

Environmental Pollution of Medical Waste and New Medical Plastic Waste Treatment Technology

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Abstract. Since the global outbreak of the COVID-19 virus, the resulting medical waste has increased. Plastic pollution to the Earth's environment is already very serious, and now because of the proliferation of medical plastic waste, the environmental pollution problem is becoming more serious. This paper discusses some green medical waste treatment technology and some medical waste reuse retreatment technology. This paper mainly expounds on the problems being in the disposal of medical waste, such as the amount of medical waste being too large, and there is no standard place for recycling daily medical waste. The treatment methods are usually incineration and landfill, but these treatment methods will produce harmful substances and gases, will pollute the environment, and affect biological health. And there is a high chance that COVID-19 will spread again. At the same time, some environmental treatment methods for medical waste, such as microcapsule technology and photocatalytic degradation technology, are introduced. It can reduce the emission of polluting gases and reduce the pollution to the environment. Or by recycling medical waste, processing and reusing it to produce new materials. For example, plastic cracking oil production technology and waste mask iron-making technology will recycle medical waste for reuse. This paper hopes that the new medical waste treatment technology can be widely understood and used. It is also hoped that some more efficient, low consumption and low pollution medical waste treatment methods can be developed to reduce the environmental pollution caused by the existing treatment methods.

Keywords: Medical Waste, Environmental Protection, Technology, Pollution, Plastic.

1. Introduction

Since the global outbreak of COVID-19, many medical supplies have become essential for People's Daily life, such as surgical masks and medical protective clothing. As COVID-19 continues for nearly three years, the amount of medical waste is growing. It is reported that 129 billion facemasks are consumed worldwide every month. Plastic pollution to the earth's environment is already very serious, now because of the soaring amount of medical plastic waste, the environmental pollution problem is becoming more and more serious. Until now, medical waste has been dealt with mainly by incineration and landfilling. Air pollution is mainly manifested as harmful gases produced in the process of stacking, particles floating in the wind and so on. Secondly, water pollution is mainly reflected in directly pouring into rivers or flowing into rivers through rainwater, which will deteriorate water quality, affect the growth of aquatic organisms, destroy the ecological balance of water, spread diseases, and pollute groundwater. Third, soil pollution is mainly manifested in the occupation of land. Toxic substances infiltrate the soil, killing soil microorganisms and causing soil degradation [1]. Medical waste contains a variety of infectious viruses and bacteria, and if not properly treated, will cause water, soil, air pollution, a serious threat to human health. Pathogens like COVID-19 can spread through the air, mouth, nose, and eventually lead to human infection with the virus.

Li Shuqian et al. [2] explored the treatment method of medical polypropylene waste. They discussed several non-incineration treatments without delving into the rationale for each. There is also a lack of consideration for environmental issues. Many data surfaces, there are many kinds of environmental protection technology to treat medical waste, such as microcapsule technology, photocatalytic degradation, plastic cracking oil production technology. However, it is difficult to solve the problem of high energy consumption and low efficiency in plastic cracking oil technology. Daniel J.C. Stewart et al. [13] studied the waste mask ironmaking technology, which can reprocess

and reuse the waste medical waste. But what still needs to be explored are technologies that are not only greener but also more efficient and widely available.

The text describes the hazards of traditional medical waste disposal methods in detail, aiming to avoid large amounts of incineration and landfill disposal. At the same time, explore some environmentally friendly and green treatment of medical waste technology, and some medical waste re-processing and reuse technology. The principle and technology of each method are compared to provide references for different new technologies.

2. Causes of problems in the treatment of medical waste

2.1. The amount of medical waste is large

Because of the COVID-19 situation, the amount of medical waste, such as masks and protective suits, has increased rapidly. According to estimates by *National Geographic* magazine, about 129 billion face masks are consumed worldwide every day. The use of protective clothing increased 6.82 percent from 2015.

2.2. The way of recycling medical waste is not standard

2.2.1 Lack of clear classification of medical waste

There are no precise regulations governing what constitutes medical waste, and there is a lack of systematic and correct guidance on the disposal of used daily medical waste. Most people have limited access to the disposal of used masks. It is understood that people's understanding of disposal methods of daily medical wastes comes from online media, and they are often misled by the wrong disposal methods that often appear on the internet. Masks and protective clothing are roughly put back into other garbage.

