microplastics |
| **Melting and Extruding Process** | The final step that melts washed and dried flakes, and produces consistent recycled pellets through an extruder | **Extruder:**<br><br>- Melts flakes at a high temperature into molten state<br><br>- Removes impurity gas while moving to a screw<br><br>- Extrudes plastics into a pellet form after pulling plastics into noodle-like strands | - **High-performance deodorization technology:** Effectively removes odor generated during melting step to improve the quality of recycled feedstock<br><br>- **Compounding technology:** Various additives (reinforcing agents, colorant, etc.) are mixed into recycled pellets to enhance specific properties (strength, color, etc.) for high-added-value feedstock production |

# Always Maintaining a Shining Mindset
# ‘Anabada’


## Personally…

https://www.mygoyang.com/news/articleView.html?idxno=68802




# In Closing 1

**1860s | Plastic, the savior of elephants**
Celluloid made from solid extracts derived from camphor tree is considered as the first plastic

**1880s | Plastic, the driver of Hollywood boom**
George Eastman developed “transparent celluloid film roll” made from plastic

**1880s | Plastic, the driver of Hollywood boom**
George Eastman developed “transparent celluloid film roll” made from plastic

**1900s | New material with a thousand uses, the advent of first synthetic resin, Bakelite**
Bakelite, produced by compressing phenol and formaldehyde, offered excellent heat resistance, electrical insulation, and chemical resistance such as resistance to alkalis, salts, and other chemicals. It was the invention of the “new material with a thousand uses” that can endure any environment

**1940s | Food storage using plastic**
Tupper

**1940s | Love travels on melody, and melody rolls on plastic**
As PVC (polyvinyl chloride) LP records become more popular, wider audience was able to enjoy music. Cassette tapes, CDs and other smaller and lighter plastic-based media placed music as a part of a cultural commodity

**1960s | A giant leap for humanity with plastic**
Spacesuits are made with 21 different types of plastics including polyethylene. Disposable masks, syringes, artificial joints, artificial blood vessels and artificial hearts

https://gscaltexmediahub.com/esg/gsc-esg/plastic_history/

# In Closing 2

| Key Field | Major Technologies | Key R&D Goals | Major Participating Institutions / Companies |
|---|---|---|---|
| **Chemical Recycling** | **Pyrolysis post-processing technology** | - Remove pyrolysis oil impurities (chlorine) and improve purity<br>- Feed directly into refinery and petrochemical processes as feedstock (naphtha)<br>- Optimize commercial plant processes | SK Geo Centric, GS Caltex, HD Hyundai Oilbank, etc. |
| | **Depolymerization Technology** | - Efficiently depolymerize PET and other plastics into feedstock monomers<br>- Develop low-energy, and eco-friendly processes (e.g., supercritical technology)<br>- Ensure high-purity feedstock equivalent to virgin | LG Chem, Lotte Chemical, etc. |
| **Physical Recycling** | **AI-based super precision sorting** | - Automate sorting system using AI vision and robots<br>- Maximize recognition accuracy of materials, color, and contamination<br>- Improve the purity of high-quality recycled feedstock | Recycling installation companies, and AI and robotics companies |
| | **Food container recycling** | - Recycle transparent PET bottles into food containers<br>- Advanced washing, sterilizing and disinfecting technology to remove foreign substances<br>- Satisfy food-contact material safety standards at home and abroad | Food and beverage, recycling and installation companies |
| **Bioplastic** | **Next-generation biomaterials** | - Enhance productivity and processability of PHA that degrades in the nature such as marine environment<br>- Develop high-functioning bioplastic with heat-resistance and durability | CJ Cheiljedang, LG Chem, SK Chemical, etc. |
| | **Alternative feedstock technology** | - Technology to utilize non-edible biomass (waste wood, etc.)<br>- Utilize 3$^{rd}$ generation feedstock such as carbon dioxide, microalgae, etc.<br>- Secure sustainable feedstock that does not conflict with food resources | KRICT and other government-funded laboratories |

# In Closing 3

Waste plastic reduction technology fused with radiation technology development project

(New project in 2024)

- **Budget for 2024:** KRW **20 billion**
- **Total project period:** 2024 – 2026 (3 years)
- **Total project cost:** approx. KRW 23 billion
- **Key research areas:**
  - Development of biodegradable plastic feedstock using radiation technology
  - Development of microorganisms that can break down refractory plastics
  - Development of risk assessment technology for recycled materials

| Major Project | Project Duration | Total Project Cost (government funds) | Ministry (assumed) | Key Technology Area |
|---|---|---|---|---|
| **Development of technologies that convert waste plastic into feedstock and fuel** | 2022 – 2026 | **KRW 34.4 billion** | Ministry of Environment | Chemical recycling such as pyrolysis, gasification, etc. |
| **Development of technologies that convert waste organic resources into C2 monomers** | 2022 – 2025 | **KRW 27 billion** | Ministry of Environment | Convert waste resources → ethylene / acetylene (chemical recycling) |
| **Development of technologies that promote recycling of future waste resources** | 2022 - 2024 | **KRW 25.2 billion** | Ministry of Environment | Recycling of waste solar panels, waste batteries |

# In Closing 4


Plastikos

↓

'capable of being shaped' 'capable of being molded'

Using C of petroleum as a raw material, it can be

'shaped' 'molded'

'Using C of the plastic structure as a raw material, it can be'

shaped' 'molded'

CCU

Plastics (etymological origin)

https://v.vivasam.com/themeplace/energy/energyLife.do

# In Closing 5

## Plastic and resource circulation

8 5 3 5 4 6 5 8

3 8 8 0 1 3

1 6 1 4

7 5

2

<

## Plastic and recycling

8 5 3 5 5 10 5

3 8 8 5 5

1 6 0

7 0

7