2.2.2 Lack of fixed daily medical waste collection

At present, there are few special recycling places for medical waste, so it is difficult to achieve unified recycling and treatment of medical waste. Daily medical waste carries viruses and bacteria, which are likely to be retransmitted if not properly recycled. Regulatory institutions are deficient. Although many hospitals set up the medical waste management organization and have a part of the management system, by a third party, shall be carried out in accordance with the unified standard for medical waste disposal. However, many problems exist in the implementation, performance in preparation and capital investment, develop the system and measures that cannot implement, and management organization is not really playing the role of the regulators.

2.3. Problems in the transport process of medical waste

In the process of transportation, treatment and disposal of medical waste, many non-professional personnel are involved. They do not have professional skills and relevant knowledge, lack of social responsibility education, and have serious accidents or potential threats to the safety of the entire transportation, storage and other processes due to different education levels. Medical waste accidents according to the statistics in outflow causes environmental pollution investigation, points out that medical waste is missing, missing, leakage and diffusion causes of environmental problems is not a medical waste disposal methods and technical problems, but hire non-specialists environmental damage caused by wrong handling medical waste, this is because the disposal operation personnel's professional level Incomplete, personal quality is not enough, resulting in errors in the classification and collection of medical waste, or the illegal sale of medical waste to criminals, or the arbitrary disposal of medical waste in the process of transportation, storage and treatment, resulting in environmental problems [3].

2.4. The public's awareness of the treatment of medical waste is not strong

Publicity on proper disposal of medical waste is low, grassroots people do not know the importance of harmless treatment of medical wastes. For medical waste disposal and control limited to prevent COVID virus infection, most people do not realize the importance of harmless treatment of used masks and the harm caused by poor disposal of used masks, so directly mix them into household garbage. Some people even wear protective masks repeatedly.

3. The environmental impact of the wrong disposal of medical waste

Because COVID-19 masks and protective clothing are now the most rapidly consumed item. As discarded masks get more and more, there are some questions we can't help but consider. Medical wastes are mostly made of plastic (PP or PVC), which is difficult to deal with. In some reports, many medical wastes have been collectively burned or landfilled, and others have been discarded, then will into the ocean. These treatment methods will cause certain pollution to the environment and damage to the biological system.

3.1. Incineration

Now people commonly used disposable medical masks that are mainly composed of a waterproof layer (spun-bonded non-woven fabric) and a filter layer (melt-blown non-woven fabric). Among them, the waterproof layer and filter layer are polypropylene (PP) non-woven microfiber as the main material, more than 90% of the total materials. PET plastic and polyurethane (PU) are used as common materials for ear bands. At present, the treatment of medical waste in the world mainly uses incineration technology, because incineration technology has wide adaptability, almost applicable to the treatment of all medical waste. Medical waste after the high-temperature treatment of about 1000 °C, has been a relatively thorough elimination of viruses and removal of the pollutants. But because COVID-19 medical waste is extremely contagious, it must be placed in a closed environment and then put in an incinerator. However, the existing incinerators are not completely sealed, and the incineration process will not only produce CO₂, which is a greenhouse gas that causes global warming and environmental pollution. If incomplete combustion will produce CO particles; but may produce dioxins, which is highly toxic pollutants. In addition, there may be a fire in the process of incineration, and there are safety risks, which will not only harm individuals but also affect public safety.

3.2. Landfill disposal

Medical waste from landfills can contaminate the land. It will reduce the fertility of the soil and makes it difficult for plants to survive. CO₂ released from medical waste landfill will dissolve into groundwater and break the balance of CO₂ in the original groundwater. It will promote the dissolution of CaCO₃ and lead to an increase in groundwater hardness. Medical waste also carries viruses and bacteria that accumulate in the soil over a long period of time, affecting life and microorganisms in the soil. Some studies suggest that masks can take up to 450 years to break down. For example, masks, usually break down first into micro-plastic (less than 5 millimeters) and then into nano-plastics (less than a millionth of a millimeter). Nano-plastics not only affect plant growth, but they may also enter cells in the body and skin contact and disrupt their activity. Although functional research on the toxicity of nano-plastics is extremely rare, certain potential impacts of exposure to nano-plastics can be deduced from vertebrate models. Although skin penetration is still debatable, nanoscale polymers from a variety of sources primarily enter organisms through the digestive and respiratory systems or epidermal injury. Nano-adults may stimulate local immune cells after adhering to the gut or lungs. This causes localized inflammatory reactions that damage cells and alter the makeup and operation of the gut microbiota. An alternative route for nano-adults to reach lymph and blood arteries is through the epithelium. Access to metabolic and endocrine organs like the liver and kidney is ensured upon entry into the blood, having an impact on the weighing processes of nutrient and energy management and excretion. Nano-plastic exposure may also result in behavioral changes, as shown in Fig. 1 [4].

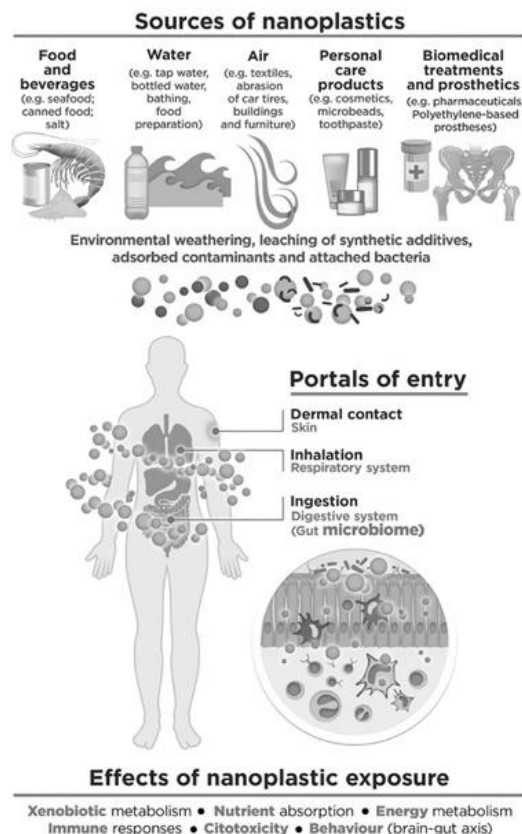


Figure 1. Potential effects of nano-plastics on human health [4]

3.3. Pour into the sea

Plastic contained in the medical waste can contaminate water supplies. In 2020, nearly 52 billion masks were manufactured worldwide. With an estimated loss rate of 3%, that's about 1.56 billion masks flowing into the ocean. The World Health Organization says the flow of medical waste into the ocean is a serious threat to Marine life. The masks, which look like jellyfish, are eaten by large seafood creatures. The medical waste is not broken down in Marine animals and can clog the gastrointestinal tract. Or it could cut through the internal organs and kill the animal. Most medical waste that ends up in the ocean contains bacteria and viruses. These viruses not only pollute the Marine environment but also cause fatal damage to Marine animals. A new kind of Marine pollution has emerged, which will also cause problems of water pollution and water quality deterioration. As a result, the Marine ecosystem is out of balance and the Marine environment deteriorates.

4. Environmentally friendly treatment of medical waste

4.1. Biodegradable PP was used to produce medical supplies

PP fiber is used a lot in medical supplies, but PP is not easy to be degraded. There are a lot of biodegradable fibers out there, and biodegradable fibers are fibers that are spun from biodegradable polymers. After being eroded by natural organisms (such as bacteria, fungi, algae, etc.), it can be completely degraded and eventually metabolized into water and carbon dioxide by enzymes. There are mainly cellulose fiber, chitosan fiber, polylactic acid fiber, etc., and two components of degradable fiber composed of two different polymers. Because of the need to consider environmental protection, but also to meet the medical waste can achieve degradation. The following describes the method of producing degradable PP fiber.

A degradable PP fiber microcapsule technology was developed in a textile printing and dyeing company in Zhejiang, China. This technology is the micro material wrapped in polymer film technology, is a kind of storage solid, liquid, gas micro packaging technology. With starch as wall

material (wall thickness 0.5-150 μm) and a special deoxidizer containing ultra-fine TiO_2 as core material, the deoxidizer was coated and complex into 10-20 μm particles, and the microcapsule particles uniformly adhered to the surface of PP fiber in the process of spinning. The microcapsule wall material will gradually break itself after the material reaches its service life, and the special degradation agent containing ultra-fine TiO_2 coated in the core material will be slowly released, accelerating the degradation process of PP fiber, so that PP fiber can be degraded into carboxylic acid that can be absorbed by nature, without causing pollution to the environment. Miyazaki et al. [5] prepared a kind of poly (ethylene oxide) microcapsule containing TiO_2 particles and coated it on the surface of PP fiber to produce a kind of photodegradable PP fiber.

The principle of microcapsule technology, specifically refers to the one goal object (or phrase) in a variety of natural or synthetic polymer continuous thin film was covered up to the wall or foreign minister, and the original chemical properties of goal object intact, then gradually by some external stimulation or slow-release effect makes the function of the item on display outside again, The diameter of microcapsules is generally 1-500 μm , and the thickness of the wall is 0.5-150 μm . Microcapsules with particle sizes below 1 μm have been developed. The microcapsule particles were expanded to 0.25-1000 μm in some instances. When the particle size of microcapsules is less than 5 μm , it is difficult to collect because of the intensified Brownian motion. When the particle size is larger than 300 μm , the surface friction coefficient will drop suddenly, and the microcapsule function will be lost. Generally, the thickness of the capsule wall is 1-30 μm .

Microencapsulation technology has many characteristics. It can effectively reduce the reaction of active substances to external environmental factors (such as light, oxygen and water); Reduce the diffusion and evaporation of heartwood into the environment; Control heartwood release; Masking the odor of heartwood; Changes heartwood's physical properties (including color, shape, density, dispersion), chemical properties, etc.

4.2. Photocatalytic degradation

Due to its enormous energy, UV radiation is thought to be the most harmful source for plastic polymers. Therefore, photodegradation will occur if the polymer is repeatedly exposed to UV radiation, which will cause damage to both its physical and chemical structure.

Usually, in the presence of ultraviolet radiation and oxygen, polymer photodegradation includes chain breaks, molecular structure changes, molecular weight reduction, and deterioration of polymer properties. An electron in the valence band will be excited and jump from the top of the valence band (VB) to the bottom of the conduction band (CB), leaving a hole (h^+) in VB, leading to electron-hole separation, as shown in Fig. 2. when the photon energy striking the photocatalyst is larger than its bandgap. The charge carriers produced by photosynthesis are then transported to the catalyst surface where a series of reactions can take place. In the photocatalytic degradation of plastics, hydroxyl and superoxide anion radicals, which can also react with O_2 or H_2O , can also continue to degrade the plastic to produce small molecules of organic matter or eventually degrade to CO_2 and H_2O . e^- and h^+ produced by photocatalysis can also directly oxidize the plastic in this process.

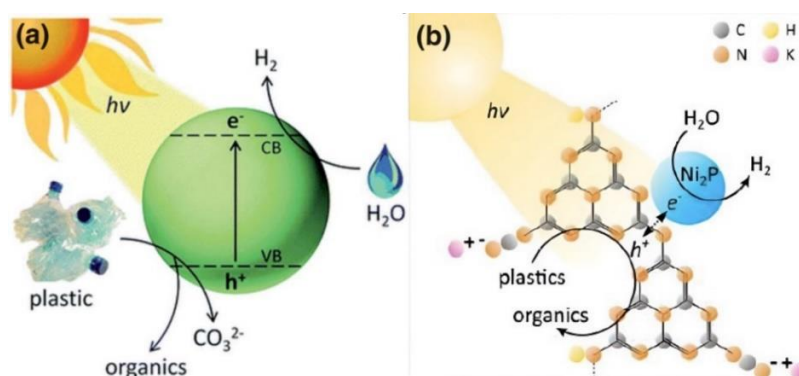


Figure 2. (a) Schematic diagram of plastic degradation process involving photocatalyst. (b) Photocatalytic reforming of polymers by photocatalysts [6].

4.2.1 Polyvinyl chloride (PVC)

Due to the low photocatalytic activity of TiO_2 photocatalyst under visible light, it is considered to be modified on the basis of TiO_2 . The photocatalytic degradation of PVC film by TiO_2 photocatalyst modified with vitamin C (VC) was studied. Because Ti atoms are easy to form coordination bonds with oxygen-containing ligands, VC is specially combined with TiO_2 surface to form a complex. UV-vis spectra showed that compared with PVC- TiO_2 and PVC-VC, the absorption range of PVC-VC- TiO_2 was significantly widened, as shown in Fig. 3a. The absorption widening is attributed to the unsaturated bond between TiO_2 and VC. The reason for the red shift of the absorption threshold wavelength to as high as 600 nm is that the Ti atom binds to the bidentate of the VC- α -substituted surface, leading to the appearance of a five-membered ring on the surface of the Ti atom, as shown in Fig. 3b. The findings demonstrate that the five-membered chelating ring structure of the Ti-VC charge-transfer complex significantly boosts photocatalytic activity. Fig. 3b illustrates how the Ti-VC charge-transfer complex boosted the VC and TiO_2 's synergistic impact after illumination. In order to create superoxide radical, photogenerated electrons are transported from VC to the conduction band of TiO_2 . Through the one-electron reduction of surface oxygen, superoxide radicals damage neighboring polymer chains and speed up the breakdown of PVC [7,8].

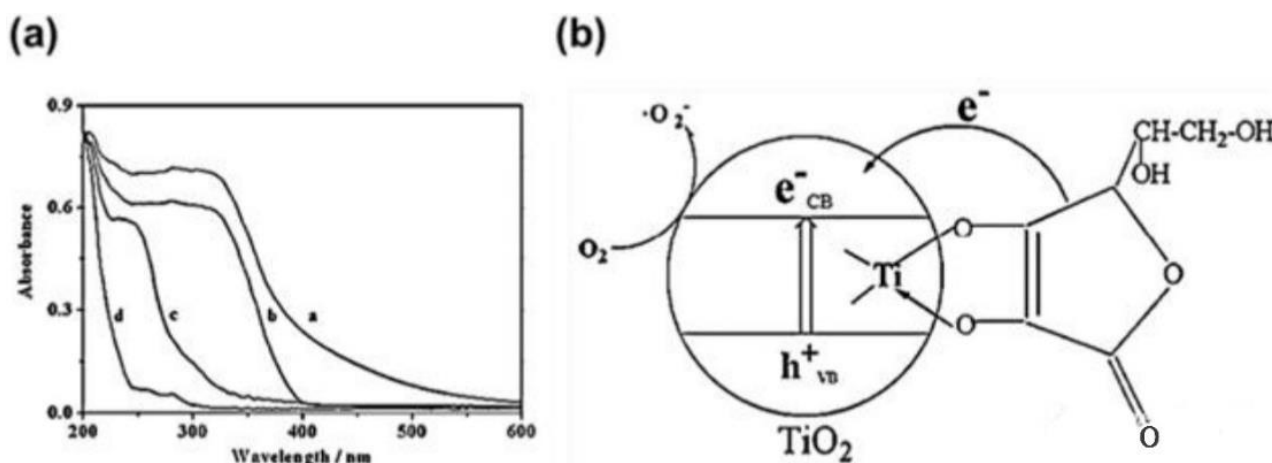


Figure 3. Photodegradation of PVC-VC- TiO_2 film (Curve a: PVC-VC- TiO_2 film; Curve b: PVC- TiO_2 film; Curve c: PVC-VC film; Curve d: pure PVC film) [7]

4.2.2 Polypropylene (PP)

It is found that the particle size of TiO_2 plays an important role, and the fine TiO_2 powder is more suitable for plastic photodegradation than the large TiO_2 particle. Similar, the improved TiO_2 photocatalyst improved the photocatalytic degradation efficiency of PP. TiO_2 immobilized organic clay (TiO_2 -OMT) photocatalyst was studied. Quantitative molecular weights characterized by gel permeation chromatography showed that the molecular weight of PP was reduced by 2 orders of magnitude after 300 hours of irradiation. Photogenerated electrons and holes in TiO_2 can react with absorbed H_2O or O_2 to generate various reactive oxygen species (ROSs), including O_2^- , HOO^- , HO^- , etc. These ROSs capture the hydrogen atoms in the PP polymer chains, which then generate a $-\text{CH}_2$ (CH_3) C- macromolecular radical, which then cuts the polymer chains, as shown in Fig. 4 [9].

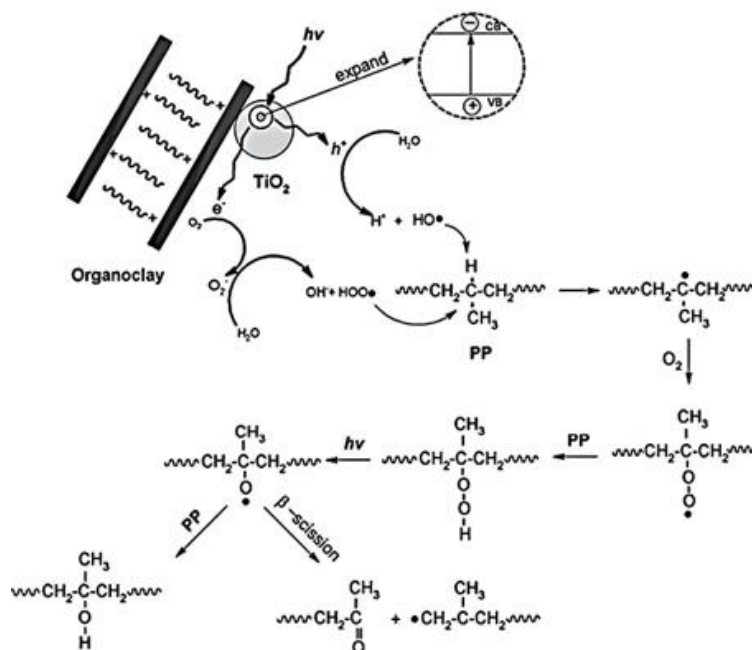


Figure 4. Degradation mechanism of PP/ TiO₂-OMT composites [8].

4.3. Plastic pyrolysis oil production technology

As a kind of polymer product, medical plastic waste can further reduce the molecular weight by C-C bond fracture, so that solid plastic can become an oily liquid product. Among them, thermal cracking refers to the fracture of C-H bond fracture, and the resulting free radicals continue to generate different small molecule hydrocarbon mixtures through various combination reactions.

Waste plastic is polymer waste that is suitable for cracking technology. Based on these conditions. After treatment, exhaust gas, and flue gas emission standards, will not cause pollution to the environment. The core technology of waste plastic cracking technology. It is a qualitative chemical decomposition process in which waste plastic and tires are heated in a state of less oxygen or hypoxia. So that they become gaseous, liquid or solid combustible. Through this technology, waste plastics can be converted into products such as cracked oil, carbon black and combustible gas. The pyrolysis process has been widely studied and can be divided into three stages: thermal initiation reaction, chain breaking reaction and chain termination reaction [10].

Technical classification of plastic pyrolysis oil production. According to the role of catalysts, plastic pyrolysis to oil technology can be divided into four categories: thermal cracking, catalytic cracking, pyrolysis-catalytic upgrading and catalytic cracking-catalytic upgrading [11].

4.4. Waste mask ironmaking technology

The use of medical plastic waste can reduce the need for reducing agents in the process of making steel and iron from fossil fuels such as coal. But the two current areas of commercial use of plastic for iron making are the incorporation of small amounts of waste plastic into the coke oven process and the injection of waste plastic into the spout of BF [12]. Converter (PHF) is an emerging technology used to separate volatile metals (Zn, Pb, etc.) from steelmaking by loading a mass prepared from black byproduct dust and carbon sources (coal, coke breeze, blast furnace dust) into a rotating converter and heating to 1200-1300 ° C for 10-30 minutes. There are zinc and iron oxides in medical waste masks, which generate direct reduced iron (DRI) particles and components containing volatile metals during thermal reduction and use their separation to recover the secondary oxidized dust. It has been shown that the CO₂ gasification reaction is the rate-determining factor in the reduction process of cold-bond self-reducing iron condensates, although the carbon source heat transfer effect becomes more significant at extremely high temperatures. Therefore, increasing the gasification reaction of carbon sources in RHF self-reducing aggregates can provide reduced rates and thus increase productivity [13].

5. Conclusions

The rapid global spread of the COVID virus has led to a massive increase in the use of masks and protective clothing. Therefore, a large amount of medical waste is generated, and it is difficult to cure the environmental pollution caused by PP and PVC materials. This paper introduces many methods and technologies to deal with medical waste. Microcapsule technology is a newly developed degradable PP fiber as a material, which solves the problem of difficult degradation of traditional PP. Photocatalytic degradation technology is to use TiO₂ film to catalyze the degradation of plastic medical waste to produce small molecular organic matter or CO₂ and H₂O. Plastic cracking oil can convert waste plastic into cracking oil, black carbon and combustible gas. Waste mask ironmaking technology is through thermal reduction to produce iron oxide dust, and then recycling. The latter two enable reprocessing and reuse to produce materials that can be used continuously. It not only avoids producing harmful gas to pollute the environment but also generates new resources for human use. In the future, we should focus on developing new technologies to process medical waste into other usable raw materials, so to further achieve the goal of energy saving and emission reduction

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